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Solar Energy Scenarios

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ABSTRACT: *The Crises of energy has been increased over the years due to increasing world population and expansion of global industries especially for food and basic requirements. Most of the energy is consumed in power generation, industries & factories, transportation, and community sectors. Moreover, in order to fulfill our demand we are mostly dependent on energy, taken from fossil oil, gas and coal. In developing countries like India, more than 70% of the population lives in the rural areas where more than 85% of the energy being consumed comes from non-conventional sources, the major one being fuel wood. The increasing cost of conventional fuel in urban areas necessitates the exploration of other energy sources. Solar energy provides an alternate source of energy in rural and urban India as a substitute for fossil fuels. We can get the solar energy from sun; the sun is a major source of solar energy. In Gujarat the fossil resources are limited, and they impose a high burden on the environment therefore looking at the ecological and economical perspectives, solar energy is an important source of energy for the state. Thus as effective Solar energy is strategic the review highlights the various Solar energy scenarios that can facilitate the vision of a cleaner environment and to effectively deal with the energy crises problems.*

Keywords*: - Solar energy, Energy crisis*

I. Solar Energy And Gujarat

The range of application of Solar energy in Gujarat is currently being limited to applications in the developing world such as India, Africa, and the Philippines for uses such as cooking fuel and heating homes [1, 2]. After independence it was realized that the country was facing severe power shortage. Therefore there was a crying need to overcome this shortage by rendering services and making the availability of Renewable Energy Sources in the most rural parts of the country. Therefore from a primitive stage long term R&D goals were set to enhance the idea of renewable energy in Gujarat state with a ultimate aim to enlighten each and every house, facing power problems. Furthermore R&D aimed to effectively utilize renewable sources of energy like the Sun, biomass and wind to provide sophisticated services with generation of employment. Thus, solar energy development in Gujarat can facilitate the vision of a energy-independent state and ultimately can add to the country's economy.

Looking at Gujarat's ecological and economical perspectives, solar energy is an important source of energy. The fossil resources are limited, and they impose a high burden on the environment. Solar energy units for heating water are commercially available and used by millions of people in various parts of the world. solar energy use in solar water heating system, In this system low and medium temperature process heat requirements hot water up to 90^0C,hot air up to 110^0Cand low pressure steam up to 140^0C.Solar radiation plays the most important role for generation of solar energy .Mainly three parts of solar radiation,

GLOBAL RADIATION = BEAM RADIATION + DIFFUSE RADIATION

Solar radiation is depends upon the wavelength of solar rays. The percentage of solar radiation obtained up to a certain wavelength is also given in Table.

Wavelength of solar ray (μ)	**0-0.38**	**0.38-0.78**	**0.78-4.0**
Approximate energy (W/m^2)	**95**	**640**	**618**
Approximate percentage of total energy	**7%**	**47.3%**	**45.7%**

In Gujarat, Gujarat state Electricity corporation Ltd.had set up a 1MW solar power plant on Narmada canal of Sardar Sarovar Nigam Ltd.near chandrasan village in kadi taluka in Gujarat. This unique Project prevents water evaporation from the canal to the tune is 90 lakh litres annually besides saving land required from the project.Besides,efficiency of the solar modules go up,due to the water from the canal cools them.

Gujarat Solar Park is the name used for a group of solar parks being constructed in Gujarat. Certificates of completion were issued on April 19, 2012 for a total of 605 MW, but this includes sections that were already

operational. One is the Charanka Solar Park a group of 17 thin-film photovoltaic (PV) power systems, on a 2000 ha site in the district of Patan.

At completion the project will save around 8 million tonnes of carbon dioxide of being released into the atmosphere and around 900,000 tonnes of coal and natural gas per year. The 600 MW is expected to save 900,000 tones of natural gas, and reduce CO_2 emissions by eight million tones, annually. A total of 84 developers have registered to build a total of 968.5 MW, from 1 to 40 MW. 1000 MW is expected to be completed by 2013.

II. INDIA AND ENERGY

The role of energy in India's economy has become globally relevant in recent years due to the country's high economic growth and rising concerns about the environmental impacts of energy use. Primary energy demand grew at the rate of 6 per cent a year between 1981 and 2001 (Planning Commission, 2002), and India now ranks fifth in the world in terms of primary energy consumption. It accounted for about 3.5 per cent of the world's commercial energy demand in 2003. Although there has been a gradually increasing dependency on commercial fuels, a sizeable amount of the national energy requirement, especially in the rural household sector, continues to be met by noncommercial energy sources. These include fuel wood, crop residue, and animal waste, as well as human and draught animal power. Future economic growth will lead to a rapid increase in demand for commercial energy higher levels of urbanization, and adoption of modern lifestyles. The Renewable Energy Plan 2012 calls for achieving a 10 percent share for renewable energy in incremental power capacity by adding about 10,000 MW of new renewable energy (RE) based generation. In addition to the grid-connected RE goal, other major RE initiatives include-installment of 1 million household solar water heating systems; electrification by renewable mini-grids for 24,000 villages without electricity; deployment of 5 million solar lanterns and 2 million solar home lighting systems; (4) and establishment of an additional 3 million small biogas plants. The Electricity Act of 2003 has provided a major thrust to RE technologies via its mandate: "To promote cogeneration and generation of electricity through renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any persons, and also specifying, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee." The National Electricity Policy of 2005 gives each State regulator authority to create a Renewable Energy Portfolio Standard for the transmission and distribution companies serving their jurisdictions.

The Ministry of New and Renewable Energy (MNRE) is involved in the development, demonstration and utilization of various renewable energy-based technologies, including Solar Thermal, Solar Photovoltaic's, Wind power, Biomass combustion/co-generation, Small Hydro power, Biogas, Geothermal, Waste-to-energy, and tidal power. Major MNRE activities include: (i) Project development and financing of RE-based grid power; (ii) Urban solar hot water heaters; (iii) resource mapping. India has the most developed and diversified renewable energy market. The Government of India has set a goal of electrifying 18,000 remote villages and meeting 10 percent of the country's power supply through RE by 2012. These targets are in addition to those fixed for other RE devices or programs, including establishing 1 million solar PV systems for lighting; 8,000 solar PV pumps for irrigation; 10,000 solar PV generators, stand-alone solar PV power plants, solar water heating systems, solar air heating systems, and solar cookers, including large steam cooking systems; 360 energy demonstration parks, and; more solar retail outlets and solar passive buildings.

III. Conclusion

Although renewable energy power generation is a genuine clean development success story, there are some problems that need to be addressed to make the industry sustainable and self-supporting. There is currently some retrenchment going on with respect to RE policy amongst the State regulators. States with strong RE policies include Andhra Pradesh, Tamil Nadu, Maharashtra, and Gujarat. A strong RE policy consists of: (i) Preferential treatment; (ii) Portfolio standards; and (iii) Standardized PPA. However, care must be taken towards over-subsidizing renewable energy development relative to other energy sources at the expense of rate payers and taxpayers. The disaggregate nature of implementing the Electricity Act's renewable energy portfolio standards has created considerable disparities and lack of analytic basis for the relative pricing of various forms of RE within and between different States (e.g., Hydro gets a lower price than Wind or Biomass in one state, or the price is very different between two adjacent states). Because the price made available to RE project developers does not seem to be firmly grounded, transmission and distribution licensees are going to court to avoid entering into power tariffs for purchases of renewable energy. There is a need for standard methods of valuation of the relative environmental benefits accruing to different forms of RE, which could then be reflected in PPA price differentials RE resources should also play a bigger role in providing decentralized power to remote areas, in line with the goal of providing modern energy access to all by 2012. Decentralized power generation, especially in remote locations where the grid cannot be extended, should necessarily be based on RE forms to provide these regions with access to clean and reliable energy.

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Energy Audit And Energy Conservation Potential For Water Treatment Plant

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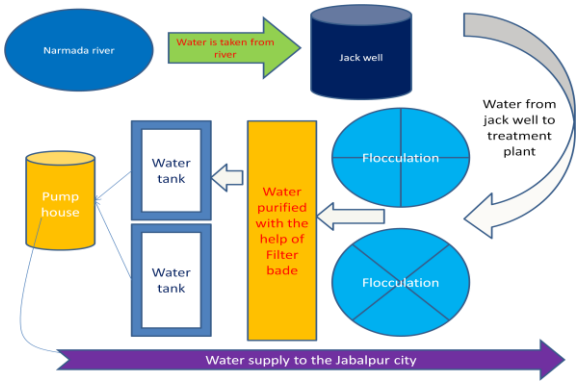
Abstract : *This paper present energy audit process on water treatment plant located at Lalpur, Jabalpur Madhya Pradesh. This plant has established in 1986 and supplying 97 MLD (million liters per day) water to Jabalpur City. Generally Water treatment plants are highly energy and cost intensive. To achieve effective and efficient energy management scheme, energy audit analysis was employed on water treatment plant.This paper Provides customers with recommendations which will increase the comfort, health, safety and prolong the durability of the property. Before appointing Energy Auditor conduct our own visual walkthrough and make a list, so when we bring in an auditor we are prepared. Become more aware! , check savings calculations by determining whether more savings have been identified than are actually achievable. Some analysts use the average cost of electricity to calculate energy savings.*

Keywords: *- Water treatment plant, energy audit, energy saving, cost analysis, Overall Equipment Effectiveness.*

I. Introduction:

Energy means is the capacity of a system to do work. We use energy to do work and make all movements, Energy can be found in a number of different forms. It can be chemical energy, electrical energy, heat (thermal energy), light (radiant energy), mechanical energy etc. The most general definition of an audit is an evaluation of a person, organization, system, process, project or product. Audits are performed to ascertain the validity and reliability of information, and provide an assessment of a system's internal control.

An energy audit was performed on the Water Treatment Plant (WTP) located at Gwarai Ghat Road Lalpur in Jabalpur. This report provides the energy use pattern, the measures considered and the recommendations for energy saving, more effective equipment use for water purification/water distributed to Jabalpur area. Water treatment plant has been highly energy and cost intensive. Continues running of the plant i.e. 8760 operating hours per year produce 35405 ML (million liters) water. To achieve effective and efficient energy management scheme, thermal energy audit analysis was employed on water treatment plant. The flow chart of water treatment process is as follows:-



Many types of equipment used just like a pump, motor, color, lighting, water etc. lalpur plant 97 MLD water supplies per day, these water taken from Narmada River. 3 hours cycle is required to purify water. The Water Flow from Jack Wall to Raw Water Pump House through gravity. 10 pumps (215h.p) are Establish in the pump house, however 6 Pumps are required 24 hr running at a time & 4 pumps are stand. Every 12hr Pumps are Change from another pump. Then with the help of 6 pump water flow to the 42 mld and 55 mld section. Water

is purifying in these section. After that water is pumped by 6 pumps are established in 42mld & 8 pumps are established in 55 MLD.

1.1 Conduct Auditing Process:

- Study of plant process
- Meeting
- Energy Audit Team
- Plant Data Collection
- Field Investigation and observations
- Equipment Inventory and use
- Classification of Demand and Energy
- Develop ECMs and Implementation Strategies.
- Follow-Up

II. Parameter which affects the energy audit for water treatment plant:

- Raw Water quality
- Pumping
- Lighting
- Power factor

2.1 Pumping Systems:

11 pumps (215, 225, 300 HP) are Running 24 hrs, at present the system power factor is about 0.93. But after auditing PF will maintained nearly unity by establishing capacitor Bank. One of the most critical elements to improving water system efficiency is to optimize energy consumption by the pumping systems. Optimizing the system includes improvements such as matching the pump to requirements, optimizing the distribution piping, eliminating unnecessary valves, controlling pump speed where appropriate, and institutionalizing improved O&M practices. Replace inefficient pumps with efficient. Install variable speed drives. Regular preventative inspection and maintenance, including cleaning or replacing impellers and checking lubrication of bearings. Trim impellers where pumps too large for the application but otherwise suitable. Create a system for regular monitoring of system components and performance. Install and maintain water meters; replace on a regular basis (about every 10 years). Develop metrics to track system performance and compare performance to appropriate benchmarks and targets. Monitor the pump system (such as valves, flow, pressure, rotating speed, energy used, volume pumped, and velocity in the main headers).

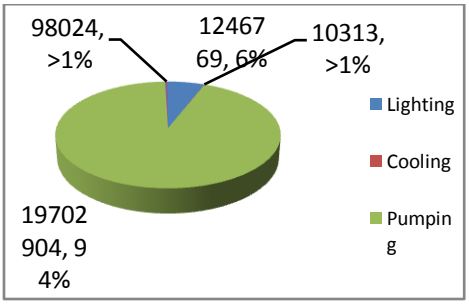


Figure 2:-.energy consumption chart

Figure 3:-: Pump House at Lalpur (Jabalpur) water treatment plant

2.2 Lighting:

Light Level or luminance, is the total luminous flux incident on a surface per unit area. The work plane is where the most important tasks in the room or space are performed. In lalpur plant total 17 MU electricity is being consumed per year. But after implementation of recommendation of energy auditing, electricity consumption will reduce by 15000 units per year. Apart from this about 153 kVA demands will be reduced by installing a Capacity Bank.

2.3 Transformer:

There are six numbers of transformers (33KV) are installed in lalpur water treatment plant and three transformer are standby out of six transformer. Transformers are extremely efficient devices; however, since the entire power consumption of the plant is through the transformers, some loss does take place. Site testing of transformers is not possible without isolation of the transformers

$$\text{Transformer efficiency} = \frac{\text{KW}}{KW + no\ load\ losses + (\%loading)^2 \times load\ losses}$$

2.4 Water:

Addition of alum and discharge of waste water from Flocculator should be regulated as per raw water quality. Fix water leaks. Test for underground water leaks. Check water overflow pipes for proper operating level. Provide proper tools for wash down especially self-closing nozzles. Eliminate continuous overflow at water tanks.

Figure 4:-Flocculator clarifiers at Lalpur (Jabalpur) water treatment plant

2.5 Flocculator clarifiers:

Effluent from the rapid mix structure flows by gravity to the flocculator clarifiers for the sedimentation process. The purpose of the flocculator clarifiers is to continue the flocculation process and produce clarified effluent, as well as to collect sludge and scum from the gravity settling basins. Specifically after the influent is mixed within the flocculator well. it migrates radically outward and enters the clarifier. Sufficient detention time is allowed to permit the solids to settle out in the clarifier during the time of flow to the outer ring of the clarifier. The effluent is removed at the tank periphery**.**

III. Bill detail of lalpur water treatment plant

1. Tariff f category-2301HV-5.1 33KV
2. Monthly fixed charges-165 RS/ KVA (total maximum demand x 165)
3. Energy charges- 3.60 (Rs per unit) (consumption x 3.6)
4. Contract demand-2500 KVA

More energy consume in lalpur water treatment plant. Because overall plant power factor 0.93 hart show monthly consumption to one year. Average energy consumes per month 1400000 kWh.

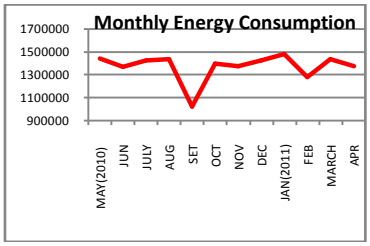


Figure 5:-overall unit consumption of lalpur water treatment plant.

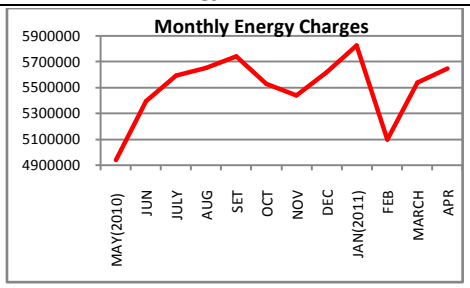


Figure 6:- annual bill detail o of lalpur water treatment plant (before auditing)

month	Consumption KWH	Demand KVA	PF	Demand reduces on the base of .93 KVA	Reduction in KVA	Saving on fix charge only demand	unit x energy charge x incentive %	save
April	1376600	2452	0.92	2280	172	28380	247788	276168
March	1436600	2416	0.92	2246	170	28050	247777	275827
Feb	1282600	2384	0.92	2217	167	27555	230868	258423
Jan	1480800	2392	0.93	2224	168	27720	266544	294264
Dec	1424900	2356	0.93	2191	165	27225	256482	283707
Nov	1373700	2374	0.93	2207	167	27555	247610	275165
Oct	1399200	2356	0.93	2191	165	27225	241856	279081
Sept	1026300	2440	0.93	2269	171	28215	258462	286677
Aug	1435400	2472	0.93	2299	173	28545	258372	286917
Jul	1423800	2388	0.93	2221	167	27555	256284	283839
Jun	1367000	2362	0.93	2196	165	27225	246060	273285
May	1440000	2456	0.93	2284	172	28380	259200	287580
TOTAL	16466900			24545		308630	3017303	3360933

Figure7:Saving due to Installation of Capacitor Bank

IV. Recommendations:

The main recommendation is to replace the recessed fluorescent lighting system in the general area and maintenance office.

- By Replacement of magnetic Ballast with electronics in existing tub light s i.e. 119 fittings having potential saving of 14700 kWh that save 51750 Rs/Year.
- Select ballasts and lamps carefully with high power factor and long-term efficiency in mind.
- Upgrade obsolete mercury lamp with Compact fluorescents with electronic ballasts Consider day lighting, skylights, etc
- Consider painting the walls a lighter color and using less lighting fixtures or lower wattages.
- Use task lighting and reduce background illumination.

For Water & Wastewater:-

- Seal sumps to prevent seepage inward from necessitating extra sump pump operation
- Balance closed systems to minimize flows and reduce pump power requirements.
- Fix water leaks.
- Test for underground water leaks.
- Check water overflow pipes for proper operating level.

- Provide proper tools for wash down -- especially self-closing nozzles.

- Eliminate continuous overflow at water tanks.
- Promptly repair leaking toilets and faucets.
- Use self-closing type faucets in laboratory.

Pump and motor:-

- Power factor improvement by installing capacitor bank which increase the power factor (0.99) and gives 153.38 KVA reductions in demand at a load of 2400 KVA (Connected Load) that saves 39 lacks per annum.
- Properly size to the load for optimum efficiency. (High efficiency motors offer of 4 - 5% higher efficiency than standard motors)
- Balance the three-phase power supply. (An imbalanced voltage can reduce 3 - 5% in motor input power)
- Repair seals and packing to minimize water waste.
- Balance the system to minimize flows and reduce pump power requirements.

V. Results:

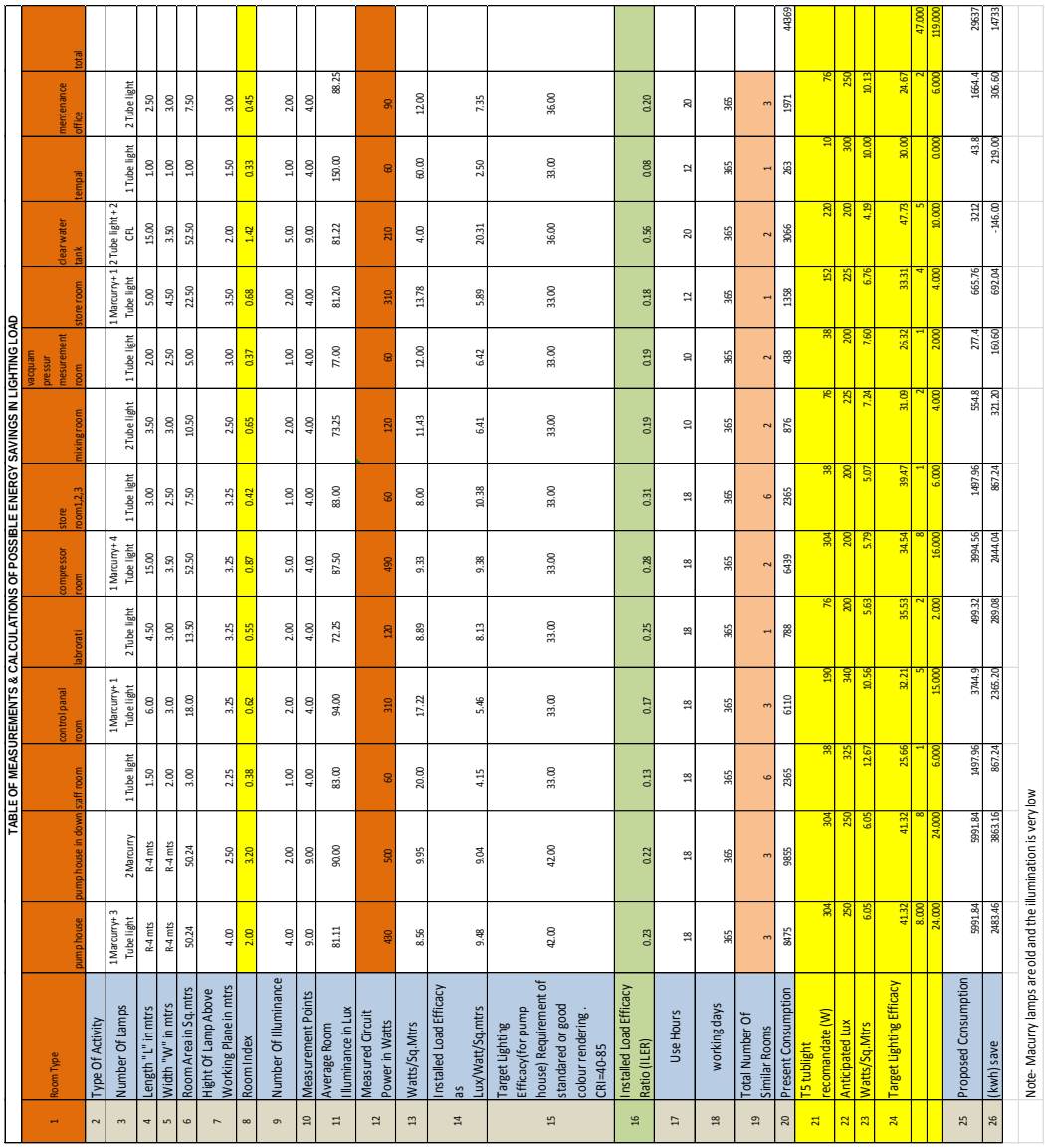


TABLE OF MEASUREMENTS & CALCULATIONS OF POSSIBLE ENERGY SAVINGS IN LIGHTING LOAD

	Room Type	pump house	pump house in down	staff room	control panal room	labroati	compressor room	store room1,2,3	mixing room	vacquam pressur mesurement room	store room	clear water tank	temoal	mentenance office	total
2	Type Of Activity	1 Marcurry+ 3 Tube light	2Marcurry	1 Tube light	1Marcurry+ 1 Tube light	2 Tube light	1 Marcurry+4 Tube light	1 Tube light	2Tube light	1 Tube light	1 Marcurry+ 1 Tube light	2 Tube light + 2 CFL	1 Tube light	2 Tube light	
3	Number Of Lamps	R-4 mts	R-4 mts	1.50	6.00	4.50	15.00	3.00	3.50	2.00	5.00	15.00	1.00	2.50	
4	Length "L" in mtrs	R-4 mts	R-4 mts	2.00	3.00	3.00	3.50	2.50	3.00	2.50	4.50	3.50	1.00	3.00	
5	Width "W" in mtrs	50.24	50.24	3.00	18.00	13.50	52.50	7.50	10.50	5.00	22.50	52.50	1.00	7.50	
6	Room Area in Sq.mtrs	4.00	2.50	2.25	3.25	3.25	3.25	3.25	2.50	3.00	3.50	2.00	1.50	3.00	
7	Hight Of Lamp Above Working Plane in mtrs	2.00	3.20	0.38	0.62	0.55	0.87	0.42	0.65	0.37	0.68	1.42	0.33	0.45	
8	Room Index	4.00	2.00	1.00	2.00	2.00	5.00	1.00	2.00	1.00	2.00	5.00	1.00	2.00	
9	Number Of Illuminance	9.00	9.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	9.00	4.00	4.00	
10	Measurement Points	81.11	90.00	83.00	94.00	72.25	87.50	88.00	73.25	77.00	81.20	81.22	130.00	88.25	
11	Average Room Illuminance in Lux	630	500	60	310	120	490	60	120	60	310	210	60	90	
12	Measured Circuit Power in Watts	8.56	9.95	20.00	17.22	8.89	9.33	8.00	11.43	12.00	13.78	4.00	60.00	12.00	
13	Watts/Sq.Mtrs	9.48	9.04	4.15	5.46	8.13	9.38	10.38	6.41	6.42	5.89	20.31	2.50	7.35	
14	Installed Load Efficacy as Lux/Watt/Sq.mtrs	42.00	42.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	36.00	33.00	36.00	
15	Target Lighting Efficacy(for pump house) Requirement of standared or good colour rendering . CRI=40-85	0.23	0.22	0.13	0.17	0.25	0.28	0.31	0.19	0.19	0.18	0.56	0.08	0.20	
16	Installed Load Efficacy Ratio (ILER)	18	18	18	18	18	18	18	10	10	12	20	12	20	
17	Use Hours	365	365	365	365	365	365	365	365	365	365	365	365	365	
18	working days	3	3	6	3	1	2	6	2	2	1	2	1	3	
19	Total Number Of Similar Rooms	8475	9855	2365	6110	788	6439	2365	876	438	1358	3066	263	1971	44369
20	Present Consumption	304	304	38	190	76	304	38	76	38	152	220	10	76	
21	T5 tublight recomandate (W)	250	250	325	340	200	200	200	225	200	225	200	300	250	
22	Anticipated Lux	6.05	6.05	12.67	10.56	5.63	5.79	5.07	7.24	7.60	6.76	4.19	10.00	10.13	
23	Watts/Sq.Mtrs	41.32	41.32	25.66	32.21	35.53	34.54	39.47	31.09	26.32	33.31	47.73	30.00	24.67	
24	Target Lighting Efficacy	8.000	8	1	5	2	8	1	2	1	4	5	2	2	47.000
		24.000	24.000	6.000	15.000	2.000	16.000	6.000	4.000	2.000	4.000	10.000	0.000	6.000	119.000
		5991.84	5991.84	1497.96	3744.9	499.32	3994.56	1497.96	554.8	277.4	665.76	3212	43.8	1664.4	29637
25	Proposed Consumption	2483.46	3863.16	867.24	2365.20	289.08	2444.04	867.24	321.20	160.60	692.04	-146.00	219.00	306.60	14733
26	(kwh) save														

Note- Macurry lamps are old and the illumination is very low

VI. Conclusion:

From this paper, we have concluded, An Energy audit increases the productivity of Organization. Energy audit helps to increase output of any industry and decreases cost of Production without scarifying the efficiency. Energy audit provides batter stability to the industry or organization then the statutory audits. With the help of above observations table it is found that Lalpur Water Treatment Plant needed to improve its efficiency in terms

of pumping power, transformer's function, and lighting. Energy audit is done to improve its pumping power and lighting power for improving overall performance of Lalpur water treatment power plant. During energy audit it is found that 25 halogen light of 250 watt , used, electricity bill of last on year 66019849 Rs.kr calculated finally it is concluded that electricity bill will reduced 14733kwh by the audit.

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Building Information Modeling (BIM) and Sustainability – Using Design Technology in Energy Efficient Modeling

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Abstract *-- This study intends to highlight how some of the latest design technology can be used to accurately analyze daylight in our buildings today. Architecture and Engineering firms are using Building Information Modeling (BIM) software to model their design projects three-dimensionally these days. Some of the popular modeling software platforms for Architecture are, Autodesk's Revit Architecture, Autodesk Ecotect Analysis and Green Building Studio.*

Using BIM allows the user to export the model into analysis tools for daylight and energy analysis. Revit Architecture is used for BIM models, allowing the user to export to daylight analysis tools like Ecotect and 3d Studio Max Design. As the use of BIM in projects becomes more popular, the opportunities to seamlessly integrate daylight analysis into the design process become more abundant and more convenient.

It is found that using this technology, both the owner and designer can be more confident of what the outcome will be before the building is even constructed. This has the potential to save money from design changes and energy costs as well as material changes and retrofitting that is common from older methods of daylight control. In the end it can improve the aesthetics of the building, improve visual comfort and reduce the overall electrical lighting usage within the building.

Keywords: *Sustainability, Building Information Modeling (BIM), Architectural designs, and Importance of Energy Efficiency*

I. Introduction

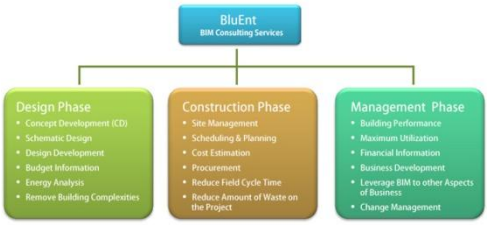
Review of Current State of Profession

Over last 20 years information technology has revolutionized the design and production of movies, music, airplanes and, machinery. Architects and engineers are now applying similar tools to building design. The most sophisticated of these tools are delivering continuous and immediate feedback on far greater range of characteristics than conventional design tools. Materials quantity and properties, energy performance, lighting quality, site disturbance and what-if comparisons between new construction and renovation are some types of information that are easily available from these tools. This approach to building design is so different from using conventional CAD software that the industry has a new name for it: Building Information Modeling (BIM). [1]
BIM is an integrated process which is used to facilitate the exchange of design and construction information to project participants. BIM models can be extended to store energy performance data such as power consumption, temperature, CO2 emissions, occupancy and humidity. Furthermore, the adoption of the sustainable guidelines such as LEED™ by federal, state and local governments calls for more comprehensive BIM models describing environmental performance such as indoor air quality, water consumption, and solid and hazardous waste (USGBC 2009).

BIM has risen to prominence out of a desire to streamline the building design and documentation process, to simplify construction management, and to provide the owner with inherently better capabilities for ongoing facilities management during building occupancy. The initial benefits of BIM were seen through the lens of economics: by making building design, construction, and maintenance more efficient, we can ultimately deliver a better project value at a lower construction cost. On the other hand, "Sustainable Design" has become another buzz word in the construction industry. It has emerged out of global concern for the state of our natural environment. As we add more buildings to our collective built landscapes, sustainable thinking is needed to meet the future challenges of land use, energy consumption, and availability of material resources for building construction. Although BIM and Sustainable Design have emerged from somewhat different underlying market factors, they share a significant common thread: the success of both endeavors depends heavily on a front loaded, deeply integrated building design philosophy that aims to include all team players from the very beginning of a project.

Applying BIM for sustainability can be a great advantage. For energy analysis the model can be imported into programs such as IESVE and eQUEST to determine the efficiency of the building. For daylight design and analysis you the model can be brought into Ecotect Analysis, 3ds Max Design and Daysim. The choice of software depends on the type of analysis desired. 3ds Max Design and Daysim has been validated in

other studies. [2] This paper will provide an overview of how purpose-built BIM solutions and integrated analysis tools can help to assess building performance, prioritize investments, and evaluate proposals to reduce operational costs, conserve energy, reduce water consumption, and improve building air quality, helping to meet sustainability and energy-efficiency goals.



II. Need For Study

In spite of the recent efforts toward sustainability, lifecycle energy efficiency and the resulting value and corresponding cost savings are not key criteria in the building development process, resulting in lost opportunities to maximize the use of energy efficient building design and technology options. Energy and performance analysis are typically performed after the architectural design and construction documents have been produced, if at all. This lack of integration into the design process leads to an inefficient process of retroactively modifying the design to achieve a set of performance criteria.

Most importantly, some issues are involved in the application of design analysis integration in actual building design practice as follows: (1) the difficulty of effective exchange of information among the stakeholders (2) the amount of design information/knowledge (3) the significant amount of time and effort required for finding the optimal design alternatives, and (4) the different assessment method required at each building design stage. Building energy consumption is affected by architectural elements (geometry, type of envelope, floor plan and site plan) which are determined from the design stages.

The use of BIM-based energy performance assessment during the design stages is believed to be essential to achieve energy-conscious green buildings. BIM allows architects and engineers to receive building information as a detailed and digitalized virtual model. However, the use of BIM-based energy performance simulation in the design phase of a building project is still controversial. In other words, for an improved BIM-based simulation, one of the important issues is how architects and HVAC engineers cope with interoperability between design and energy performance tools.

Therefore the paper intends to introduce various analytical BIM-based simulations which can be used during early design phase of sustainable construction for selection of optimal design alternatives on multi-criteria problems. It can be used as a basis to assist designers and engineers to obtain subtle knowledge about application of information technology in sustainable construction and pave the way for further improvement.

III. Literature Review

Following points emerged from the literatures review:

1. 95% of firms using Green BIM will do energy performance simulations within two years, compared with 73%now. 79% of non-green BIM firms will conduct such simulations, a dramatic increase from only 21% currently. This rapid increase reflects the growing importance of energy efficiency in buildings and the capacity BIM tools have for this purpose. [3]

2. BIM allows architects and engineers to become "digital" master builders who are able to see the building, its materials, its structures and its performance in real time as it being designed, and (more importantly) before the design is converted to very expensive bricks and mortar or more likely metal studs and gypsum board. At the same time, this model can very efficiently provide a fully coordinated set of conventional documents that is accurate and reliable. [1]

3. BIM and sustainable design are connected by utilizing the capabilities of the model to provide useful data to analyse tools that report on a design's predicted performance on key sustainable characteristics. For example, BIM authoring tools can convert the model into a non-proprietary format for sustainable design information, such as Green Building xml, or gbxml. [4]

4. Building Information Modeling (BIM) allows for multidisciplinary information to be superimposed within one model incorporating structural, mechanical, electrical, plumbing and lighting (Tucker, 2010). Hence an ideal opportunity exists for sustainability measures and performance analysis to be integrated within the BIM model (Azhar & Brown, 2009). With programs such as Autodesk Ecotect that can import BIM models, interior designers can holistically study the performance of interior environments leading to creation of more comfortable, healthy, and sustainable spaces for its inhabitants. [5]

6. Autodesk Building Information modeling (BIM) solutions help make sustainable design practices easier, more efficient and less costly. BIM solutions from Autodesk-Autodesk Revit Architecture software and Autodesk Revit MEP Software- are interoperable with Autodesk Ecotect Analysis software.

7. IFC is a common language which may be used by all engineering disciplines, and which enables sharing information between all AEC/FM (Architecture, Engineering and Construction / Facility Management) project participants and storing the entire valuable data in one virtual model unit that can be preserved and used beyond the life of the project (BuildingSMART 2011c).

8. It is often difficult to leverage the full potential of BIM due to inadequate data exchange between BIM and energy simulation programs. Although the potential of using BIM for energy simulation is well known, a systematic approach to share the necessary information is yet lacking (Young, Jones and Bernstein 2009). Data exchange between BIM and simulation programs is currently limited to the transfer of 3D geometries of the building projects. Building systems data related with HVAC and internal loads such as occupancy and lighting should be included in data exchange between BIM and energy simulation programs to avoid any repetitive data inputs. [6]

IV. Objectives And Data Collection Techniques

In spite of the recent efforts toward sustainability, lifecycle energy efficiency and the resulting value and corresponding cost savings are not key criteria in the building development process, resulting in lost opportunities to maximize the use of energy efficient building design and technology options. Energy and performance analysis are typically performed after the architectural design and construction documents have been produced, if at all. This lack of integration into the design process leads to an inefficient process of retroactively modifying the design to achieve a set of performance criteria. In addition, traditional CAD-based planning environments do not support the possibility of early planning and decision making process. [7] Although BIM is a recent development, a lot of research has been conducted in order to further enhance its capabilities in design and construction.

However, there has been very little research done so far on the impact that BIM has on sustainable construction practices. Hence, the overall goal of present paper is to introduce various BIM - integrated software to increase sustainable building performance. It is anticipated that the conclusions and recommendations may guide the procurement of future sustainable educational facilities.

A thorough literature review is conducted in this area with the majority of information from international sources. The main strategy adopted is:

- Collection of data with search in existing observations and studies
- Collection of data through documentation and archival evidence

V. BIM and Sustainable Construction

Building Information Modeling (BIM) is both the creation of a set of digital models of a planned or built environment, as well as the process of working collaboratively with these models during the lifecycle of that facility. BIM typically contains a set of 3D models and information about relevant components and attributes. Currently, BIM is used mostly during the design phase of a building project although its use during the construction and operation phases is increasing.

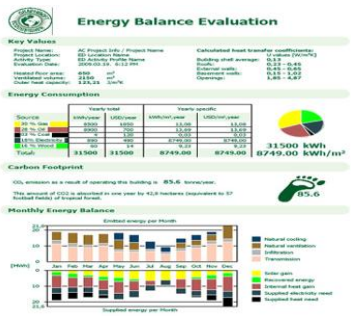
Sustainability means meeting the needs of today without compromising the ability of future generations to meet their needs. Most of the advances promoted by the sustainability mega-trend are derived from something very intangible, software. Software is a sustainable product, especially when it comes to supporting other sustainable tools to do more with less.

The sustainability of the construction business can be measured by defining how 'green' the building is in terms of energy and material consumption during its construction, usage, maintenance, and demolition. There is no need to invent that much new; a lot can be learned from established practices used in, for example, electricity distribution and the maintenance processes of off-shore structures. Software can be used to optimize material selection, utilize the resources of the construction process more efficiently, and improve the maintenance of buildings by a diversity of applications.

In current practice, many digital models do not contain sufficient information for building performance analysis and evaluation- the building blocks of sustainable building design. As with traditional physical models and drawings, evaluating building performance based on graphic representation of conventional CAD or object-CAD solutions requires a great deal of human intervention and interpretation, which renders the analysis too costly and/ or time consuming. The BIM-based building modeler represents the building as an integrated database of coordinated database. Beyond graphically depicting the design, much of the data needed for supporting sustainable design is captured naturally as design of the project proceeds. Linking the building model directly to the analysis software, allows for preliminary verification of the "broad stroke" or "big picture" sustainable design goals. With architectural computer software design tools and modeling programs, the design team can quickly generate multiple design options during the schematic phase that take into account site specific characteristics such as solar orientation and sky path.

VI. Energy Analysis

Quality sustainable design requires an understanding of how a building will perform after it's built, which in turn requires computer-based simulation software for rigorous building analysis. The advent of BIM (building information modeling) offers even greater opportunities for building analysis by pairing the analysis software and BIM for the seamless assessment of building performance. For decades, energy simulation software tools have been available to assist in designing energy-efficient buildings. However, most building energy analysis is conducted late in design, when other building features cannot be changed. Using traditional CAD solutions, energy analysis can be a painful process. If it's a 2D solution, either special 3D analysis models are created or manual plan take-offs from the floor plans are done. If it's a 3D solution, building data is extracted from disparate CAD files and then merged into a single input file. In most cases, the data must be massaged for analysis import and then the output has to be "translated" for the designer's consumption.

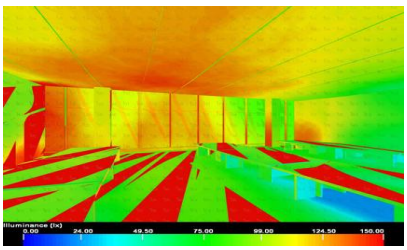


Now, with Revit Architecture and Green Building Studio, the process is simple. When you initially register for Green Building Studio web service, you download a small Green Building Studio client. Then each time you run an analysis, you simply make sure the rooms have a room number (the unique space ID used in the analysis programs) and the model has a defined project type and address (for building codes, local climate information, etc.). On the file menu, you click Export, select the file type and save the export file to your hard drive. Then launch Green Building Studio from your Internet browser and submit your saved file for energy analysis. Within minutes you can view the results, which provide energy statistics for your project and recommendations to improve your design based on local standards for building type, climate, etc. You can then modify your building design and repeat the process to see what impact a design change has on the energy efficiency of the building. This simple process belies enormous computational power. Behind the scenes, Green Building Studio relies on a large network of relational databases containing hourly weather data, design data, and regionally relevant libraries of default building characteristics with common energy code baselines. It will even make recommendations regarding building products appropriate to any building (greatly simplifying the early specification process).

VII. Daylight Analysis

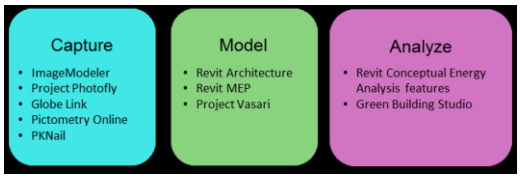
Daylighting, the practice of using natural light to illuminate buildings, not only makes people more comfortable and productive, it can sharply reduce the electrical lighting load and subsequent heat and energy loads. A sustainable high performance design can derive much of its ultimate success from effective relationship to, and integration of sun's energy in to the design of the building envelope and fenestration. Using your building model for sustainability can be a great advantage. For daylight design and analysis the model can be brought into Ecotect Analysis, 3ds Max Design and Daysim. Older processes would include creating a separate digital model for analysis or creating a physical model and placing it on-site to measure the daylight levels. This could take a great deal of time to get an accurate analysis. Now the BIM model can be exported to a format that can be imported into Ecotect Analysis or 3ds Max Design. This saves time and can be more accurate since the materials are assigned in the model, windows are placed in precise locations, and curtain walls and storefronts are modeled to exact dimensions.

When bringing this information into 3ds Max Design, the program will recognize most material assignments and all of the model geometry. Furthermore, in the 3ds Max Design program it is possible to modify and adjust material characteristics, glazing characteristics, reflectance and refractive values and many other variables. This takes into account the entire interior environment of the building so that the designer can adjust these elements as necessary for the visual comfort of the future occupants. It is very important to get more accurate feedback from the daylight analysis, especially because each material has specific reflective and refractive values to consider.



One way of taking a BIM model (Revit Architecture) into daylight analysis software (3ds Max) is First, model the building in Revit to the extent that it would be ready for analysis (preferably it has interior spaces defined and windows positioned). By using Day light system and accurate whether data file and most importantly by setting up the cameras, the first set of analysis can be run. Rapid energy modelling is a streamlined process that helps you analyze and estimate building energy consumption using Building Information Modeling (BIM) solutions. With a smaller budget, shorter timeframe, and less initial data, building professionals can evaluate expected building performance and identify areas for improvement.

This paper outlines rapid energy modeling workflows using Autodesk solutions and documents results from real-world validation. The table below shows how the various software options are used in the three-step rapid energy modeling process.



The combination of these various software options translate into a series of distinct rapid energy modeling workflows.[8]

VIII. Autodesk Revit Architecture

A computable Revit design model is a great fit for the analyses needed for sustainable design — even during schematic design. As soon as the layout of a building's walls, windows, roofs, floors, and interior partitions (elements that define a building's thermal zones) are established, a Revit model is ready for whole building analyses.

Performing these analyses in a CAD workflow is a fairly difficult undertaking as the CAD model has to be exported and carefully massaged to work with analysis programs. In addition, most analysis software is complex and requires special training — making it unsuitable for casual users like architects or designers. Furthermore, the output of most analysis programs is complicated, making it hard for architects or designers to understand what to do to improve upon their designs. [9]

Revit Architecture 2010 is used to develop the 3D model. Built for Building Information Modeling (BIM), Autodesk® Revit® Architecture software helps to capture and analyze most innovative design concepts

and maintain vision through documentation. The information-rich models that the software provides support decision-making for sustainable design, clash detection, construction planning and fabrication, while helping to work collaboratively with engineers, contractors and owners.

Autodesk Revit Architecture generates every schedule, drawing sheet, 2D view, and 3D view from a single foundational database, automatically coordinating changes as the project develops and evolves.

Bidirectional Associativity: A change anywhere is a change everywhere. In Autodesk Revit Architecture, all model information is stored in a single, coordinated database. Revisions and alterations to information are automatically updated throughout the model, minimizing errors and omissions

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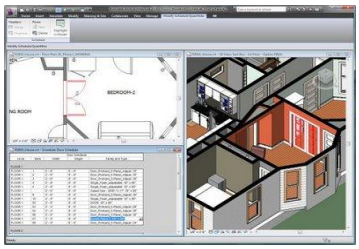
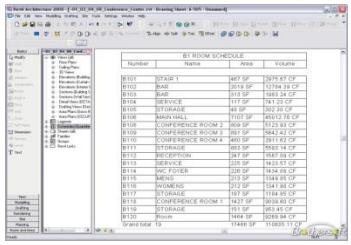
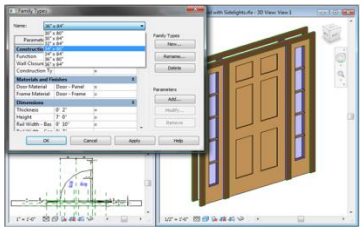


Schedules: Schedules provide another view of the comprehensive Autodesk Revit Architecture model. Changes to a schedule view are automatically reflected in all other views. Functionality includes associative split-schedule sections and selectable design elements via schedule views, formulas, and filtering.



Parametric Components: Parametric components, also known as families, are the basis for all building components designed in Autodesk Revit Architecture. These components offer an open, graphical system for design thinking and form making, while providing the opportunity to adjust and express design intent at increasingly detailed levels. Use parametric components for elaborate assemblies, such as cabinetry and equipment, as well as for elementary building parts, such as walls and columns. Best of all, no programming language or coding is required.

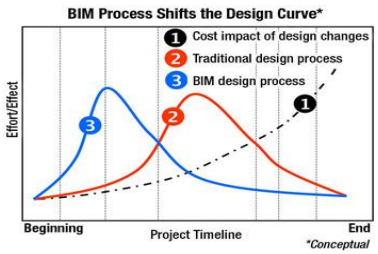


Material Takeoff : Calculate detailed material quantities with Material Takeoff. Ideal for better calculation of material quantities on sustainable design projects and cost estimates, Material Takeoff helps smooth the material quantity tracking process. As projects evolve, the Autodesk Revit Architecture parametric change engine updates material takeoffs.

Sustainable Design: Conceptual energy analysis tools help one to make every design more sustainable. Cloud-based analysis tools are used to quickly compare the energy consumption and lifecycle costs of design alternatives right from within Autodesk Revit Architecture software. Analysis results are presented in a highly-visual, graphical format for easy interpretation.[10]

Building Information Modeling (BIM) is poised to be a major innovation in architecture industry in the 21st century, and Revit supplies oxygen to this wonderful innovation. There are considerable numbers of reasons behind the increasing acceptance of Revit software in architecture industry. BluEnt, a globally leading construction documentation firm, has observed the following advantages of Revit Building Information Modeling software:

1. **Preview the Future Home in 3D BIM Modeling**: Revit Parametric modeling is a significant tool for conceptual design. With Revit software, architectural designers can quickly sketch a rough layout of the floor plan, or make changes to the standard set of building designs and instantly let their customers preview their future homes. 3D design views give designers to try out different design ideas and guide their design decisions at early stage.
2. **Quick Changes to Design, No Repetitive Tasks:** During the design phase, the building structure and floor plans needed to be modified frequently. With Revit BIM software, architecture designing and drafting becomes very fast and accurate. In Revit architecture model, all building components such as plans, sections, and elevations are intelligently connected to each another. Whenever a change is made to the model, the software automatically updates every related component, affecting the whole building model.
3. **Vast Library of Parametric Building Components:** BIM authoring tool Revit software comes with a full set of parametric building design components. It also allows quick changes to the existing components. It stores the newly created or customized parametric objects to be reused in other projects. While designing a new project, architectural designer can use the stored parametric building objects for quick references to the prospective clients.
4. **High Quality Construction Documents:** 3D modeling capacity of Revit architecture enables designers and drafters to easily identify the clashes and areas of congestion, and resolve them early in the process. It results in error-free and high quality construction documentations.
5. **Accurate Estimation of Quantities and Cost**: One of the most important advantages of building information modeling software is the automatic generation of bill of quantities (BOQ). BIM modeling software like Revit produces accurate material quantity takeouts as a by-product, with less-efforts. This advantage helps the contractors and owners to determine if the project adheres to budgets.
6. **Improved Coordination:** BIM drafting software Revit unifies design, drafting, construction and facility management processes in single environment, allowing all stakeholders to remain updated and aware of their responsibilities, and thus improving overall coordination. A total understanding by everyone on the project of what's happening removes the design conflict and risks.
7. **High Level of Flexibility:** Unlike AutoCAD, Revit allows all project data to be stored in single project file. It allows multiple users to work on the same project file and merge their changes with every save. Besides, Revit exports and imports DWG, DXF, DGN, PDF, JPEG files.



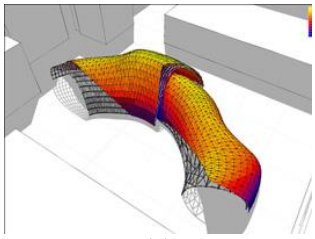
The list of Revit advantages continues. It is proved that BIM approach is "significantly more efficient" than the traditional drafting-based approach. Architectural design and drafting firms are realizing the benefits of BIM implementation software. For example BluEnt BIM, a leading BIM construction documents developer has started drafting in Revit BIM software for large and complex building practices, and delivering the clients significant benefits in terms of TIME and COST.

IX. Autodesk Ecotect Analysis

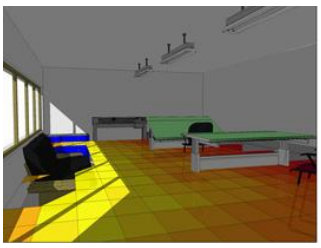
Autodesk® Ecotect® Analysis 2011 software is a comprehensive concept-to-detail sustainable design analysis tool, providing a wide range of simulation and analysis functionality on a single platform. Revit-based design models can be exported to gbXML format and imported directly into

Autodesk Ecotect Analysis for simulation and analysis throughout the design process. At the onset of the design process, very early stage Autodesk Revit Architecture massing models can be used in combination with site analysis functionality in Autodesk Ecotect Analysis to help determine the optimal location, shape, and orientation of a building design—based on fundamental environmental factors such as daylight, overshadowing, solar access, and visual impact. What makes Ecotect a very popular tool in its category is its extremely user-friendly interface. Since its introduction into the market, it has represented a big step forward in terms of "usability" if compared with other building simulation tools. The new Ecotect Analysis includes an expanded array of environmental analysis and simulation capabilities including shadows and reflections, shading design, solar analysis, photovoltaic array sizing and load matching, lighting design, right-to-light analysis for neighboring buildings, acoustic analysis, thermal analysis, and ventilation and airflow. An example of solar

analysis in Ecotect is shown in Figure (a), where a freeform façade is being analyzed for solar radiation exposure so to determine the optimal shape for minimizing direct solar gains. Another example is shown in Figure (b), where the daylight factors and illuminance levels are calculated and used to design a space to maximize the use of daylighting. Other examples include shading design analysis, shown in Figure (c) and ventilation and airflow analysis, shown in Figure (d).



(a)



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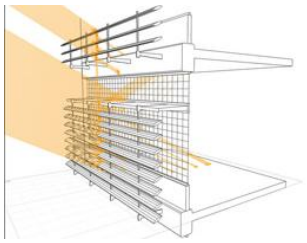
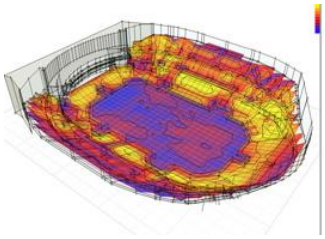


(c)



(d)

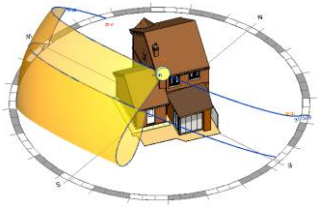
Once the fundamental design parameters have been established, Autodesk Ecotect Analysis can be used again to rearrange rooms and zones, to size and shape individual apertures, to design custom shading devices, or to choose specific materials—based on environmental factors such as daylight availability, glare protection, outside views, and acoustic comfort.

X. Features of Autodesk® Ecotect™ Analysis software

- **Visual Feedback:** Perhaps the most unique aspect of the software is its visual and interactive display of the analysis results. The inability of the designer to easily interpret the results of analyses is often the biggest failing of building performance analysis software. Autodesk Ecotect Analysis provides actionable feedback to the designer in the form of text-based reports as well as visual displays. These visual displays are more than just charts and graphs. The results are presented directly within the context of the model display: shadow animations resulting from shadow casting analysis; surface-mapped information such as incident solar radiation; and spatial volumetric renderings such as daylight or thermal comfort distribution in a room. This type of visual feedback lets designers more easily understand and interact with analysis data, often in real time. For instance, a designer can rotate a view of surface mapped solar radiation looking for variations

over each facade, or watch an animated sequence of solar rays to see how sunlight interacts with a specially designed light shelf at different times of the year.

- **Usability**: Usability in Ecotect Analysis is one of most important features and is due to the good quality of the graphical interface provided, and also to the numerous "presets" and wizard windows that guide the new user to a better management of settings and options. Even though the software is capable of performing multiple environmental analyses its complexity does not compromise its usability. New users find Ecotect a tool to explore and learn while expert users may find it practical, fast and remarkable in some cases (shadow analysis, environmental analysis and pre assessment of solar radiation). [11]



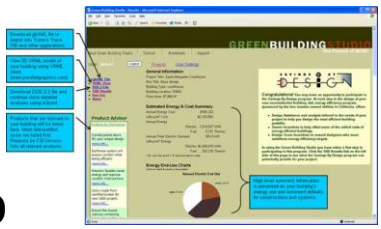
During conceptual design, Autodesk Ecotect Analysis and the Autodesk Revit Architecture model can be used for a variety of early analysis. For example, the designer can perform overshadowing, solar access, and wind-flow analyses to iterate on a form, and orientation that maximizes building performance without impinging on the rights-to-light of neighboring structures. As the design progresses and the elements that define a building's thermal zones are established (the layout of the walls, windows, roofs, floors, and interior partitions), the Revit model can be used for room-based calculations such as average daylight factors, reverberation times, and portions of the floor area with direct views outside.

Ecotect continues to rely on the gbXML format to get model data from BIM applications such as Revit Architecture, ArchiCAD, and Bentley Architecture, and is thus not that closely tied to Autodesk solutions yet. Over time, however, it is possible that Autodesk will build API-level integration between Ecotect and Revit, allowing Ecotect to not only provide "one-click evaluation" for Revit users—similar to what the new Graphisoft EcoDesigner provides for ArchiCAD users—but go beyond it to provide bi-directional integration—where a change made to the model in Ecotect can be brought back automatically into Revit. This level of seamless integration is really what we need for sustainable design analysis to become a fundamental component of the design process.

XI. Autodesk Green Building Studio

Autodesk Green Building Studio is a web-based service that includes industry leading building energy and carbon analysis tools. Green Building Studio tools enable architects and designers to evaluate the energy profiles and carbon footprints of various building designs. Files are shared between engineering software programs and among engineers and architects early in the design cycle, making sustainable design more efficient and cost effective. It is offered free to members of the Education Community. This web service supports products in the architecture and building design family such as; Autodesk Ecotect Analysis, Autodesk Revit Architecture, Autodesk Revit MEP, AutoCAD Architecture, AutoCAD MEP. Autodesk Green Building Studio supports the needs of those who challenge themselves with design of sustainable and environmentally responsible structures.

D



Based on the building's size, type, and location (which drives electricity and water usage costs), the web-based service determines the appropriate material, construction, system and equipment defaults by using regional building standards and codes to make intelligent assumptions. Using simple drop-down menus, architects can quickly change any of these settings to define specific aspects of their design; a different building orientation, a lower U-value window glazing, or a 4-pipe fan coil HVAC system for example.

The Green Building Studio web-based service analysis process collects data from three sources:

1. Revit® software model. All the building geometry come from the model, including the number of rooms, the connections between rooms, and their relationship to the exterior, exposure, and aspect to the sun; and the shape and total area of built surfaces or openings. If Revit MEP is being used, it can also specify space types, interior loads, constructions, and HVAC equipment.
2. Responses to a few basic questions. In order to explain the building's use or context, a building type is specified and geographical location of the project is entered. It can be used to select a weather station for the project too.
3. Regionalized databases. Based on the above information, Green Building Studio extracts additional information about local weather conditions, construction, and materials. The service automatically adds any information that has not been provided in order to adapt to the requirements as the design evolves.

Green Building Studio relies on an extensive and continually updated database of building constructions, schedules and equipment to supply the assumptions needed to perform whole building energy analysis. You can view these assumptions in the Building Assumptions and Details section of the Energy and Carbon Results for a given simulation. You can modify the assumptions in the Design Alternatives or Project Defaults page.

XII. Features of Autodesk® Green Building Studio®:

With the Autodesk® Green Building Studio® web-based energy analysis service, architects and designers can perform whole building analysis, optimize energy efficiency, and work toward carbon neutrality earlier in the design process.

- **Energy and Carbon Results:** The Green Building Studio energy engineering results pages provide extensive information on a building's energy performance and resource use to help compare the relative energy costs of building design scenarios at the conceptual design stage.

- **Whole Building Energy Analysis:** With Green Building Studio, a virtual building's total energy use and carbon footprint are determined, and can be reduced. Annual energy use, including all electrical and fuel uses, is broken down into lighting, HVAC, and other equipment, with hourly analysis simulations using the DOE-2.2 simulation engine. Further breakdowns of energy use for major electric and gas end users—such as lighting, HVAC, and space heating—are provided in graphical format. Percentages associated with each category can be seen by clicking on the pie charts with your mouse.

- **Carbon Emission Reporting:** Carbon dioxide (CO2) emissions are reported for nearly all aspects of the building, including on-site fuel use and emissions at power plants that supply electricity to the building. The power plants that generate electricity to the electric grid that serves the building are also summarized by their fuel type.

- **Water Usage and Costs Evaluation:** A summary is given of the estimated water use, in, and outside the building, based on the number of people in the building, as well as the building type. To obtain Water Efficiency LEED credits, you can make adjustments to your fixtures, and get immediate results in water use calculations. The water usage analysis allows the user to apply a variety of water savings measures, including efficient fixtures, water catchments, and native vegetation. It also provides the potential LEED credits available for these measures.

- **Photovoltaic Potential:** Every exterior surface on your building is analyzed to determine the amount of electricity that could be generated if photovoltaic panels were on the surface. A high-level summary of your building's photovoltaic electricity potential is provided.

- **Energy STAR Scoring:** The United States Environmental Protection Agency's ENERGY STAR® score is provided for each building design. The ENERGY STAR score is the basis for the Architecture 2030 goals for carbon and fossil fuel reduction.

- **Daylighting:** Qualification for LEED daylighting credit is automatically provided for every analysis. Each room's glaze factor calculations are summarized to allow you to determine the action required to improve this factor, and increase eligibility for LEED daylight credits.

A Revit model can be taken and exported as a gbXML file (Green Building extensible Markup file) and imported into either Green Building Studio, or Ecotect, and through either one, exported out as to an inp (eQUEST ready file format) or idf (EnergyPlus ready file format) – converting that metadata into a file format that will propagate a DOE-2 model instantaneously. [12]

Comparison between Green building Studio and Ecotect Analysis	**Autodesk Green Building Studio** *Measures how the building consumes resources*	**Autodesk Ecotect** *Measures how the environment impacts building performance*
Life cycle costs	*	
CO2 Emissions	*	
LEED Credit Analysis (Lighting)	*	
Water use	*	
Energy use and cost	*	
Airflow/Ventilation	*	*
Thermal Loads	*	*
(Day) Lighting(LEED & Energy Savings) Luminosity Fluxes	*	*
Shading		*
Solar		*
Acoustic		*
Climate	*	*
Energy code compliance		*

XIII. Interoperability

BIM interoperability specifications and formats remain in their early infancy and often fail to live up to the promise of smoothing interoperability and communication challenges faced by today's construction professionals. Significant long-term challenges remain in addressing the different levels of detail required to support different construction activities including design, analysis, detailing, fabrication and coordination activities. Furthermore, industry groups continue to strive to establish testing and certification of implementations of interoperability standards to ensure that rapid continued progress is made by software developers toward making data transfer reliable and routine. However, current specifications and implementations already provide useful functionality to end users and they actively remain under development and gaining momentum due to efforts by multiple International and North American stakeholder groups including:

- the General Services Administration (the biggest property owner in the US)
- non-profit organizations, such as the National Institute of Building Sciences, building SMART International, the Steel Construction Institute and Green Building XML, and indirectly, by the Construction Specifications Institute
- professional organizations such as the American Institute of Architects, the Associated General Contractors of America and discipline-specific professional societies like the ASHRAE
- Software companies, such as Autodesk®, Bentley, Graphisoft.

The efforts to create the new BIM interoperability standards are benefitting from previous technology. IFC standards rely significantly on the EXPRESS language and the work done to standardize CAD geometry exchange (the ISO 10303 - STEP Standard) gbXML and other standards are benefitting from the existing broad technology support for XML schemas for defining domain specific documents. The construction sector provides

a significant challenge in the scope of the knowledge that needs to be unambiguously defined, represented and agreed upon, even if broken down by discipline or business transaction or construction process.

Other issues remain that have yet to be addressed satisfactorily by the communities developing the standards. These include Intellectual Property (IP), security, risk of misuse and implied warrantee, tracking and authorizing changes, comparison mechanisms and revision management, proprietary documents and linking related documents or data to individual elements of a model. These challenges are not unique to the construction industry but exist wherever knowledge is digitally encoded for exchange between entities and as such, legal approaches, insurance, business practices and technology will all play a part in addressing these issues in the future.

XIV. CONCLUSION

The increase in the number of analysis tools is a testament to the increasing importance of sustainable design in architecture and the need to optimize building performance. The BIM-based design and documentation system is ideally suited for delivering the kind of information that can be used to improve design and building performance. Much of the data needed for supporting green design is captured naturally during the design process and is extracted from the building information model as needed. Revit Architecture facilitates the very complex process of sustainable design like daylighting and solar access, and automates the drudgery of activities like material takeoffs- all the while capturing and coordinating information in the documentation set.

The analysis products it leverages such as Green Building Studio and Ecotect analysis expand its natural capabilities to provide specialized function bounce light calculations, energy analysis and specification management. Linking these products to Revit Architecture make this technology far more accessible than before, giving architects easy access to tools that provide quick feedback on green design alternatives.

In the next step, BIM-integrated software are used to design various components of an Energy Efficient Building to be based on building location and orientation to maximize the efficiency.

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Friction Stir Welding of Stainless Steel 304: A Survey

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Abstract: *Stainless steel 304 is a class of iron based materials which has certain resistance to rusting and to corrosion in some environments. Due to its properties, it is the most widely used material in the engineering applications. Most of stainless steel welding to this date is done by fusion welding. This survey revealed that very little amount of work has been done with few exceptions only mechanical properties have been characterized.*

I. Introduction

Friction Stir Welding is one of the emerging welding techniques and due to its advantages over fusion welding technique it has drawn attention of various researchers around the world. Literature review has indicated that various metals and their alloys have been successfully welded by this process but FSW of Stainless steel 304 has not progressed as rapidly as for aluminum and other metals because of various reasons some of which are given below:

i. The material from which the tool is made has to survive much more strenuous conditions because of strength of steel and high softening temperature of steels.
ii. The consequences of phase transformations accompanying FSW have not been studied in sufficient depth.
iii. The variety of steels available is much larger than for any other alloy system, requiring considerable experiments to optimize the weld for a required set of properties.

Since, Stainless steel 304 it is one of the most widely used materials in the engineering application. Researchers around the world are studying various aspects of FSW like tool design, rotational speed, welding speed, tool material etc, and their effect on the welding of stainless steel 304.

FSW of stainless steel is premature with only few exceptions: only mechanical properties have been characterized. Most reports are limited to simple bend, tensile and hardness tests.

Zhu and Chao [1] studied the variation of transient temperature and residual stress in a friction stir welded plate of 304L stainless steel. Using experimental records of transient temperature at specific locations during the FSW process, an inverse analysis method for thermal numerical simulation was developed. They also determined the residual stresses in the welded plate. Further they studied effect of fixture release on residual stresses and it was found out that residual stress in the welds after fixture release decreased significantly as compared to those before fixture was released.

Hwan et. al [2] studied the microstructures of Friction Stir Welded stainless steel 304 which was carried out using PCBN tool. They also examined the microstructural evolution during FSW. It was observed that stir zone (SZ) and TMAZ showed typical dynamically recrystallized and recovered microstructures as shown in Figure 1[2].

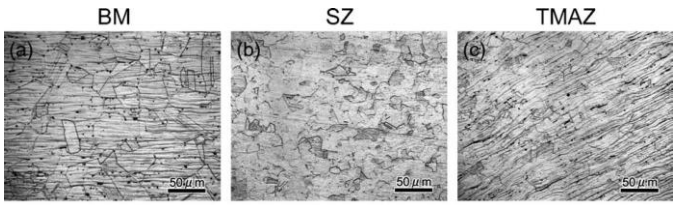

Figure1- Optical micrograph - base material, stir zone and thermomechanically affected zone.

Further, microstructural observation also revealed the formation of sigma phase with numerous stacking faults which was formed at the advancing side of the stir zone. They also found that during FSW rapid formation of sigma phase took place due to the transformation of austenite to delta-ferrite in the stir zone which occured due to high strain and dynamic recrystallization during the FSW [2].

Reynolds et. al [3] compared the tensile properties, optical microstructure, and residual stresses of two friction stir welds in 304 stainless steel produced at two different tool rotation rates. They determined that for

given welding speed, higher tool rotation was observed to correspond to a higher energy input per unit length of weld. Further, they showed that lower energy input resulted in:

a) Lower weld temperature,
b) Finer weld nugget grain size, and
c) Greater weld overmatching compared to the higher energy input weld.

They also found that residual stresses produced in FSW of 304 stainless steel are similar in character and magnitude to those resulting in fusion welding. Further, they concluded that magnitude of longitudinal stress is limited by the base metal yield strength for both tool rotation rates. The bending moment about the longitudinal axis was also observed when sign of transverse residual stress changes from tensile at the crown to compressive at the root.

Kokawa et. al [4] studied the microstructural evolution and hardness distribution in the welds of 2 mm and 6 mm-thick 304 austenitic stainless steel plates. It was found that hardness of the SZ was higher than that of the base material and the maximum hardness was located in TMAZ. The higher hardness of TMAZ is due high density of dislocations and sub-grains. Further, observation also revealed that ferrite and sigma phase were formed in austenite matrix in the SZ depends on the cooling rate during FSW.

Meran and Kovan [5] studied the microstructural features of 304 stainless steel welded plates.. Welding was performed on 11 KW vertical milling machine on 2.5 mm plate. The tool used was tungsten-based alloy they found out that tungsten carbide tool yielded good results. They also observed that best welding appearance was obtained when tool dipping angle was 1.45°. It was also revealed that cold working conditions are not suitable for FSW of stainless steel. Higher strength of welding was observed when travel speed is 63mm/min and rotational speed is 1000 rpm

Not much literature is available on FSW of stainless steel 304 with regard to tool design and specific tool material. This may be because it possesses very high softening temperature and its strength is also very high. Under these circumstances the tool design, tool material and its fabrication is the major difficulty. Although FSW of stainless steel 304 has been carried out before but the technology might have been patent. That's may be the reason that on stainless steels not much literature review is available.

India is one of the fastest developing countries in the world. Due to the eco-friendly nature of FSW it has found important position in India. Though in initial phases, many research and academic institutions are undertaking to FSW but most literature available in Indian context is on Al alloys. Attempts have been made to weld mild steel at places like BARC Mumbai, IISC Banglore, Annamalai University, and NIT Trichi. Among some of the breakthrough researches in India, Welding Laboratory, IIT Delhi, is doing pioneering work under the leadership of Professor S. Pandey [6, 7].

II. Conclusion

In the present study, an attempt has been made to study the feasibility of using FSW for welding of stainless steel 304 and also to study the effects of FSW parameters on the microstructure of welded specimen.

III. Scope for Future Work

Although the suitability of using FSW for stainless steel 304 has been explored in the present work. There are still many other aspects of FSW that need to be addressed in future. In terms of scope of future work the following suggestions are proposed:

- Rigorous experimental investigation needs to be carried out to obtain optimal FSW parameters.
- An appropriate tool design needs to be developed by taking into consideration factors such as metal flow, heat flow and power requirement.

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Construction Safety Culture and Promotion, Conceptual approach based on the Labor Law of Pakistan

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Abstract : *The aspect of safety is taken on low priority basis during the execution of projects in Pakistan. Metropolitan cities of Pakistan are well developed by mega projects but safety of labors within construction is not encountered. This predominantly associated with the loss of lives with the decreasing mortality and social value. Negligence of safety standards correspond to the severe and serious injuries. Keeping in view the gravity of issue, the focusing parameter is the use of modernized equipments during construction. As per the statistics, personal safety of deputed workers is less than 40%. The system will be more susceptible by provoking the deployment of policy regulations and awareness programs with implementation procedures governed by functionary bodies. The ultimate goal of research study entices with the sorting of expert labor with their signified requirements. The key controlling features resemble with the locale of labor law, safety development programs and instrumental knowledge.*

Keywords *- Safety, Construction, Policy, Equipment, Labor*

I. CONSTRUCTION INCIDENTS AND LACK OF TRAININGS –AN OVERVIEW

Construction accidents are entirely dependent on the improper training of labors. Researchers have shown that in many sites no skilled development plan exist in Pakistan. Negligence of safety standards will absolutely result in the form of disasters and loss of precious human life. According to a study, most common types of accidents that occur to specific job, investigation has shown that carpenters have more finger injuries compared to masons [1]. During execution of construction work labors faced different types of accidental issues including falls, scaffolding, electrical related matters, operating equipments or machineries, welding and explosion accidents etc [2]. All of these are equally hazardous and deadly, and each of these can be avoided through effective safety trainings and measures.

II. IMPLICATIONS FOR THE CITY OF KARACHI AND DEPENDENT AREAS

Karachi is the capital economical hub of Pakistan, for getting employment, education and medical facilities peoples migrated all around the Pakistan to Karachi. Many of them getting employment related to construction work. Construction companies getting benefits of this unemployment ratio and hire cheap unskilled labor on daily wages to perform the job, this might cause to the increased number of site accidents [3]. Many contactors do have the safety policy, on paper but in practice there is no check and balance of safety constraint. Unemployed labor putting themselves in danger during execution of construction projects and learn from their own mistakes. Also construction equipments manufacturers have a responsibility to design and maintain safe products for use at the work site. This responsibility includes preventing the use of defective or unreasonably dangerous products, which include: scaffolding, power tools, cranes, woodworking tools, ladders, winches, trucks, tractors, bulldozers, forklifts etc [4]. When a construction site accident occurs, the owners, architects, insurance companies and manufacturers of equipment can be held responsible for inadequate safety provisions. For the detailed feature enhancement, the situation is clearly defined in the pictorial views as follows.

Fig. 1. Unsafe Working Environment (implemented procedures and lack of advanced equipments) [5]

III. OBJECTIVES OF THE STUDY

The major objective of this research is to minimize the root cause of accidents, by introducing step to step program for the successful accomplishment of construction site. The general contractor and all subcontractors are required to provide a reasonably safe site, to warn of hazards inherent in the site and work, to hire careful employees, to coordinate job safety and to supervise compliance with safety specifications. The idea and concept should be transformed to the workers and users with the provision of full specifications in the form of booklet and training.

IV. ANALYTICAL FACTS AND FIGURE BASED ON THE LABOR LOCALE & METHODOLOGY OF THE RESEARCH STUDY

A brief questionnaire was designed by taking the help form different questions. In the similar fashion, numbers of targeted sites are visited in Karachi with the stringent observation that labors are having associated with the number of problems and these problems are directly engaged with the inadequate construction safety process. The picture is quite clear from the analysis below:

Table 1. Designed questionnaire with assigned code.

Question Code	Question
A	How many hours you work daily?
B	Is this income sufficient to support your dependents?
C	Have you aware about safety in construction?
D	Do you get any safety training to work in construction site?
E	Have you ever been injured during construction work?
F	Have you get any compensation against your injury from the contractor or owner?
G	Have you ever been refuse to work, because you think you are putting yourself in danger?
H	If you will not get work on daily basis for 2 or 3 days, will you ready to work any type of construction site or nature of work and ignore your personal safety?

Each question is assigned with a separate code for the effective formulation in graphical representation; data is then collected and represented as follows. As per the question code C, D and E more than 80% answers are imparting to the unsafe construction safety procedures. It is quite evident from the analytical facts that effective designing of policy with predefined rules for the labor locality is mandatory and it is only possible with the introduction safety culture in the environment.

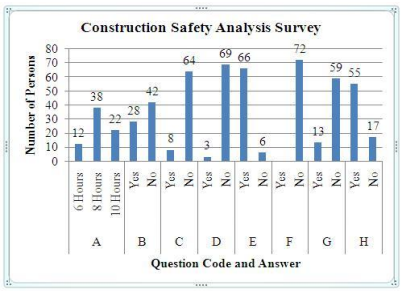

Fig. 2. Construction Safety Analysis Survey Results

V. CAUSES AND PARENTAL APPROACHES TO CONSTRUCTION SITE ACCIDENTS

Uncontrolled, unplanned and undesirable incident might not be necessarily result in an injury is term as an accident [4]. All incidents regardless of the damage or loss and nature should be concern, because it may cause prefigure future accidents. An accident does not happen without cause, many accidents are caused by either unsafe act or unsafe conditions or both [6]. In the same way, number of entities is discussed below that are the root cause and giving the solutions in their own as well.

2.1 Safety Factor Avoidance

According to the respective research, around 90% labors agreed they are injured due to negligence of safety parameters. Not only that, 70% workers are injured due to the unskilled performance and this again correspond to the provision of safety trainings to concerned labors. During the survey, several pictorial views

are to be taken for the clear justification. The system is also dependent by the improper handling of equipments by labors.

2.2 Unemployment Ratio

It is also one of the important factor and proved form the collected data that many construction workers are unemployed (or working on just contract basis) and they are agreed to work without considering safety standards. The whole family is entirely based on that particular labor and they are willing to do extra work in order to get extra beneficial money. In some cases, children of the labors also engaged with that work on daily wages, which is against the Labor Law of Pakistan [7] and also against the Human Rights.

2.3 Imposition of Extra Working hours to get Extra benefit

The working hours for desired and particular group of labors are not predefined, with the extra consumed time at site given by workers jobsite accidents increased. Referring to figure 1, the year of 1999 revealed that the most accidents occurred when a worker stayed on the jobsite for more than forty hours per week [8]. Accidents and injuries affecting workers in developing countries are more, because they are the wage earner of their families and their pay scale is low as compare to developed countries. For the fulfillment of their family needs they work more than forty hours per week and neglect the safety polices.

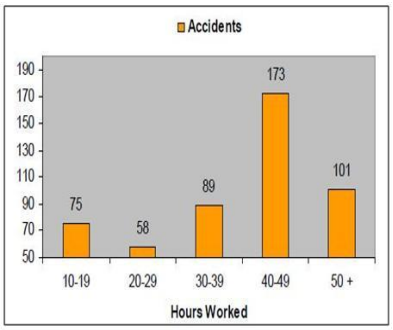

Fig. 3. (EU Construction accidents by hours worked in 1999) [9]

2.4 Specific Domain for Specific Labors

As per the statistical data, 60% of the labors are owned to the specific type of working strategy and transformed to its expertise. The domain of that particular labor is set and the person tries to entrapped with this domain and eventually unskilled in other areas.

2.5 Age Factor

The nature of work in our case is independent from this factor. The whole family of the labor is associated is concerned with the specific project due to excessive needs and requirements, policy is not coupled with these issues.

2.6 Indirect Cost ascertain by the Construction Incident

When accident occurs in construction site, it has many adverse effects on labor and as well construction site. Indirectly it may involve:

- Disappointment of other workers
- Initiation of low productivity
- Extra imposition of time due to investigation
- Repair and maintenance
- Damage of equipment etc

VI. POLICY DEPLOYMENT AND INSTRUMENTAL USAGE

For the successful accomplishment of any construction project, adequate planning and management of safety ensuring policies should be adopted. All personal safety equipment and signs should be kept available for the use of the persons employed on the site and worker are not allowed to enter the site until they wear protection equipments [10]. The policy makers should stumble upon the basics of Labor Law. These include orientation of safety training programs, introducing permit/licensing for operating construction machineries, increasing literacy to work on construction site.

VII. CONCLUSION AND RECOMMENDATIONS

Construction safety is preamble with several basic facts but they are transformed to the adverse perceived contributions by their avoidance. As the study correlates with ideological items including negligence of labor law, improper working exposure, unsafe construction site etc, all allied with the documented, strategic and sound planning of the existing system. Updating of the existing system is the burning issue because presently the things are taken at the documented level but not the implementation level. In this contrary situation, Education and Enforcement both are part and parcel important at separate stages. Education with ground realities of all type of stakeholders should be signified. Experts, Practitioners and Foreigners should play important role in the effective training sessions. Determinate rules should prefer for each class of stakeholder and they should be monitored at different stages of construction. Not only that, for the avoiding maneuvers, penalty should be imposed to the respective person. New and technology should be introduced to the existing system, it tends to the long term proposal but it should started at small scale like the housing schemes etc. For any construction industry, manpower should be strong enough in order to meet the challenges and demand of intact network.

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Mathematical modeling for selection of process parameters in induction hardening of EN8 D steel

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Abstract: *Mathematical modeling with computer application is becoming more and more popular in study, development of setup, maintenance of induction heating process. It can be used to explain, demonstrate and predict the process performance of induction hardening system. Different methods used to solve the field problems. In this paper, an effective Taguchi methodology has been utilized for selection of optimum process parameters of induction hardening of EN8 D steel. Various parameters such as power and heating time have been explored by experimentation. An orthogonal array, L9 , analysis variance of ANOVA are applied study the performance characteristic of induction hardening process. Hardness has been considered as performance characteristic. Analysis of variance (ANOVA) of response variable shows a significant influence of process variables i.e. power and heating time. The experimental results shows that the predicted mathematical models suggested could describe the performance characteristics within the limits of the factors being investigated .The results of regression equations have been verified by confirmation tests. Also microstructure analysis is done for justification of hardening work.*

Keywords*: ANOVA, induction hardening, mathematical model, micro structure , orthogonal array, Taguchi methodology .*

I. Introduction

Induction hardening process have found ever-increasing applications to improve the performance and life of the parts used in automobile engineering. Thin surface layers i.e 0.25 to 2.3 mm of the work piece made of steel can be hardened by this process.

Y.Totic ,R.Sadeler,H.Altum investigated the effects of heating time, feed rate and temperature on wear characteristics of AISI 4140 steel in induction hardening process.[13] Julie.K, Timothy James.[12] studied the effect of feed rate and gap between coil and work piece, quench distance and part temperature by using design of experiment neural network optimization technique on induction hardening process and reported a significant improvement in the process.

R Kolleck, R.Veit[7] focused on reduction of processes cycle time, rising energy, costs eco friendly process and need of new heating technologies in hardening process and proposes the inductive heating alternative methodology for boron alloyed steel. Robert Cryderman , Nima Sham Soei , Al Fatemi [9] In this paper study investigates the influences of induction hardened parts produced from steel bars.

Resit Unal, Edwin B.Dean[8] In this paper authors were presented the overview of the Taguchi method its steps involved and state that , it is a systematic and efficient approach for determining the optimum experimental configuration of design parameters for performance, quality and cost. Principle benefits include considerable resource savings determination of important factors affecting operation. Performance and cost,and quantitative recommendations for design parameters which achieve lowest cost, high quality solutions. In this paper, best working parameters are selected for generation of desired hardness values and pattern in EN8 D steel, by using Taguchi method. Because Taguchi method showed to be a very useful in process improvement provide confident information about influence of factors on a response variable and less number of experiments than traditional method to improve the process while not compromising the desired goals.[3]

The Taguchi method uses a special design of orthogonal array to study the entire parameters space with less number of experiments. The experiments results are then transformed in to signal to noise (S/N) ratio. Taguchi recommends the use of |S/N ratio to measure the quality characteristics deviating from the desired values i.e. lower the better higher the better, and nominal the better. The S/N ratio of each level of process parameter is computed based on S/N ratio analysis. A greater S/N ratio corresponds to the better quality characteristics. The ANOVA tables has been used to investigate and test the significance of design parameters. It indicates which parameters are significantly affecting the response parameters. In the analysis. the sum of squares and variance are calculated. F test values at 95% confidence level is used to decide the significant factors affecting the process.

II. Experimental procedure.

2.1 Work piece material

Figure 1a : case study shaft

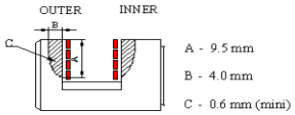

figure 1 b :detailed view of slot

The automobile shaft i.e. selector and shifting shaft was selected for study. The work piece material used for present study was EN8 D steel. Its composition was 0.40% Carbon, 0.22% Silicon, 0.71% Manganese , 0.02% Sulphur , and 0.024% Phosphorus . Material conforms to BS 970(1955) for EN8 D steel. This material is suitable for variety of automotive components such as axle, crank shaft, spline shafts and gears etc. The length of work piece is 177 and diameter 19mm respectively. The static induction hardening has been performed on the slot portion of work piece.

2.2 . Experimental apparatus

High frequency induction hardening machine (40 kw, 200khz) make Sanket Power Systems has been used for the performing the experiments . A source of high frequency of electricity is used to drive a large alternating current through a copper coil. The passage of a current through this coil generates a intense and rapidly changing magnetic field in the space within the work coil. The work piece to be heated is placed within this magnetic field where eddy current is generated within the work piece and resistance leads to heating of work piece. The core of the work piece remains unaffected by this process . Induction hardening temperature was above 850 ºC .

2.3 Experimental plan.

In this investigation two factors at three levels have been studied. Factors and their levels are shown in table 1 . The factors and levels are selected on the basis of literature review and their range were finalized after pilot runs.[11]

Table 1 : process parameters and their levels

Symbol	Process parameters	Level I	Level II	Level III
P	Power (kw)	10	12	14
T	Heating time (sec)	02	03	04

The values of factors of induction hardening process were utilized for conducting design of experiments in induction hardening machine for EN8 D steel. The response variables to be investigated were hardness HRc, and its developed pattern i.e. case depth , Based on available in put parameters and their levels an orthogonal array lay out is designed for Taguchi method by using soft ware MINITAB .

Table 2 : Experimental data as per designed array L9

Exp.Runs No	Power kw	Heating time sec	Hardness HRc	Case depth(mm) Outer Vertical	Outer Top	Outer Centre	Inner Vertical	Inner Top	Inner Centre
1	10	02	55	8.70	2.0	0.4	8.75	2.2	0.5
2	10	03	56	8.75	2.3	0.5	8.85	2.4	0.6
3	10	04	57	9.20	2.5	0.8	9.25	2.7	0.9
4	12	02	57	9.00	2.2	0.5	9.05	2.3	0.6
5	12	03	57	9.20	2.4	0.9	9.25	2.8	0.7
6	12	04	58	9.45	3.3	1.5	9.50	3.6	1.6
7	14	02	58	9.00	3.0	1.0	9.10	3.2	1.1
8	14	03	58	9.35	3.2	1.3	9.30	3.5	1.4
9	14	04	60	9.60	4.0	1.8	9.50	3.9	1.8

As given in table 2 performance test involves nine runs. Accordingly nine runs were carried out to study the effects of input parameters. Same work coil is used for all runs.[14]

2.4 Experimental technique

As shown in table 2 nine experiments are conducted. Each experiment is conducted for three times to reduces the experimental errors. Hardness was measured by Rockwell hardness testing machine for C scale at 150 kg load, having diamond indenter at 120 degrees . While automatic Vickers's hardness testing machine is used to measure case depth achieved at various locations.

III. Results and discussions.

The mean of three experimental values of each run is mentioned in the table 2 further analysis of results were carried by using software MINITAB.

3.1 Analysis of variance (ANOVA)

The ANOVA tables has been used to investigate and test for significance of design parameters. It indicates which parameters are significantly affecting the output parameters. In the analysis the sum of squares and variance are calculated . F-test values at 95% confidence level is used to decide the significant factors affecting the process and percentage contribution. Since the p values are less than 0.05 and larger F values indicates that these factors have statistically significant effects on the performance . The ANOVA analysis for response are shown in table 3.

Table 3: ANOVA results for hardness.[2][5]

Source	DF	SS	MS	F	P	
Power	2	10.6667	5.33333	32.00	0.003	
Heating time	2	4.6667	2.33333	14.00	0.016	Significant
Error	4	0.6667	0.16667			
Total	8	16.0000				
S = 0.4082 R-Sq = 95.83% R-Sq(adj) = 91.67%						
All F-ratios are based on the residual mean square error.						

Fig. 2 a : plot for hardness

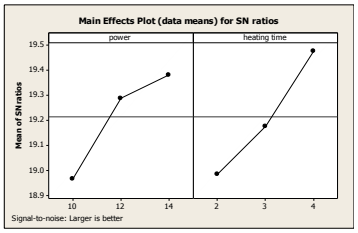

Fig. 2 b : plot for hardness

Fig. 2a and 2b shows main effects plot (data means) of mean and S/N ratio graphs for hardness. Where the horizontal line is the value of total mean of S/N ratio. Basically larger the S/N ratio better is the quality characteristics for process.

Table 4: Significance of induction hardening parameters for hardness

Response	Process parameter	Mean S/N ratio			Significance of induction hardening parameter
		Level 1	Level II	Level III	Max-Min
Hardness					
	P	34.96	35.17	35.37	0.41
	T	35.06	35.12	35.32	0.25
P = power , T = heating time					

Significance of induction hardening parameters (difference between max and min values) indicates that power is significantly contributing towards the induction hardening performance as difference gives higher values .According to ANOVA analysis as shown in the table 3 most effective parameter with respect to hardness

is power. As per the S/N ratio analysis from the graphs and significance the levels of parameters to be set getting optimum values of hardness are P3- T3 i.e. 14 kw-4 sec. The analysis of graphs and ANOVA results clearly indicates that the increase in power and heating time increases hardness of work piece

Confirmation test: After identifying the best levels of process parameters, a new experiment was designed and conducted with predicted levels of process parameters optimum parameters found are P-14kw, T-4 sec, comparison between estimated values and confirmation test value shows a small difference between these values.These values correlate each other. This indicates that ANOVA results are closely match with the Taguchi results.[1]

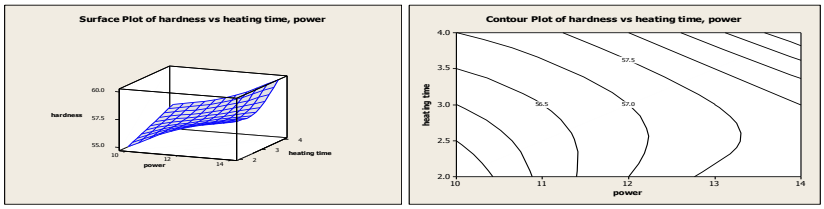

Fig. 3 a : 3D surface plot for Hardness Fig. 3 b: Contour plot for Hardness

Fig. 3 a and 3b shows 3D surface graph and contour plot for hardness of EN8 D steel respectively . These fig.s show the effect of power and heating time on the response as hardness. It is clear from the above figures that increase in power and heating time increases hardness of work piece.

IV. Mathematical Model

The relationship between dependent variables and independent variables is characterized by a mathematical model called a regression model. Multiple linear regression equations were modeled for relationship between process parameters i.e. power and heating time to evaluate hardness for any combination of factor levels in a range specified model for multiple regression equation is

$$y = \beta_0 + \beta_1 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \text{------} + \beta_p x_p + \varepsilon \qquad (1)$$

Where y is dependent parameter, $x_1, x_2, x_3 \ldots\ldots x_p$ are independent parameters , β are regression parameters and ε is residue.[3]

The regression coefficients have been obtained by using experimental data. The regression equations for response characteristics as a function of two parameters of the material EN8 D steel considered in this experiment are given below. The insignificant coefficients identified from ANOVA have been omitted from equation for various responses . In this case, regression equation is formulated in terms of parameters i.e. power and heating time by using MINITAB software.

The regression model equation for response in terms of power and heating time is given below

- Hardness = 46.8 + 0.667 Power + 0.833 Heating time (2)

Table 5: confirmation for regression equation of hardness

Response	Exp No.	Exp value	Model value	%Variation
Hardness	2	56	55.269	0.055%
	3	57	58.802	3.161%
	5	57	57.303	0.531%
	8	58	58.637	1.098%

V. Confirmation for regression equation

In order to validate the regression equation , experimental data were compared with data obtained by putting the same experimental conditions in the regression equation . The results are given in the table 5. Percentage variation estimated for the equation 2 for hardness in the range of 0.055% to 3.161 %. These results obtained by regression equation closely co relate with each other which validated the regression equation developed . Thus the developed equation can be used to predict hardness for any combination of factor levels in the specified range[2].

VI. Micro structure analysis

Fig. 4 : Micro structure of the surface of induction hardened EN8 D steel

Uniform distribution of carbon cannot be assumed in the case of induction hardening many times carbon can not be diffused to a uniform concentration throughout the structure. The fig. shows micro structure image of the surface of induction hardened EN8 D steel at 250X , polished and etched at 3% Nital solution. Micro structure shows fine tempered martensite with uniformly distributed ferrites. No micro cracks observed in the induction hardened zone. Uniform distribution of ferrites and pearlites are observed in the core. which indicated the distribution of uniform hardness .

VII. Conclusion

Taguchi method of experimental design with L9 orthogonal array has been applied for selection of optimum process parameters of induction hardening of EN8 D steel. The experimental investigation shows the effects of process parameters such as power, heating time on hardness and case depth pattern achieved on work piece. The optimum parameters found are 14 kw power and heating time 4 sec. power is the most influential parameter. Further multiple regression equations are formulated for estimating predicted values of hardness of slots for a specified range. The results obtained by regression equations closely co relate each other which validates the regression equation developed. And micro structure analysis justified the hardening work.

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Isolation and Screening of Cellulose Degrading Bacteria in Kitchen Waste and Detecting Their Degrading Potential

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Abstract: *The present paper investigates cellulose degrading bacteria present in kitchen waste for highest cellulase activity at optimum temperature and pH. Sample was collected from domestic kitchen waste and bacterial strains were isolated using nutrient agar media. Enrichment technique was used for isolating CDB (cellulose degrading bacteria) strains. The objective of research was to utilize effective bacteria for degrading complex polymer cellulose into simpler sugars like glucose under optimum working conditions. Out of 21 isolated bacterial strains, only four were having effective cellulose degrading bacteria. These four isolates were screened for qualitative estimation through Congo red dilution assay and quantitatively tested by DNS method (Miller, 1959). The optimum pH and temperature for most potent isolate was recorded as 7.1 and 35ºC respectively. It was concluded that these findings were in accordance with previous results. These optimum working conditions were recommended for biomass utilization.*

Keywords: *Kitchen waste, Cellulose degrading bacteria, optimization, solid waste*

I. Introduction

Kitchen Waste forms a significant part of domestic waste. Food waste is an unwanted raw or cooked food discarded during or after food preparation that is no longer fit for consumption or desirable (N.Jean *et al*,2009). About 0.1 million ton of municipal solid waste is generated in India every day (www.toxiclinks.org). So, annual production reaches approximately 36.5 million tones. There is a large variety of micro organisms present in waste such as bacteria, fungi, protozoa et al. In this research study, main focus will be on cellulose degrading bacteria in food waste. Cellulolytic microorganisms are those that degrade cellulose present in waste into other useful products. These play an important role in the biosphere by reducing complex polymer cellulose into various economically important products like monomeric sugars, microbial biomass proteins, compost, antibiotics etc, to everyday use for man. Annual production of cellulose is estimated to be $4.0x10^7$ tons (A. Singh *et al*, 1995).

Biodegradation is breakdown of organic contaminants occurring due to production of extracellular enzymes by microorganisms. These contaminants can be considered as the substrate or microbial food source (Maier *et al.,* 2000). Enzymes have also been an interesting topic of research all over the world considering their broad range of physiological, industrial and analytical applications; especially from microorganisms due to their broad biochemical diversity, feasibility of mass culture and ease of genetic manipulation (Chakrabortya *et al.,* 2009). The optimization of the development of any fermentation process, particularly physical and chemical parameters are of primary importance, owing to their impact on the economy and practicability of the process (Wenster-Botz, 2000). Worldwide interest in microbiological decomposition of cellulose is still as strong as when it started more than three decades ago. Cellulose degrading bacteria have been isolated by Han and Srinivasan (1968), Kauffmann et al (1976), Thayer and Murray (1977), Steward and Leatherwood (1976) based on enrichment culture technique utilizing different sources of carbon(Leticia M Coronel, 1986).

Cellulose consists mainly of long polymers of β 1-4, linked glucose units and forms a crystalline structure (Shallom & Shoham, 2003). Cellulase enzymes, which can hydrolyze cellulose forming glucose and other commodity chemicals, can be divided into three types: endoglucanase (endo-1, 4-β-D-glucanase); cellobiohydrolase or exoglucanase (exo-1, 4-β-D-glucanase) and β-glucosidase (1,4-β-D-glucosidase) (Li *et al*., 2006; Gao *et al*., 2008). Cellulases are important industrial enzymes and find applications in several industrial processes (Hanif *et al*., 2004; Jamil *et al*., 2005). Researchers have strong interests in cellulases because of their applications in industries of starch processing, grain alcohol fermentation, malting and brewing, extraction of fruit and vegetable juices, pulp and paper industry, and textile industry (Gao *et al*., 2008; Zhou *et al*., 2008).

The purpose of this work was basically to examine the possible utilization of cellulose degrading bacteria in kitchen waste for maximum cellulose activity at optimum working conditions such as pH and temperature. This purpose was achieved through different steps; isolation of cellulose degrading bacterial strains

from kitchen wastes; selection of the most potent isolate producing cellulase activity; and optimization of working conditions affecting glucose biosynthesis by the preselected isolate.

II. Materials And Methods

Culture media:

Nutrient agar medium: This medium was used for obtaining auxenic culture. It has main composition of 0.5 % Peptone; 0.3 % beef extract/yeast extract; 1.5 % agar; 0.5% NaCl in distilled water and pH adjusted to neutral (6.8) at 25 °C.

Enrichment of cellulolytic bacteria was achieved in mineral salt solution of (in g/l): NaCl,6.0;$(NH_4)_2SO_4$,1.0;KH_2PO4,0.5;K_2HPO_4,0.5;$MgSO_4$,0.1;$CaCl_2$,0.1and supplemented with 0.1% CMC as cellulose source.

Sample Collection

Sample was collected directly from waste receiving dustbin of domestic kitchen in many replicates. Pre -sterilized screw cap glass vials of 15 ml capacity were used for collection purpose. Randomly selected one cm^2 blocks of waste patch were scrapped with scapula and collected in separate vials and these were brought to laboratory for isolation of cellulose degrading bacteria.

Isolation of Bacterial strains

Streaking plate method was used for obtaining pure bacterial strain. After 21 bacterial strains were isolated, the one with cellulose degrading ability were determined using Enrichment technique.

Screening of CDB strains

Isolated cellulose degrading bacterial strains were screened for determination of highest cellulase activity. Quantitative assay using Congo red Dilution assay (Apun *et al.,* 2000) was performed where zone of clearance was observed visually by staining plate with 0.1% congo red for 15 minute and destained with 1 M NaCl. Diameter of clear zone was measured in zone of clearance where cellulase activity occurred.

Qualitative assay was performed by determining the amount of reducing sugars liberated by using Dinitrosalicyclic Acid (DNS) method (Miller 1959). A cellulolytic bacteria was recorded to have highest cellulase activity and selected for optimization of production of cellulase enzyme.

Determination of optimal pH, Temperature

Preselected isolate is dispensed in test tubes containing mineral salt broth medium with 0.1% cellulose and was adjusted to pH 5.0, 6.0, 7.0 and 8.0. It is incubated at 37°C for 96 h. Following the incubation, growth of the cultures was measured by observation of the optical density at 560 nm.

Same procedure was followed for determining cellulase activity at varying temperature. Tubes were incubated at different temperatures 30, 35, 40 and 45°C for 96 h.

III. Results And Discussions

Isolation and screening of CDB Strains

Out of 21 isolated bacteria, four isolates (CDB1, CDB 12, CDB18, CDB 20) were screened for showing noticeable cellulase activity.

Highest cellulase activity was recorded by CDB12. Enzymatic activity was determined through congo red test where zone of clearance was measured in mm and compared with standard cellulase. This indicated that these cellulolytic bacterial strains utilized the available sources of cellulose present in waste and carried out their degradation.

Quantitative test of these isolate showed highest enzymatic activity in CDB 18 with 24 U/ml.

The diameter of zone of clearance observed in congo red dilution assay did not predicate the amount of cellulase activity occurred in sample. According to report published in 2000, out of number of thermo tolerant bacterial isolates grown on CMC agar, an isolate CMU 4-4 recorded smaller clear zone than other strains but it had highest enzymatic activity (Krootdilaganandh 2000).

IV. Optimum pH and Temperature of CDB isolate

The maximum cellulase activity was found at pH 7. The growth was also recorded at other pH values i.e 5 to 8. . Lu (2005) has reported that organisms can grow well at a pH ranging from 5.7 to 7.5.

The optimum temperature at which maximum cellulase activity was produced was 35 degree Celsius. The cellulase activity also occurred at other temperature values which showed that CDB strains are tolerant to both higher and lower temperature.

V. Conclusion

The results from this research support the general conclusion that introduction of cellulose degrading bacterial (CDB) strains is an advantageous tool of microbiology to support energy recovery from degraded ecosystems. Upon screening, only one isolate was found to have highest cellulase activity which was an indication of presence of cellulose decomposer that can break down large organic molecules into smaller molecules that can be used by the biotic community. This in turn will provide some medium to utilize renewable sources of energy with the help of micro organisms and processes they undergo during degradation of complex polymer to simpler sugars.

VI. Acknowledgement

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Input Shaping for Sway Control in Gantry Cranes

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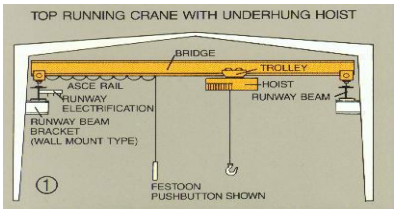
Abstract: *Bridge Cranes or Gantry Cranes are an essential element in the day to day activities of a manufacturing plant. The most common operation of a gantry crane is point to point transportation of payload. The use of cables for hoisting and support of payload can lead to natural swaying. This natural sway is detrimental to safe and efficient operation. Swinging degrades the speed, accuracy, and safety of transport operations. It lowers the speed of transport operations because the payload swing must die out before the payload can be safely lowered into position. The swing makes it difficult to perform alignment, fine positioning, or other accuracy driven tasks. Swing also causes safety problems because of the potential for collisions with objects or people. Under certain conditions, the problem gets more complicated when the payloads creates a double pendulum effect. This report develops a technique for improving the control of two mode double pendulum crane called input shaping. Input shaping is a control strategy that uses a series of impulses to modify the reference command to suppress unwanted vibration in a system. This report presents a method for optimizing a robust input shaper called Specified insensitivity input shapers using the knowledge of amplitude contributions of each mode to the overall response.*

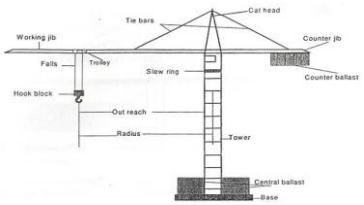
Keywords – *Command Shaping, Input Shaping, Gantry Cranes, Sway Control*

I. Introduction

Cranes have been used for thousands of years to lift and transport heavy materials. They are used in shipyards, construction sites, and warehouses. In all cases the most common operation of a crane is point-to-point transport of a payload. The most common types of cranes used are Bridge cranes and Tower Cranes. Figure 1 shows the most commonly used bridge as well as tower crane.



Bridge Crane



Tower Crane

Figure 1.1. Types of cranes

There are three factors are of paramount importance in crane operations: speed, accuracy, and safety. All cranes use cables to hoist and support the payload. And because of this structure, the payload swings during handling operations. The natural sway of crane payloads degrades speed, accuracy and safety.

If the crane behaves like a single pendulum, an experienced human operator can act as the feedback controller. He can eliminate much of the payload sway by causing an oscillation during deceleration that cancels the oscillation induced during acceleration. However, in most cases certain types of payloads and riggings induce double pendulum dynamics. Under these conditions, the manual method of eliminating oscillation becomes difficult, even for skilled slingers.

The most widely used control method for reducing payload vibration is to simply limit the acceleration and maximum velocity. When the crane operator pushes the button, the crane motors are slowly ramped up to the full speed. The resulting effect is command smoothing that acts as a low pass filter. This method is somewhat effective, but it leads to a sluggish response and large deceleration distances. This method increases the travel time from point to point payload handling and hence is not preferred. If a computer controller is utilized and cable swing is considered in the control design, the time optimal commands that result in zero-residual vibration can be generated. The implementation is often impractical because the boundary condition i.e. the point to point distance (the move length) must be known at the outset. Another method for controlling sway is the technique of feedback control. Using feedback control is challenging due to the difficulty of measuring the payload motion. The crane would require a camera mounted on the trolley to measure the payload swing in the horizontal plane and velocity and position sensors.

1.1. Input Shaping

Another successful approach uses the technique of Input Shaping to reduce the crane sway. Input shaping is easier to derive and implement than time-optimal control schemes and does not require feedback mechanisms of closed-loop and adaptive controllers. Input Shaping is implemented in real time by convolving the command signal with an impulse sequence (an input shaper). The result of the convolution is then used to drive the crane motors. Real Time convolution only requires a few multiplication and addition operations at each time step. Therefore, it can be implemented on the simplest of digital processors.

The earliest incarnation of input shaping was developed in 1950 by Smith. His posicast control ensures there will be zero residual vibration when the system model is perfect, and hence it is referred to as a zero vibration (ZV) shaping.

This input shaping process is demonstrated in figure 1 using a typical velocity pulse and an input shaper consisting of three impulses.

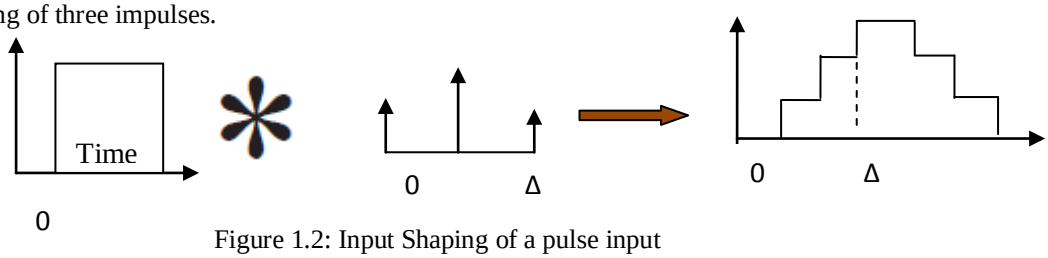


Figure 1.2: Input Shaping of a pulse input

The velocity pulse commands are very common in crane control because human operators often press on-off buttons to drive cranes. Proper timing and scaling of the impulses can ensure that the payload oscillation is suppressed to within a desired tolerance

II. Modelling Of Gantry Cranes

In order to apply multiple-mode vibration suppression using input shapers to cranes, the dynamics of the crane must be understood. This chapter deals with the dynamics of crane that act as a double pendulum with point mass payload as well as the dynamics of a distributed payload mass.

2.1. Double Pendulum Dynamics

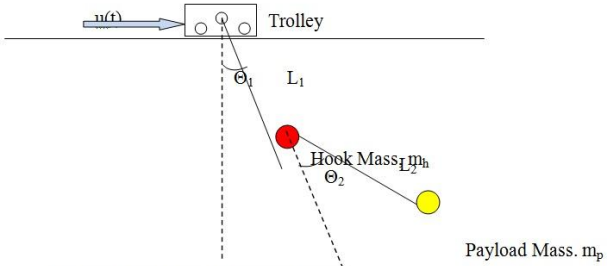


Figure 2.1 Double pendulum gantry crane

Figure 2.1 shows a schematic representation of a double pendulum gantry crane. The crane is moved by a applying force, u(t), to the trolley. A cable of length L_1, hangs below the trolley and supports a hook of mass, m_h, to which a payload is attached using riggings cables. Hence the rigging and payload can be modeled as a second cable of length L_2, and a point mass, m_p.

Assuming that the cable and rigging lengths do not change, the linearized equations of motion, assuming zero initial conditions, are:

$$\ddot{\theta_1}(t) = -\left(\frac{g}{L_1}\right)\theta_1 + \left(\frac{g}{L_1}R\right)\theta_2 - \frac{u(t)}{L_1} \qquad (1)$$

$$\ddot{\theta_2}(t) = \left(\frac{g}{L_1}\right)\theta_1 - \left(\frac{g}{L_2} + \frac{gR}{L_2} + \frac{gR}{L_1}\right)\theta_2 + \frac{u(t)}{L_1} \qquad (2)$$

Where θ_1 , θ_2 are the two pendulum angles, R is the ratio of payload mass to the hook mass $\left(\frac{m_2}{m_1}\right)$.

The linearized frequencies [2] of the double pendulum are

$$\omega_{1,2} = \sqrt{\frac{g}{2}}\sqrt{(1+R)\left(\frac{1}{L_1}+\frac{1}{L_2}\right) \mp \beta} \qquad (3)$$

Where

$$\beta = \sqrt{(1+R)^2\left(\frac{1}{L_1}+\frac{1}{L_2}\right)^2 - 4\left(\frac{1+R}{L_1 L_2}\right)} \qquad (4)$$

The frequencies depend on the two cable lengths and the mass ratio.

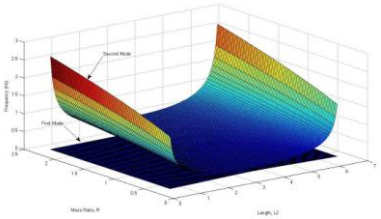


Figure 2.2 Variation of low and high frequencies

Figure 2.2 shows the two oscillation frequencies as a function of mass ratio and rigging length, L_2, (assumption that the sum of lengths L_1+L_2 remains a constant). The low frequency changes very little and corresponds closely to the frequency of a single pendulum. On the other hand, the second mode has a strong dependence on the rigging length.

The low frequency is maximized when the two cable lengths are equal. But the variation is very little from the median value. In contrast, the second mode deviates highly over the same parameter range. The low frequency changes very little and corresponds closely to the frequency of a single pendulum (L_1 +L_2).

The responses of two swing angles, θ_1 , θ_2 , to an impulse of magnitude A, introduced at time t_0, are:

$$\theta_1(t) = \frac{A\omega_1(1+\omega_2^2 L_1\alpha)}{k}\sin\{\omega_1(t-t_0)\} - \frac{A\omega_2(1+\omega_1^2 L_1\alpha)}{k}\sin\{\omega_2(t-t_0)\} \quad (5)$$

$$\theta_2(t) = \frac{A\omega_1}{k}\sin\{\omega_1(t-t_0)\} - \frac{A\omega_2}{k}\sin\{\omega_2(t-t_0)\} \quad (6)$$

Where

$$\alpha = \frac{-g(1+R)}{\omega_1^2\omega_2^2 L_1 L_2}, and$$

$$k = \beta L_1 g$$

If we assume small angles, then the impulse response of the payload in the horizontal direction can be approximated as

$$x(t) = C_1\sin(\omega_1 t + \varphi_1) + C_2\sin(\omega_2 t + \varphi_2) \quad (7)$$

Where

$$C_1 = \frac{\omega_1 L_1(1+\omega_2^2\alpha(L_1+L_2))}{k}\sqrt{\left(\sum_{j=1}^{n} A_j\cos(\omega_1 t_j)\right)^2 + \left(\sum_{j=1}^{n} A_j\sin(\omega_1 t_j)\right)^2}$$

$$C_2 = \frac{-\omega_2 L_1(1+\omega_1^2\alpha(L_1+L_2))}{k}\sqrt{\left(\sum_{j=1}^{n} A_j\cos(\omega_2 t_j)\right)^2 + \left(\sum_{j=1}^{n} A_j\sin(\omega_2 t_j)\right)^2}$$

The coefficients C_1 and C_2 indicate the contributions of each mode to the overall payload response.

The design of input shaper should be such that the double pendulum crane moves with very little residual vibration, hence, we need to limit the maximum amplitude of the residual vibration from a series of impulses. The maximum amplitude can be found out by adding the maximum amplitude due to each mode.

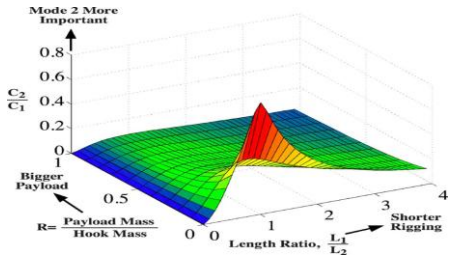


Figure 2.3. Ratio of high mode amplitude to low mode amplitude

Figure 2.3 shows the ratio of the mode 2 to mode 1 for a range of length ratio and mass ratios [2]. It is clear that the input shaping would be essential for systems where the payload to hook mass ratio is less, and when the hook cable length and rigging lengths are approximately equal.

2.2. Distributed Payload

Crane Dynamics

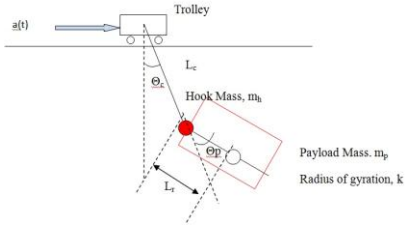


Figure 2.4 Distributed mass gantry crane system

Figure 2.4 shows a schematic representation of a planar bridge crane with a distributed payload. The acceleration of the overhead trolley is a(t). A mass less cable, of length L_c , hangs below the trolley s a hook, of mass m_h , to which the payload is attached. The distance from the hook to the centre of mass of the payload is L_r. The payload is characterized by its mass m_p and radius of gyration '***k***' about its centre of mass.

If the cable and rigging lengths do not change, then the linearized equations of motion [1] are

$$\left(m_p k^2 + L_r m_p (L_r + L_p)\right)\ddot{\theta}_p + \{m_p k^2 + m_h L_c^2 + m_p (L_c^2 + L_r^2 + 2L_c L_r)\}\ddot{\theta}_c = -(gL_c m_h + g m_p L_c + gm_p L_r)\theta_c - (gm_p L_r)\theta_p - \{L_c m_h + m_p (L_c + L_r)\}a(t)$$

$$\left(m_p k^2 + m_p L_r^2\right)\ddot{\theta}_p + \{m_p k^2 + L_r m_p (L_r + L_c)\}\ddot{\theta}_c = -L_r m_p g\theta_c - L_r m_p g\theta_p - L_r m_p a(t)$$

Where θ_c , θ_p are the swing angles that measure the cable rotation and payload rotation.

The Linearized frequencies [1] of the system are:

$$\omega_1^2 = \frac{g(1+R)}{2L_c}(\alpha - \beta) \qquad (9)$$

$$\omega_2^2 = \frac{g(1+R)}{2L_c}(\alpha + \beta) \qquad (10)$$

where

$$\alpha = \frac{k^2 + L_r L_c + L_r^2}{L_r^2 + k^2(R+1)}$$

$$\beta = \sqrt{\alpha^2 - \frac{4L_r L_c}{(R+1)\{L_r^2 + k^2(1+R)\}}}$$, where R is the mass ratio.

The frequencies depend on the two cable lengths, the radius of gyration of the payload, ***k*** and the mass ratio, R.

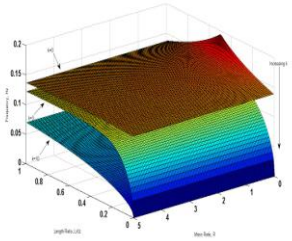


Figure 2.5 Low Mode frequency

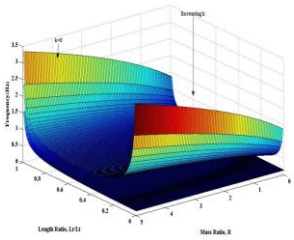


Figure 2.6.High Mode frequency

The figure 2.5 and 2.6 shows the variation of low frequency and high frequency modes variation with length ratio, mass ratio and radius of gyration. Table 1 shows the median value of the two frequencies and how they vary with radius of gyration. The low mode frequency doesn't vary much from the median value when the radius of gyration is near to 1.

Radius of Gyration k	Mode	Median Frequencies(Hz)	Variation
0	Low High	0.14 0.572	11% 78%
1	Low High	0.1388 0.422	12% 84%
5	Low High	0.0963 0.22	56% 77%
10	Low High	0.0552 0.1988	65% 73%
50	Low High	0.0155 0.1936	68% 69%

Table 1: Frequency Ranges for a variety of payloads

The analysis indicates that an oscillation control scheme would need more robustness to variations in the second mode than in the first mode. However, if the amplitude of the second mode is very small, then the controller need not attend to the second mode. This can be examined by decomposing the overall dynamic response into components from the low and high frequencies.

The payload response from an impulse input A [1] can be expressed as

$$x(t) = C_1 \sin(\omega_1 t) - C_2 \sin(\omega_2 t)$$

where

$$C_1 = A\frac{L_c + \omega_2^2 L_r \gamma (L_c + L_r)}{g\beta(R+1)}\omega_1$$

$$C_2 = A\frac{L_c + \omega_1^2 L_r \gamma (L_c + L_r)}{g\beta(R+1)}\omega_2$$

where

$$\gamma = \frac{-g(R+1)}{\omega_1^2\omega_2^2\left(L_r^2 + k^2(R+1)\right)}$$

The coefficients C_1 and C_2 give the amplitude contribution of each mode to the overall impulse response. The maximum amplitude is thus

$$V_{max} = |C_1| + |C_2|$$

The variation of second mode amplitude contribution with mass ratio, length ratio and radius of gyration is shown in figure 2.7 [1].The figure reveals that double pendulum effects are most important for point mass payloads (k=0) with low payload to hook mass ratio and length ratios near 0.5.

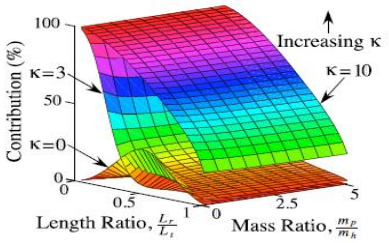


Figure 2.7.Amplitude contribution of ω_2

It's clear from the above plot that the double pendulum effects are most important for point mass payloads (k=0) with low payload to hook mass ratio and length ratios of 0.5. The dynamics of the distributed payload crane are dependent on the payload mass, rigging length and radius of gyration of the payload. The payload mass has significant effect on the system frequencies and amplitude contributions when the mass of the payload is small relative to the mass of the hook and radius of gyration is small. The radius of gyration has a large effect on the frequencies and the amplitude contributions when it is small but becomes less dominant as it increases. The rigging length has the largest influence on both the frequencies and the amplitude contributions when the radius of gyration grows large.

III. Input Shaping For Double Pendulum Gantry Cranes

3.1. Principle of Input Shaping

Input shaping command, which can be considered as a feed forward control, is an algorithm that shapes the input command to reduce the residual vibration of the system. Input shaping limits the residual vibration by generating a command profile that tends to cancel its own vibration. That is, the vibration induced in the first part of the command is cancelled by vibration induced by a later portion of the command. Input shaping is easier to derive and implement than time optimal control schemes and does not require the feedback mechanisms of closed loop and adaptive controllers.

Using estimates of system natural frequencies and damping ratios, a series of impulses, called the input shaper, is designed. Input shaping is obtained in real time by convolving the command signal with a sequence of impulses (input shaper). The result of this convolution is used to drive the system. Thus the input shaper modifies the desired velocity command before it is fed to the crane drives.

A typical implementation of a input shaper on a crane system is shown in figure 3.1.

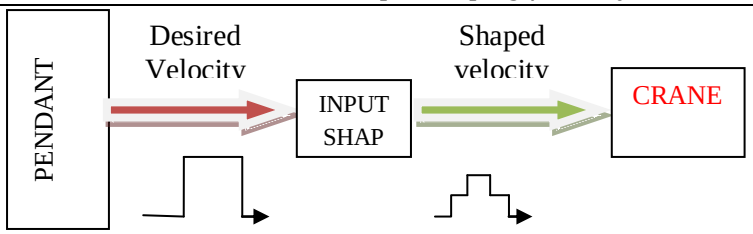


Figure 3.1- Block Diagram of an input shaped crane system

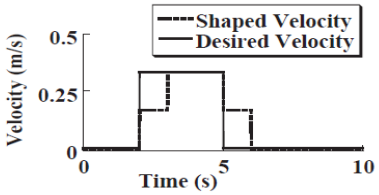


Figure 3.2- Desired and Shaped Velocity Commands

Figure 3.2 shows the original desired command and the new velocity command created by the input shaper. The desired command to achieve the point to point motion is a velocity pulse. In contrast, the shaped velocity command stays at half speed for a short time before reaching the final full on velocity. It is this modification, which the input shaper imparts on the velocity command that causes the payload to move without swinging.

This modification is achieved by applying a convolution filter to the command. The input/output formula for a convolution filter is:

$$Y(t) = G_{IS}(t) * X(t) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2.1)$$

Where X(t) is the input, $G_{IS}(t)$ is the input shaping filtering sequence, Y(t) is the output , and '*' is shorthand for the convolution integral.

A generalized input shaper is shown in Figure 3.3

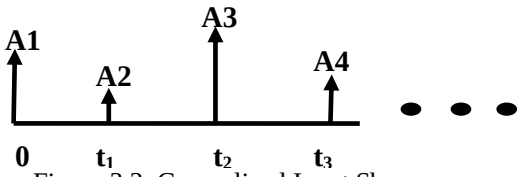


Figure 3.3: Generalized Input Shaper

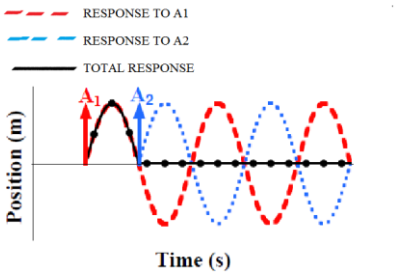


Figure 3.4: Superposition of Impulse responses.(taking only A1 and A2)

The goal is to find out the impulse times and the amplitudes such that the total response has zero residual vibration The residual vibration can be rejected by superposition of two responses and this leads to a shorter settling time. In general, input shaping is based on the linear system theory and is defined as [8];

$$y(t) = A\frac{\omega}{\sqrt{1-\zeta^2}}e^{-\zeta\omega(t-t_0)}\sin\left\{\omega\sqrt{1-\zeta^2}(t-t_0)\right\}$$

$$\text{Impulse Magnitude}, K = e^{\frac{\zeta\pi}{\sqrt{1-\zeta^2}}}$$

$$\text{Impulse Delay}, \Delta T = \frac{\pi}{\omega\sqrt{1-\zeta^2}}$$

Where A is the amplitude of vibration, ω is the natural frequency and ς is the damping ratio, t is the time and t_0 is the time of impulse applied to the system. Hence, a simple input shaper with two impulses is designed from the natural frequency and damping ratio.

To obtain exactly zero residual vibration is practically impossible on real machines, and hence, the input shaper should be designed to yield non-zero, but low levels of sway. The impulse time and amplitudes will be a function of the system natural frequency and damping ratio.
The Laplace transform of equation 2.1 is

$$Y(\omega) = G_{IS}(\omega)X(\omega)$$

We have chosen the input shaper such that it excites zero vibration at the system's natural frequency or $G_{IS}(\omega_n) = 0$. And hence it follows that $Y(\omega_n) = 0$. In other words, the shaped input, Y(t), always has zero frequency content at the system's natural frequency regardless of the input X(t).
Input shaping is a form of Finite impulse Response (FIR) filtering that places zeroes near the locations of the flexible poles of the original system. If $G_{IS}(\omega)$ has zeroes at the poles of Y(ω), then the pole-zero cancellation will occur.

3.2. General Input Shaping Constraints

In order to determine the impulse amplitudes and time locations of an input shaper, the designer must ensure that they satisfy certain design constraints. The primary design constraint is a limit on the amplitude of vibration caused. We can use the expression for residual vibration, $V_{max} = |C_1| + |C_2|$, as a constraint equation by requiring V_{max} to be less than the tolerable vibration V_{tol}. The tolerable vibration level comes from the crane and its typical manipulation tasks.

A Mathematical constraint that ensures the vibration with input shaping will be below the tolerable level is

$$V_{tol} \geq V_{max} = C_1 + C_2$$

The vibration caused by an input shaper can be limited by the above equation, but if the impulse amplitudes are not constrained, then their values can become very large. This can lead to actuator saturation. The vibration amplitude of an under-damped, second order system from a sequence of n-impulses is:

$$A_{\Sigma} = \frac{\omega}{\sqrt{1-\zeta^2}} e^{-\zeta\omega t_n} \sqrt{\left\{\sum_{i=1}^{n} A_i e^{\zeta\omega t_i} \cos\left(\omega t_i \sqrt{1-\zeta^2}\right)\right\}^2 + \left\{\sum_{i=1}^{n} A_i e^{\zeta\omega t_i} \sin\left(\omega t_i \sqrt{1-\zeta^2}\right)\right\}^2}$$

Where ω is the natural frequency of the system and ζ is the damping ratio, and A_i and t_i are the i^{th}- impulse amplitude and time, respectively. To form non-dimensional vibration amplitude, the equation is divided by the amplitude of residual vibration from a single impulse of unity magnitude at time zero. The resulting expression gives the ratio of vibration with input shaping to that without input shaping. The amplitude of residual vibration from a single unity-magnitude impulse applied at time zero is

$$A_{\uparrow} = \frac{\omega}{\sqrt{1-\zeta^2}}$$

Dividing equation by yields the percentage residual vibration (PRV):

$$PRV = V(\omega,\zeta) = e^{-\zeta\omega t_n}\sqrt{[C(\omega,\zeta)]^2 + [S(\omega,\zeta)]^2}$$

Where

$$C(\omega,\zeta) = \sum_{i=1}^{n} A_i e^{\zeta\omega t_i} \cos\left\{\omega t_i \sqrt{1-\zeta^2}\right\}$$

$$S(\omega,\zeta) = \sum_{i=1}^{n} A_i e^{\zeta\omega t_i} \sin\left\{\omega t_i \sqrt{1-\zeta^2}\right\}$$

A constraint on residual vibration amplitude can be obtained by $V(\omega,\zeta) \leq V_{tol}$.

3.3. Robust Input Shapers

Input shapers have characteristics that make them easy and effective solutions for eliminating vibration in cranes. Input shaping will eliminate vibration irrespective of the velocity command. Different types of input shapers can be used in the convolution filter. Figure 3.5 shows three basic types of shaper along with the resulting shaped pulse command

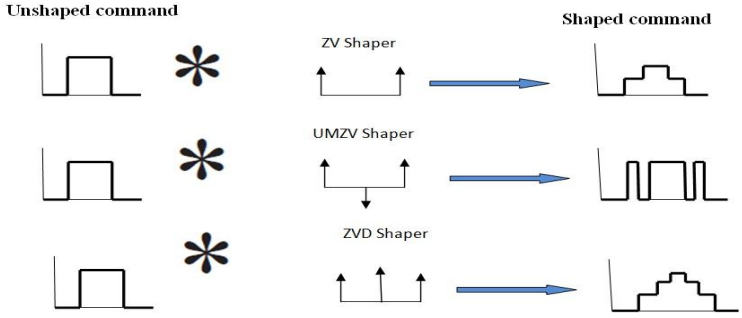


Figure 3.5 Various pulse shaped commands

The Zero Vibration (ZV) input shaper and Derivative (ZVD) are used commonly to suppress the vibration of system in a small and medium range around the design frequency. ZV and ZVD shapers have poor robustness to modeling errors [7]. If the design frequency changes by more than the shaper's inherent insensitivity, then the input shaper was ineffective to suppress the vibration. The robustness of a shaper can be measured using a sensitivity plot, which is a plot of the percentage residual vibration versus the normalized frequency (the actual frequency, ω_a, divided by the modeling frequency, ω_m). To compare robustness quantitatively, the *insensitivity* is defined as the width of the curve that lies below a specified level, normalized by the modeling frequency. The sensitivity plot of ZV and ZVD input shaper [4] is shown in figure 3.6

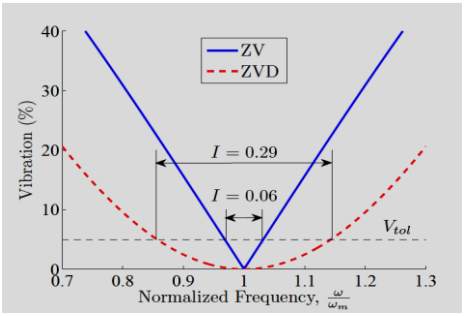


Figure 3.6 Sensitivity plot of ZV and ZVD shapers

One key quantitative measure obtained from a sensitivity curve is the Insensitivity. Insensitivity is the width of the sensitivity curve at a tolerable vibration level, V_{tol}, with respect to the parameter of interest.
In real applications, the system parameters needed to form an input shaper are not known exactly and hence modeling system parameters to within the tolerances needed for ZV or ZVD shapers is difficult. This led to the development of Robust Input shapers.

The methods used to develop robust input shapers fall loosely into four categories:

- Derivative Methods
- Tolerable Vibration limit methods
- Ad hoc methods(MIS methods)
- Numerical Optimization method.

3.4. Specific Insensitivity input shaper (SI shaper) for gantry cranes

Specified Insensitivity (SI) input shaping is a robust input-shaping technique that tailors the control robustness to suppress any desired range of frequencies. The Second mode causes the payload oscillation to exceed tolerable levels and hence it must be accounted for when designing the input shaper. A sensitivity curve for an SI shaper is shown in figure 3.7.

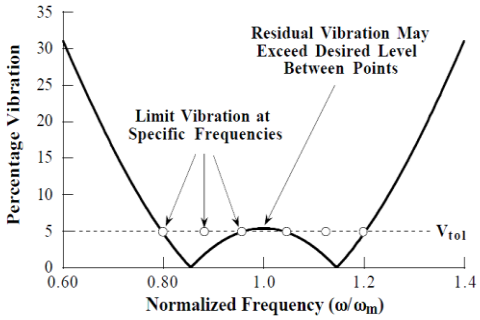


Figure 3.7 Sensitivity curve for SI shaper

Specified Insensitivity shapers provide the greatest level of robustness for an input shaper. The disadvantage is that that an optimization is required to solve for the impulse amplitudes and time locations.

A two mode Specified-insensitivity input shapers are designed by satisfying the constraint equations as listed below:

a) Residual Vibration Constraints: The maximum residual vibration amplitude, V_{max} should be less than the threshold amplitude V_{tol}. It has been shown that the robustness can be improved if the vibration is limited to a small value, rather than forced to be exactly zero.

$$V_{tol} \geq |C_1| + |C_2| \qquad (11)$$

b) Amplitude Constraints: The vibration caused by an input shaper can be limited by equation (11). However, if the input shaper impulse amplitudes are not considered, then their values can range between positive and negative infinities. There are two possible solutions to this problem: limit the magnitude of the impulse less than a specific value or require all the impulses to have positive values. The shapers discussed here will contain only positive impulses as follows

$$A_i > 0, i = 1,2,3 \ldots \ldots, n \qquad (12)$$

Where 'n' is the number of impulses in the shaper. Impulse amplitudes are also limited to sum to one, which ensures the shaped command reaches the same set point as the unshaped command. The constraint is expressed as:

$$\sum_{i=1}^{n} A_i = 1 \qquad (13)$$

c) Robustness Constraints: The residual vibration constraint of equation (11) can be used to limit the vibration at a single set of frequencies (ω_1 and ω_2). If the actual crane frequencies coincide with those used in equation (11) to design the shaper, then the oscillation will be eliminated. However, to ensure robustness to modeling errors and parameter variations, the oscillation must remain small over a neighborhood of frequencies that surround the modeling frequencies.

d) Requirement of time optimality: Two mode SI input shaper is designed by minimizing the time of the final input shaper impulse so as to ensure fastest possible solution :

$$\text{Min } (t_n) \qquad (14)$$

The figure 3.6 shows a basic flow chart for determining an input shaper.

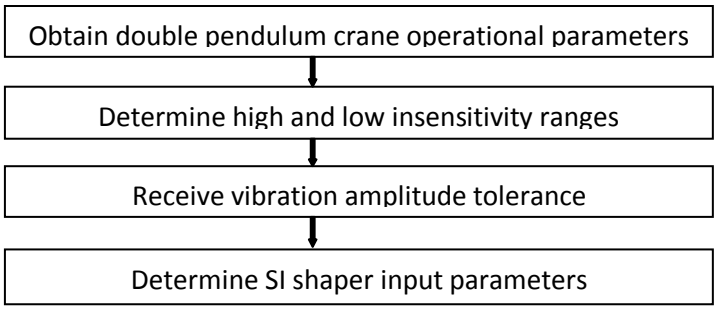


Figure 3.6 Basic flow chart for design of Input shaper

SI input shapers, by design, have a variable insensitivity that can be specified by the designer. The strength of SI shaper, is robustness to modeling errors, but the trade off is an increase in rise time of the system. Hence, from the above four constraints eqn. (11) to (14), a two mode specified insensitivity input shaper is designed. This can be done on any optimization software, like MATLAB optimization toolbar. The operational

parameters such as cable lengths, payload dimensions, etc. has to be provided by the user. This information can be obtained by crane sensors such as vision systems, load cells, strain gauges, and encoders.

3.4. Implementation

The above procedure was implemented in Georgia Tech Institute on a 10 ton bridge crane transporting a long slender beam [1]. This crane has an acceleration of 0.572 m/s^2 and a velocity limit of 0.358 m/s. The Beam used is 2.5m tall, has a diameter of 18cm and weighs 22kg. The hook approximates to 50kg point mass. The height of the crane from the floor is 6.2m. The initial suspension length is 3.5m and the shaper designed to suppress oscillations for suspension lengths varying from 2.5 to 3.5m.

The resulting SI input shaper calculated [1] was

$$\begin{bmatrix} A_i \\ t_i \end{bmatrix} = \begin{bmatrix} 0.1617 & 0.3383 & 0.3383 & 0.1617 \\ 0 & 1.34 & 2.67 & 4.01 \end{bmatrix}$$

Three separate tasks were performed by the crane unshaped as well as with SI input shaper, and the results are tabulated below

Shaper used	Average completion time (s)	Reduction (%)
Unshaped	149.0	--
SI (2 mode)	22.5	84

Table 2: Average completion times moving around an obstacle

Shaper	Button Pushes	Reduction
Unshaped	33	--
SI (2 mode)	5	85

Table 3: Average operator effort moving around an obstacle

Shaper	Average completion time(s)	Reduction (%)
Unshaped	94	
SI (2 Mode)	37	61

Table 4: Average completion times when hoisting over an obstacle

Shaper	Button Pushes	Reduction (%)
Unshaped	16	--
SI (2 Mode)	4	75

Table 5: Average operator effort when hoisting over an obstacle

IV. Conclusions

Input shaping is an effective feed forward control technique that can be implemented on bridge cranes to reduce the payload sway. For certain payloads and rigging configurations, bridge cranes can exhibit double pendulum dynamics. The second mode of natural frequency is significant when the radius of gyration and the rigging length increases. The input shaper has to be designed which can suppress multi mode vibration. Different types of possible input shapers were discussed. The robustness of each of these input shapers is discussed. Furthermore, the input shaper can be made robust to modeling errors and parameter variations by suppressing a range of possible frequencies.

Chapter 1 of this report explained the types of cranes and the need for sway control of gantry cranes in industries. It also discussed the basics of input shaping that can be used to modify the input signal command.

Chapter 2 discusses the dynamics of cranes moving with distributed payloads. Equations for determining natural frequencies and amplitudes were also discussed. It was shown that the frequencies of a distributed payload crane decreases as the radius of gyration increases or the rigging length increases in proportion to the total length of the system. It was also shown that the second mode of the system is more dominant and hence, multi-mode vibration suppression is needed for the same.

Chapter 3 discusses the various types of input shapers as well as the robustness of these shapers to modeling errors and parameter variations. An effective input shaper, known as specified insensitivity input shaper which is the most robust to modeling errors was also designed. The implementation of SI input shaper was done by the Georgia Tech 10-ton laboratory crane. The effectiveness of SI input shaper to various tasks is also shown.

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The Effect of Unbalance on Bearing Life

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Abstract: *The life of bearing is closely related to its loads which are affected by the eccentric unbalances of rotational components in the structure system of the bearing. However, since the bearing structure in some of the machinery is complicated, the exact load calculations and the life prediction for this kind of bearing are difficult. The load and life calculation for the bearing are developed with considering the magnitude of eccentric unbalances. The influences of unbalances on the loads and life of the bearing are studied. The calculation and analysis results show that the radial loads on rolling element of the bearing fluctuate significantly under the actions of the unbalances of different parts of machines and the bearing life reduces regularly with the eccentric unbalances changing. In this article, I have focused not on machines that are "supposed" to vibrate as part of normal operation, but on those that should not vibrate: electric motors, rotary pumps and compressors, and fans and blowers. In these devices, smoother operation is generally better, and a machine running with zero vibration is the ideal.*

Keywords: *permissible residual unbalance; eccentricity ,maru, urr, pump bearing*

Nomenclature
E =Eccentricity
G = Balancing quality grade
U per = The maximum residual unbalance
F lbs. = Force due to unbalance
MARU =Minimum achievable residual unbalance test
URR =Unbalance reduction ratio
L10h= Basic rating life of the ball bearing (h)
P = Effective load (actual force applied to the bearing)
C = Published catalog load rating

mCf=the eccentric unbalance of the cooling fan ($g \cdot cm$) in a pump

mCb=the eccentric unbalance of the driving wheel ($g \cdot cm$) in a pump

I. Introduction

Research showed that in the automobile wheel and its shaft had to be in a state of balance, i.e. the mass had to be evenly distributed about the rotating centerline so that the resultant vibration was at a minimum. This had to be achieved during the manufacturing process so that maximum service life could be achieved from the system. Imbalance could be caused by manufacturing defects (machining errors, casting flaws) or maintenance issues (deformed or dirty fan blades, missing balance weights). As machine speed increases, the effects of imbalance become greater. Imbalance can severely reduce bearing life as well as cause undue machine vibration.

A level of unbalance that is acceptable at a low speed is completely unacceptable at a higher speed. This is because the unbalance condition produces centrifugal force, which increases as the speed increases. In fact the forces caused by unbalance increases by the square of the speed. If the speed is doubled, the force quadruples; if the speed is tripled the force increases by a factor of nine.

It is the force that causes vibration of the bearings and surrounding structure. Prolonged exposure to the vibration results in damage and increased downtime of the machine. Vibration can also be transmitted to adjacent machinery, affecting their accuracy or performance. Load determination and life prediction calculation of the bearing are the premises of a good bearing design and a reasonable working condition matching, and yet it is one of difficulties in the practical application. In some cases, vibration is inherent in machine design. For instance, some vibration is almost unavoidable in the operation of reciprocating pumps and compressors, internal combustion engines, and gear drives. In a well-engineered, well-maintained machine, such vibration should be no cause for concern. In simplest terms, vibration in motorized equipment is merely the back and

forth movement or oscillation of machines and components, such as drive motors, driven devices (pumps, compressors and so on) and the bearings, shafts, gears, belts and other elements that make up mechanical systems.

From previous studies, it is not difficult to know that the internal load distribution of rolling element bearing is closely related to the external loads which are usually assumed to be invariable.

Machinery professionals intuitively know that by doing alignment and balancing jobs to tighter tolerances, and by reducing internal clearances in machinery, that vibration levels will be reduced with a corresponding increase in machinery reliability. However, it is often difficult to justify what needs to be done. Reliability and replacement costs for rolling element bearings are major concerns in most plants.

II. Literature Review

When man invented the wheel, he very quickly learned that if it wasn't completely round and if it didn't rotate evenly about it's central axis, then he had a problem! Modern man still suffers from the same problem – only now the problem is amplified.

As machine first patent for balancing technology was filed by Henry Martinson of Canada in 1870, four years after the development of the dynamo by Siemens. Near the turn of the century, Akimoff (USA) and Stodola (Switzerland) attempted to develop Martinson's technology and apply it for industrial use. However, it was in 1907 when a modified version of the technology was patented by Dr. Franz Lawaczek, and offered to Carl Schenck, Darmstadt, Germany, for development. Schenck built the first industrial two-plane balancer, and subsequently bought exclusive world rights to the dynamic balancing machine in 1915.

Technology advancements gave way to improved sensitivity, frequency selectivity and plane separation capability. The development of electronics and mechanical/electrical transducers, greatly reduced balancing time and paved the way for modern balancing technology.

Today balancing equipment is used with confidence for a wide range of applications - from the smallest rotors for dental drill instruments to the largest steam turbines in the world. Precision balancing machines assure accurate, dependable rotor operation.

Now a days balancing industry provides a complete range of balancing, diagnostic and special equipment for the automobile industry, power generation industry, medical, aviation industries and an engineering staff that offers a broad range of experience for nearly any balancing application which involves different sizes of bearings starting from dental drill bearing sizes (very small) to aviation/power generation rotor bearing (extremely big) sizes.

III. Basic Bearing Life Equation

Examining the basic bearing life equation we find that speed, load and the type of bearing are factors:

$L10h = (16667 / rpm) \times (C / P)r$

Where:

- L10h = 90th percentile of life in hours (the point at which only 10 percent of bearings in identical applications fail);
  Note: average life = 5 x L10h
- Rpm = Rotational speed of the bearing
- C = Published catalog load rating
- P = Effective load (actual force applied to the bearing)
- r = 3 for ball bearings
- r = 3 1/3 for other types of rolling element bearings

3.1 FACTORS AFFECTING BEARING LIFE

For those involved in predictive maintenance activities, especially vibration monitoring and analysis, two questions have always been present.

- What is the correlation between changes in vibration level and the corresponding impact on bearing life?
- What is the value in knowing this correlation if there is one?
  Few predominant factors affecting impact rolling element bearing life are:
- RPM of the shaft
- Design load rating of the bearing (as defined by the manufacturer)
- Type of rolling element bearing (ball or other rolling element type-cylindrical roller, spherical roller, needle roller, tapered roller)
- Actual load (force) applied to the bearing
- Lubricant ability
- Contamination level
- Operating temperature.

First, let's investigate the impact of rotational speed on bearing life. Reviewing the basic bearing life equation:

L10h = (16667 / rpm) x (C / P)r
The impact of increasing speed is obvious. Doubling the rotational speed (while maintaining a constant load) = L10h / 2 = 1/2 the original life.
Equation results:
2 x rpm = 1/2 life
3 x rpm = 1/3 life
1.25 x rpm = 0.8 life
Next, there is a need to investigate the impact of load on bearing life. Reviewing the basic bearing life equation again:
L10h = (16667 / rpm) x (C / P)r.
The impact of increasing load (force) is pronounced.
Doubling load (while maintaining a constant speed) = L10h / 8 or 1/8 life (1/2)3 for ball bearings.
The L10 bearing life is a published number and it is calculated as:
L10 = (16,667/RPM)*(rated load/actual load)3
The L10 life of a bearing is the life expectancy for 90% of the population, where a full load life is estimated at 1,000,000 revolutions. Guidelines for loading are as follows:
• Light loading at <6%
• Normal loading at 6% to 12%
• Heaving loading at >12%.
Typically, this works out to be a life expectancy from a few months to several years at continuous 365-day/24-hour usage.

TABLE-1
Other rolling element bearing types include cylindrical, spherical, tapered and needle bearings.

IMPACT OF INCREASED LOAD ON BEARING LIFE		
Percentage Life Decrease		
% Load Increase	Ball Bearings	Other Rolling Element Bearing Types1
5	14	15
10	25	27
15	34	37
20	42	46
25	49	52
50	70	74
75	81	85
100	87	90

vibration in motorized equipment is merely the back and forth movement or oscillation of machines and components, such as drive motors, driven devices (pumps, compressors and so on) and the bearings, shafts, gears, belts and other elements that make up mechanical systems.

TABLE-2

FORCES AND SOURCES OF VIBRATION		
Force Source	Type of Force	Reducible
Unbalance	Dynamic	Yes
Shaft Misalignment	Dynamic & Static	Yes
Belt / Drive Tension	Static	Yes, if Excessive Tension is Present
Looseness	Dynamic	Yes, if Excessive Looseness is Present
Rotor Weight	Static	No, Not Normally
Gear Reaction	Dynamic & Static	No
Process Forces	Dynamic & Static	No, Not Normally

Of these seven different forces, only the first four can normally be addressed by the maintenance department. The other three are machine design related and are not normally reducible.

TABLE-3

IMPACT OF VIBRATION REDUCTION ON BEARING LIFE (Assuming dynamic load is the major force component)		
Percentage Increase in Bearing Life		
% Reduction in Vibration	Ball Bearing Types	Other Rolling Element Bearing
5	17	19
10	37	42
15	63	72
20	95	110
25	137	161
30	192	228
40	363	449
50	700	908

IV. Effect Of Unbalanced Forces

Unbalance is one of the primary sources of machine vibration. The force produced due to unbalance can be calculated using either of the following formulae:
F lbs. = 0.062 x (rpm / 1000)2 x U gm. In. Where:
1 gm. in. = 1 gm. of mass @ 1 in. of radius from centerline of rotation
Because unbalance is a rotating load, the bearing's inner race is zone loaded. This is a different type of loading compared to most of the other force sources.

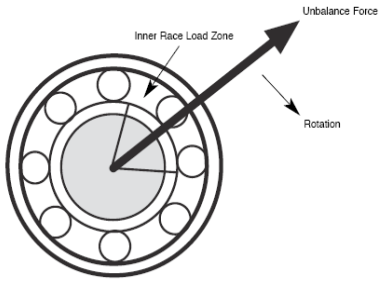


Fig 1

Because unbalance is a "rotating load or force", the following conversion must be made to use this force in the bearing life equation:
P = F lbs. x fm
Where:
F lbs. = Force due to unbalance
fm = Factor of 1.0 to 1.5 according to the ratio of static force compared to the unbalance force on the bearing
(When this ratio is 1.0 then the factor is 1.333)

4.1 CALCULATION OF PERMISSIBLE RESIDUAL UNBALANCE

U per – the maximum residual unbalance permitted for a
rotor or in a correction plane[4].
U per = e per x m
where m = rotor mass
Calculation of permissible unbalance for a pulley of radius 152 mm running at 800 r.p.m, having 8.1 kg weight.
Speed, n = 800 rpm
Weight of pulley, P = 8.1 kg
Radius of pulley, R = 152 mm
(O.D. is 314mm)
Balancing grade, G = 4 (means vibration speed=4mm/s for pulley)[3}
Max. residual unbalance e=10XG/nx1000=10x4/800x1000=50μm
e=p x R/P
p=e x P/R =50X8.1/152=2.66KG

Therefore the Permissible Residual Eccentricity is 50μm & the Permissible
Residual Unbalance is 2.66g for this Pulley.

Another way to calculate permissible unbalance in balancing machines
U per (g-mm) = 9549 x G x W/N (W in kg)
G = Balance quality grade from Table 4
W = Rotor weight
N = Maximum service RPM
MARU (Minimum achievable residual unbalance test) and URR (unbalance reduction ratio) test are performed to test reliability of balancing machines.[1]

4.2 INFLUENCES OF THE UNBALANCE CHANGES ON THE BEARING LOADS

An imbalance in the motor, for instance, would most likely cause a radial vibration as the "heavy spot" in the motor rotates, creating a centrifugal force that tugs the motor outward as the shaft rotates through 360 degrees. Another key factor in vibration is amplitude, or how much force or severity the vibration has. The farther out of balance our motor is, the greater its amplitude of vibration. Other factors, such as speed of rotation, can also affect vibration amplitude. As rotation rate goes up, the imbalance force increases significantly.

Frequency refers to the oscillation rate of vibration, or how rapidly the machine tends to move back and forth under the force of the condition or conditions causing the vibration.

The calculation results of the radial loads on a pump were obtained under the given eccentric unbalance= m_{Cb} = 15 g cm of the pump driving belt wheel, and m_{Cf} = 30 g cm of the cooling fan. [11],[12].

To analyze the changes of the radial loads when the eccentric unbalances change gradually, two cases are discussed. One case is that three sets of m_{Cb}, i.e. 0 g cm, 15 g cm and 30 g cm are selected and the eccentric unbalance of the wheel keeps invariant with the value of zero. The other is that the eccentric unbalance of the fan is selected as 0 g cm, 30 g cm and 60 g cm respectively, and the eccentric unbalance of the wheel is reset to zero. The radial load variations on the two rolling element rows of the bearing in one rotational period of the cooling fan, with the eccentric unbalance of the fan changing, are shown in Fig. 3. In a similar manner, the radial load variations with the eccentric unbalance of the wheel changing in the same period are shown in Fig. 4.[12]

The calculation results show that for the given water pump bearing, the fluctuation range of the radial load on row I(impeller side) is enlarged with the eccentric unbalance increasing of the cooling fan, while the radial load on row II (fan side)increases proportionally.

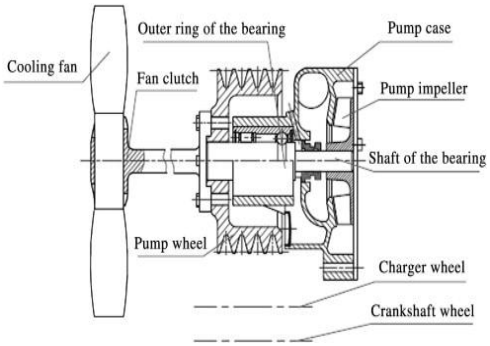
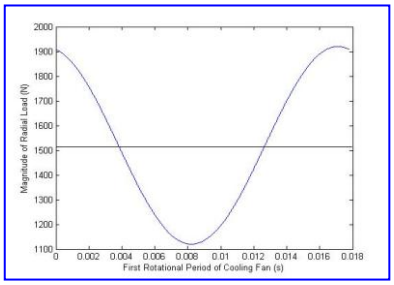


Fig. 2. Structure view of the water pump bearing.



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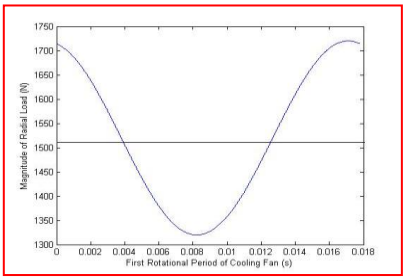

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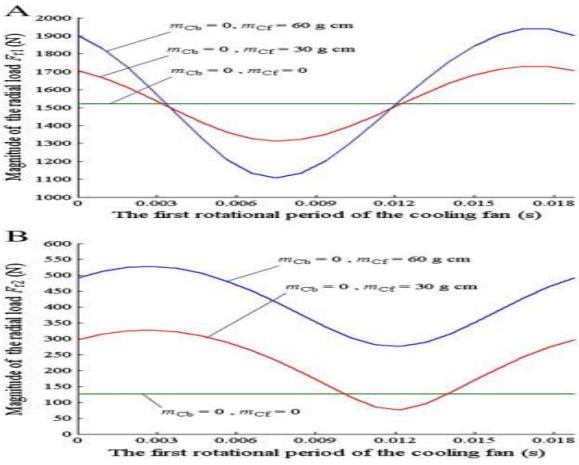

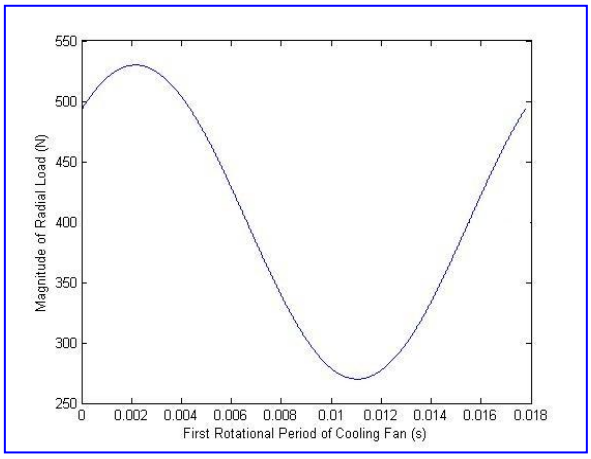

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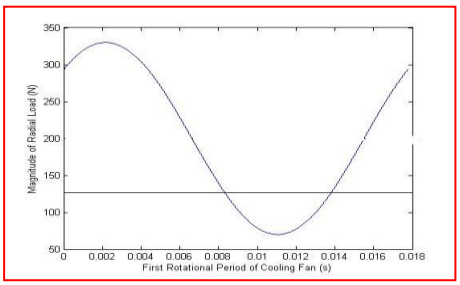
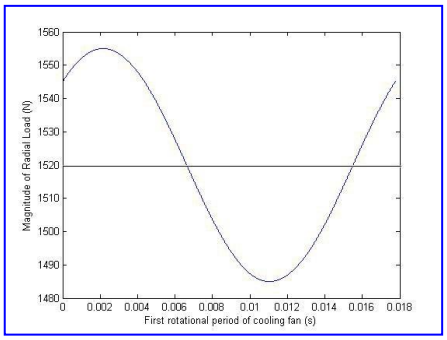


B-2

Fig. 3. Radial loads on two rolling element rows in one rotational period of the cooling fan: (A) F_{r1} under different fan unbalances; (B) F_{r2} under different fan unbalances.[12]



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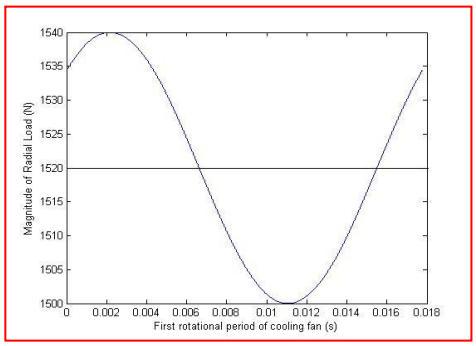

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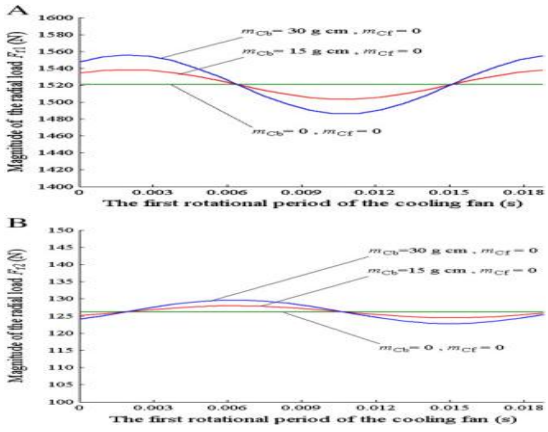

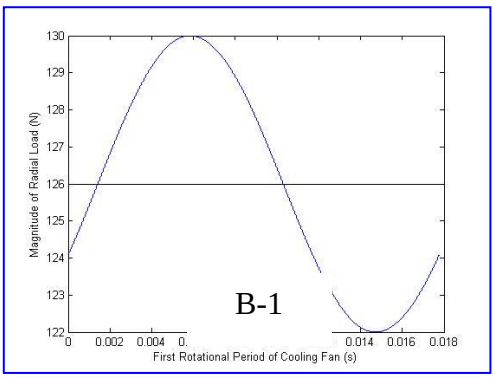

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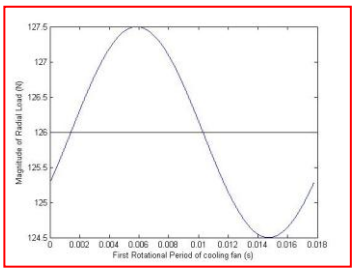

B-2

Fig. 4. Radial loads on two rolling element rows in one rotational period of the cooling fan: (A) F_{r1} under different wheel unbalances. (B) F_{r2} under different wheel unbalances.[12]

The mean dynamic equivalent radial loads are heavily influenced by the fan unbalance. On the contrary, the influences of the wheel unbalance on the mean dynamic equivalent radial loads are little. This may be caused by the fact that the cooling fan is located far away from the pump bearing and the driving wheel is near the pump bearing.

TABLE 4
QUALITY GRADES AS PER ISO-1940

Balance quality grade G	Rotor types
G 100	Crankshaft drives of large Diesel engines Complete engines for trucks and locomotives
G 40	Crankshaft drives for engines of trucks and locomotives
G 16	Parts of crushing machinery Parts of agricultural machinery
G 6.3	Fly-wheels Fans Aircraft gas turbine rotors Electrical armatures Process plant machinery Pump impellers
G 2.5	Machine-tool drives Turbo compressors Small electric armatures Turbine-driven pumps
G 1	Grinding machine drives Textile bobbins Automotive turbochargers
G 0.4	Gyroscopes Disk-drives Spindles for high-precision applications

Different quality grades are provided in I.S.O 1940 for a specific component depending upon Criticalness and accuracy required for his application.
Based on this suitable value of balancing tolerance can be calculated as per his application in different field as described above.[1],[2].

V. CONCLUSION

Vibration is a characteristic of virtually all industrial machines. When vibration increases beyond normal levels, it may indicate only normal wear – or it may signal the need for further assessment of the underlying causes, or for immediate maintenance action.

Understanding why vibration occurs and how it manifests itself is a key first step toward preventing vibration from causing trouble in the production environment. Reducing the forces caused by unbalance, looseness and misalignment will result in lower vibration levels for machines. Reducing excessive belt tension will also reduce machine forces but will not produce an appreciable reduction in vibration level. The vibrations themselves have only a minor impact on bearing life but the forces which cause these vibrations have a major

impact on the actual bearing's longevity. In addition to improving reliability and reducing the cost of maintenance of machines, several more benefits are obtained by reducing vibration levels:

- Reduced Noise Levels
- Reduced Operating Costs (Utilities)
- Improved Operating Safety
- Improved Maintenance Technician Morale
- Increased Life for Related Machine Components (seals, housings, shafts, impellers, windings, etc.)
- Reducing vibration levels on machines by correcting common machine problems or applying tighter tolerances does indeed dramatically improve bearing life and reduce maintenance and operating costs.[9]

RESULT 1- Bearing life is inversely proportional to speed changes.
(1 / speed change ratio)
RESULT2- Increased load results in an inversely exponential reduction in life.
RESULT3- Unbalance is up to 50 percent more destructive to bearing life than other vibration sources producing equal vibration levels.
RESULT4- In a specific example of water pump the basic rating life of the bearing changes slowly when the fan unbalance is constant and the wheel unbalance increases from zero to 150 g cm.

When the wheel unbalance is constant and the fan unbalance varies in the range of 0–10 g cm, the basic rating life of the bearing decreases less than 900 h. The reduction is also very little. However, the reduction of the basic rating life is nearly 7000 h when the fan unbalance increases from 10 g cm to 30 g cm. The life of the bearing reduces much faster and the life variation reaches to 16 000 h when the fan unbalance varies from 30 g cm up to 60 g cm, [12] with keeping the wheel unbalance constant.

The above results show that small eccentric unbalances have small effect on the life of the water pump bearing, but if the eccentric unbalances, especially the fan unbalance, go beyond some threshold value, the life of the pump bearing would reduce sharply.[8]

In this paper the influences of the unbalance variations on the bearing life were studied. It was found that the unbalances will cause reduction of the bearing life [7]and this effect would be remarkable if the unbalances increased to a certain level.

The main component of the vibration is unbalance of the rotor and the rotor weight is nominal. Currently if the rotor is balanced to a tolerance of ISO G6.3. per plane then by adjusting this balancing tolerance to ISO G3.2 per plane, the bearing life should be extended by 700 percent. Since the vibration should be cut in half as a result of the improved balance tolerance,

5.1 Future scope

Further area of this study can be extended for analyzing the effect of unbalances on bearings of different industrial machines of different nature such as production machines of different application, mixer, grinder, axles in automobile etc. It will also be immensely helpful in the areas of increasing life of critical machines such as power generation machines (turbine and other moving parts),dental drills, aviation rotors, turbo chargers.

Sometimes these analysis are providing important tips for changing the design Of specific machine.(such as changing the bearing position inside the housing)

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