



Continuous Improvement in Energy Efficiency – A Case Study at Automotive Component Manufacturing Processes

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Abstract

In the era of globalization, global warming and increase in fuel costs force engineers and managers in the manufacturing companies to focus on energy efficient manufacturing. Companies are driving their resources to identify the most effective measures to increase energy efficiency in manufacturing processes flow sequences. This paper is a case study of an Energy Saving Measures (ESM) related to an existing automotive axle manufacturing company located in Mysore (South India) and focuses on the improvement in energy saving measures and establishes guidelines for the companies involved in auto axle manufacturing towards implementation of EMS. Based on the results of continuous improvement (through four projects), several energy saving measures related to Liquefied Petroleum Gas (LPG) were proposed, implemented and evaluated. The implemented kaizens / projects reduced product conversion cost / processing costs by 0.8 million per annum and increased profitability by 23% in the existing manufacturing system.

Keywords: Automation, Effective utilization, Manufacturing cost reduction, Energy saving Measure, Fatigue reduction

JEL Classification: M11

Paper Classification: Research Paper

Introduction

Energy is the capacity of a physical system to perform work or simply 'the ability to do work'. Energy conservation means reduction of energy consumption by means of 'using less of an energy service'. Energy conservation differs from efficient energy use. Energy conservation refers to "using less energy for a constant service", whereas Energy efficiency refers to "using less energy to provide the same service". For example: Turning off a light is energy conservation (Upton,

1996). Replacing an incandescent lamp with a compact fluorescent lamp (which uses much less energy to produce the same amount of light) is energy efficiency.

Manufacturing has been defined as the conversion process of raw materials (RM), components (semi finished goods - SFG) or parts into finished goods (FG) which would meet customers' expectations or specifications. Manufacturing commonly employs a man machine set up with division of labor in a large scale production. Energy losses in manufacturing processes are often accepted today as a necessary evil of high quality production (Muthukumar, Tamizhjothi, Resmi & Nachiappan 2014). In particular, processes which involve changes in material states, heat treatments or which are associated with high losses of material must be re considered in energy terms.

Using minimum energy for the same or even higher output is increasingly being recognized as one of the most important and cost effective solutions to reduce green house gas emissions (Jelic, Gordic, Babic, Koncalovic & Sustersi 2010). In the short term, processes can be optimized; in the long term it is the task of research to replace energy and the material-intensive processes or even to eliminate them (Muthukumar, Tamizhjothi and Nachiappan, 2013). The method of executing the energy efficiency (either as project or regular teamwork) in manufacturing system will be termed as energy management system.

Energy Management System (EMS)

Energy management is oriented towards continuous improvement (CI) process and it is more effective when its policies, procedures and actions taken must be reviewed effectively in a routine basis (with specific schedule of repetitive review nature). It also presents a documented structure that defines an organization's goals, policies, and procedures and the processes by which they are maintained and improved (Gorodic, Babic, Jovlcic & Konealovic, 2007). The management system involves a set of planned procedures aimed towards minimizing the organization energy costs and increase productivity (Amundsen, 2005). The objective is to engage and encourage staff at all levels in the organization. EMS makes out a clear cut responsibilities for all people, provides well documented procedures, repetitive training and evaluation for conformance, corrective and preventive action, management reviews, and continual improvement (Amundsen, 2000; Christoffersen, Larsen & Togeby, 2006). In a nut shell, it may be summarized as a systematic process for energy saving and energy efficiency improvement process.

Institution of the EMS

'Commitment to the program' by top management is the key issue for successful implementation and operation of EMS program. Without this commitment, the program is likely to fail to reach its objectives. Once commitment from senior management is achieved, it is important to define and document all roles, responsibilities, authorities and the interrelating functions that influence the energy performance of the company, as well as the appropriate allocation of staffing and financial resources (Turner and Doty, 2007; Capeheart, Turner & Kennedy, 2003).

Structure of EMS in organization

There is no standard format for organizations to implement EMS program (Gordic *et al.*, 2007). Structure of this program depends on the type of the company (process flow), number of employees, used energy sources, etc. (Turner and Doty, 2007). Other than the organizational

structure type, the most crucial position is that of the energy manager. This position should be high enough in the organizational structure, so that she can have an access to top management and information of current events within the company.

By considering the company size and complex technological process, it was suggested that energy manager supervises the energy management team that has engaged zonal coordinators responsible for energy management in buildings; lighting, compressed air and water. These coordinators should have direct communication with employees responsible for energy matters in each facility of the company (Capeheart et al., 2003). The energy management policy takes care for company's decision to manage energy consumption (Gordic *et al.*, 2007; Thumann and Youngeer, 2003).

Literature Review

The increasing international concern related to the CO₂ emission levels had led to the KYOTO protocol, a global frame work that aims to reduce CO₂ emission in an economic way. Promoting energy efficiency improvements is considered to play an important role in achieving the targets because it reduces energy consumption without curtailing social welfare. Boeck, Audenaert and Mesmaeker (2013) conducted an extensive literature survey on improving the energy performance and efficiency in residential building. They found that the optimization methods considered low emission level and energy efficiency performance by modifying different characteristics of buildings, thereby, minimizing energy consumption and costs. They also identified the trends in the research field and proposed opportunities for future investigation. They conclude that specific tradeoff between winter and summer energy consumption should be taken in to account so as to find suitable energy efficiency solutions. Based on the survey of literature, it was found that companies can save around 30% of their annual energy consumption and reduce the cost through energy management by making operational changes.

Neelis, Worrell & Masanet (2008) highlighted that activities toward the improvement of energy is an important way to reduce the production cost and to increase predictable earnings, especially in times of high energy price volatility. The developed energy guide will be useful for the engineers and plant managers in the US petro chemical industry for energy consumption reduction (Kannan & Boie, 2003) in a cost effective manner while maintaining the product quality. Further research on their application to different production/ process/practice is needed to assess the cost effectiveness of improvements carried over.

Bhattacharya & Cropper (2010) reviewed the economics literature on energy efficiency in India. They summarized the findings in to four major areas, like, (i) comparison of energy efficiency in India with the world; (ii) energy savings from adopting certain improvements; (iii) the intention to adopt improvements; and (iv) policies to encourage adoption of energy saving measures. They also mentioned that majority of companies concentrated on the first two aspects compared with other two.

The importance of energy saving with respect to world scenario has been reviewed and illustrated. Abdelaziz, Saidur & Mekhilef (2011) reported that industrial sector uses more energy (about 37% of the world total delivered energy) than any other end use sectors (transportation 28%, residential 21%, commercial 14%). In the industrial sector, the major contributors are manufacturing at 15%, and bulk chemicals at 14%. Therefore, it is inferred that manufacturing plays a major role in energy consumption. The study compiled and presented a comprehensive literature on energy savings strategies. The energy saving can be achieved by energy audit,

training programs, housekeeping and kaizens like fixing of high efficiency motor, variable speed drive, economizer and reducing pressure drop.

Yang (2013) reported that the International Energy Agency (IEA) estimated the potential for efficiency improvement to be in the range of approximately 20% to 50% of the total final energy consumption. By adopting energy saving measures on 11 countries, 49% of the energy was saved during 1973 to 1998 which is presented in Figure 1.

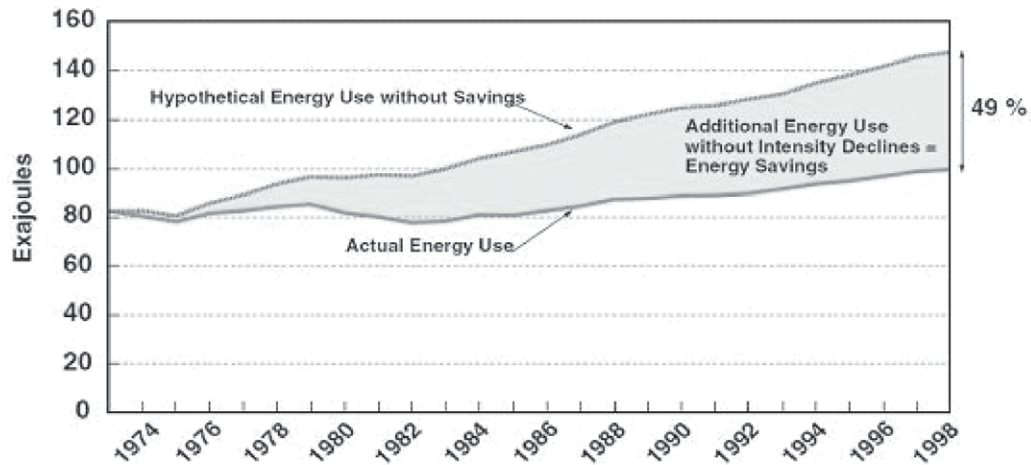


Figure 1. Energy savings in IEA countries (impact of projects)

As per the study report, the energy efficiency policy and activities would help to save around 20% of the final energy consumption from 2010 to 2030.

Problem Background

For the processing industry, conversion of material from one form to another form needs energy. And, the output (final customer required material / product) improvement will lead to increase in energy consumption. Since, each modification in the product line needs process change; it will have an impact towards energy consumption. So, this kind of process oriented manufacturing industry needs energy efficient manufacturing. During modification of the production plant or to perform replacement investments, or when supply or bottle-neck arises energy savings becomes an important factor to be considered. But as soon as the immediate problems are solved, the intention of, takes a back seat energy saving (Muller, Marechal, Wolewinski & Roux, 2007; Galitsky & Worrell, 2003). The similar kind of situation was seen in the organization where the present case study was developed. Successful, cost-effective investment into energy efficiency meets the challenge of maintaining the output of high quality product with reduced production costs. Besides, energy-efficient technologies often include “additional” benefits, like increasing the productivity of a company further. As discussed by Van Gorp (2004), an organization should measure the energy needs/usage, define appropriate standards, and implement the consistent energy management system through continuous improvement tools and techniques). In a nut shell, the energy efficiency improvement program is a sound business strategy in today’s automotive manufacturing environment. Therefore, the managers in the case study organization together with the research team (authors) initiated this EMS project for reduction of production cost through continuous improvement.

Continuous Improvement and its Importance

Continuous improvement (CI) is defined as a systematic effort to seek out and apply new ways of doing work by actively and repeatedly making process improvements (Kaynak, 2003). It is a regular activity/phenomenon aimed towards raising the level of organization-wide performance through focused incremental changes in processes (Bessant & Caffyn, 1997). The CI has been piled up with bundles of practices, such as prescribed tiny sequences (Wu & Chen, 2006; Douglas & Judge, 2001) of steps for carrying out projects and sets of sub tools / techniques commonly used to execute these projects. Additionally, various literature and several reports identified the importance of CI, as a part of energy and quality management practices, for its contribution to the manufacturing performance (Handel & Gittleman, 2004; Terziovski & Samson, 1999).

Problem

The survival of the organization depends on the performance of the manufacturing. The manufacturing performance has been evaluated using the performance index of product manufacturing cost, which includes material cost and manufacturing cost (Pil & MacDuffie, 1996). The material cost depends on the supplier and is of seasonal nature (which cannot be controlled after a certain limit), where as the manufacturing cost can be controlled by the engineers in the company. Figure 2 shows that for the cost associated towards energy is high (around 45 %) when compared with other costs in the total conversion cost, for years 2013 and 2014.

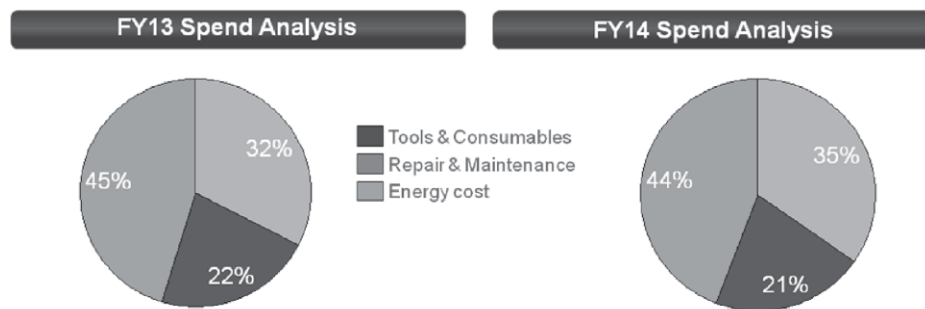


Figure 2. Pie chart of cost spend in the case study organization

Out of the total energy costs, 50% of energy spending is towards Liquefied Petroleum Gas (LPG) as a fuel for processing. So energy efficient manufacturing is needed for the process oriented manufacturing organization.

Energy Saving Measure (ESM) Adoptive Methodology

The energy evaluation has been stated as the set of procedures, which analyze the current level of energy usage practice adopted in a company and identify various alternative ways towards reduction of it. As per the methodology suggested below, potential areas for energy savings were considered. Generally, an energy saving measure (ESM) can vary between low-cost measures/ automation (basic operation precautions) to huge investments (layout change, equipment purchase). ESMs that were found during the energy evaluation were the subjects of feasibility studies. By routine practice, the status has been monitored using the data obtained during the evaluation process but more measurement was necessary in order to realize the estimations of actual benefits (% of improvement achieved). The methodology (Nachiappan, Muthukumar & Srinivasan, 2009) included two stages: a) status monitoring; and b) improvements.

- a) Status monitoring (analysis)
 1. understand all the type of energy cost associated;
 2. to understand how that energy is being used and possibly wasted; and
 3. end to end energy mapping.
- b) Suggesting improvements – (action to be taken)
 1. to describe / explain alternatives that can substantially reduce energy costs;
 2. to perform the economic analysis on those alternatives and determine the best with respect to operating cost for the industry (choosing the best alternative); and
 3. to develop the implementation plan (chosen/ selected) towards incorporating energy saving project (Thumann, 2002).

The above suggested methodology of ESM adopted in the case study organization will be explained in detail.

Case study

The *case study organization* has manufacturing facilities located at southern part of India in the state of Karnataka, in the city of Mysore. The company is currently the largest independent manufacturer of rear drive axle assemblies in the country. Over the years, the company has developed impressive domestic original equipment manufacturer (OEM) clients that include Ashok Leyland, Tata Motors, Asia Motor Works, Vehicle Factory-Jabalpur, BEML, Man Force Trucks Pvt. Ltd., Mahindra Navistar, Volvo India and SML Isuzu Ltd., VE Commercial Vehicles, Corona Bus Manufacturer, and Godrej. The company's sales trend is shown in Figure 3.

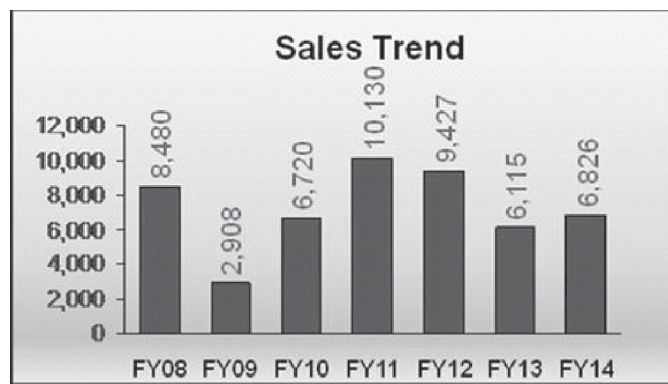


Figure 3. Sales trend of the case study organization

The processing sequence and the four areas / bay / line allotted towards it have been explained in the manufacturing facility section.

Manufacturing facility

The product varieties, manufactured at this location, are shown in Figure 4. These are the rear axles used in trucks for load carrying from one location to another.

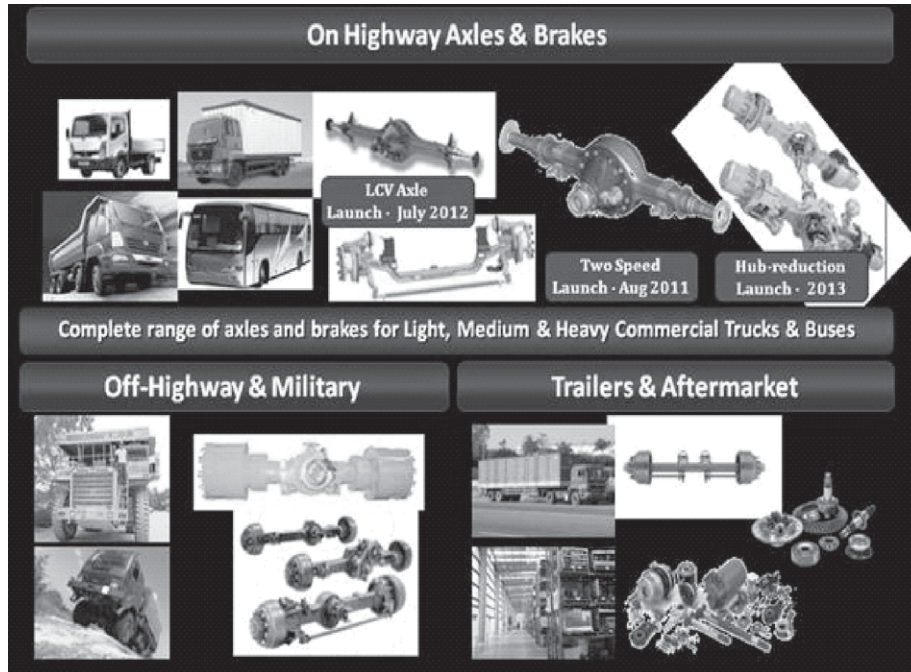


Figure 4. Axles

The complete products of axle manufacturing facility in this specific location have been categorized into four major lines, viz.,

Housing line. It is involved in fabrication, machining and customization of axle housings and has a declared capacity of 12,000 housings per month. The process flow diagram is shown in Figure 5 (Muthukumar, Tamizhjothi & Nachiappan, 2014-b).

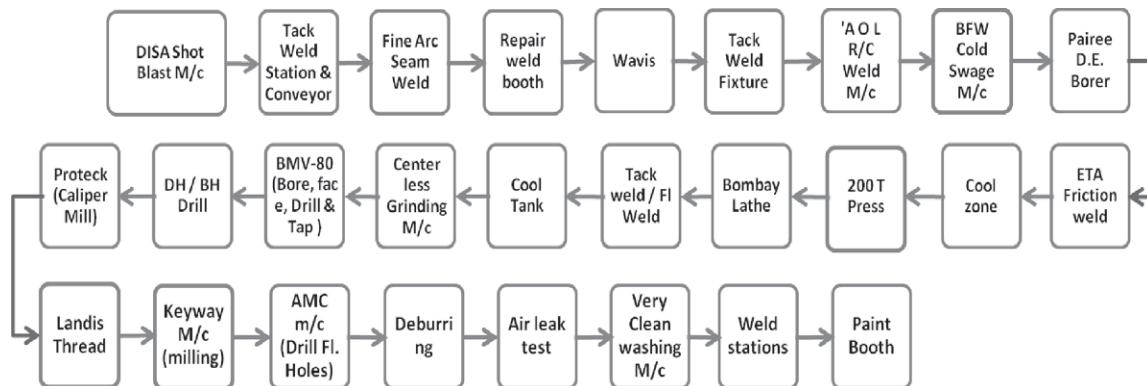


Figure 5. Housing line manufacturing

Here each box is a continuous process with a set of operators and machines involved in the conversion / value addition process of axle from raw material to semi finished goods (SFG). The SFG is like an outer shell of our human body. The output of this line will be the input for the assembly line.

Component manufacturing line. It comprises of all the differential components required into a differential drive head (shown in Figure 6) of axle. After being manufactured, these internal parts are attached to the main body (axle)/outer shell. The accuracy and quality of each components being manufactured will bring the quality (customer specification) of axle.

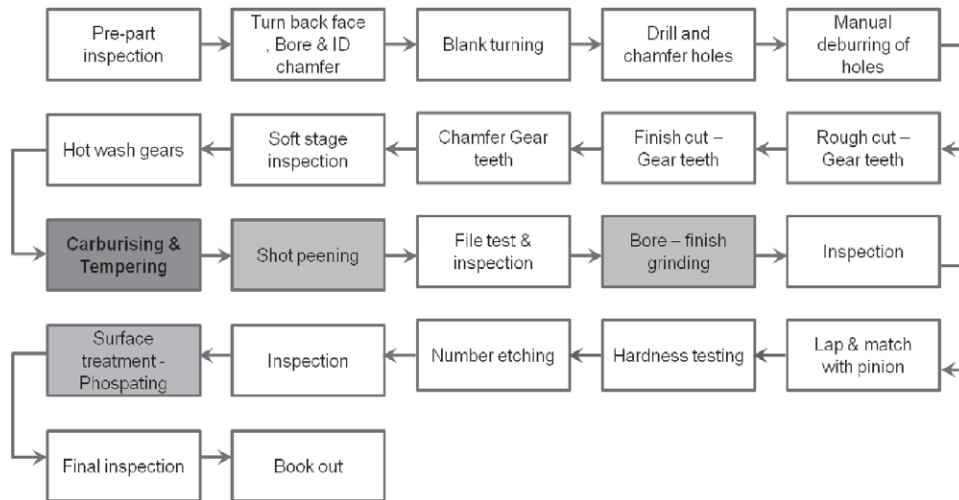


Figure 6. Component line manufacturing

Heat treatment line. It takes care of processes like carburizing, case hardening etc which impart the needed (customer required) metallurgical surface characteristics of components manufactured from the component manufacturing line. The output of this line will be the input for the assembly line.

Assembly line. It consists of drive head assembly and complete axle assembly as given in Figure 7. Each box in the diagram will be the assembly unit where the physical components are grouped with respect to the model / design. Based on the model / customer requirement, the number of cells and associated layout varies. All the internal parts (with respect to customer requirement) are incorporated into the axle. After successful completion of assembly, the axle is ready for dispatch (shipment) or usage by the end user / vehicle manufacturer.

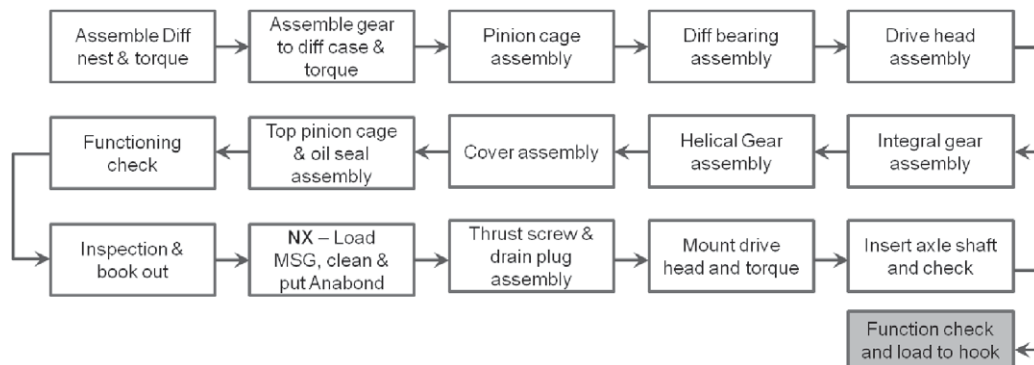


Figure 7. Assembly process

Reason for adopting EMS in the case study organization - I

Among the above mentioned four process lines, the important stage is the heat treatment line, where the product quality (tensile strength, endurance and life) is built in to the components (internal system in body) inside the axle. The functionality of axle (life) depends on the assembled components' life. So the engineers contribute more time, energy and efforts to enhance the life of the components by manufacturing them with precision. The cost of conversion (value addition) without compromising the quality is a Himalayan task for the manufacturing engineers.

In axle manufacturing, about 60 % of the product cost is consumed towards processing. In that processing cost, 50% is for energy transformation. Therefore, energy management will be the focus of attention and this project has been initiated with this motto. The cost associated with energy transformation process is collected and pie chart has been plotted. The pie chart towards conversion cost drivers (energy) are shown in Figure 8.

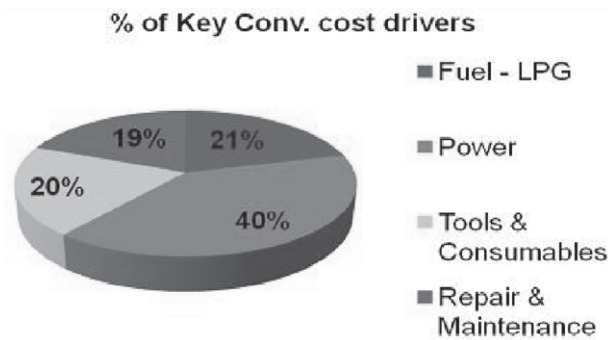


Figure 8. Cost drivers

From the Figure 8, it is inferred that the top category is the power cost (40%), which can be further reduced in the following ways:

- a) Power bidding through Indian energy exchange;
- b) Brake plant integration;
- c) Compressor operating pressure limit optimization through CI tools;
- d) Air leakage arresting by end to end mapping; and
- e) Eliminate idle running of machines through auto switch off mechanism

In order to adopt / implement the above mentioned improvement activities from top management of the company, huge investment is involved. To achieve the target of energy savings at lower project implementation cost, the second important category of 'fuel cost' (related to Liquefied Petroleum Gas (LPG)) that contributes to 21% reduction has been considered and also thus has been taken as a special project and work towards it. The project has been titled as "ESM – LPG consumption reduction".

ESM – LPG consumption reduction

In the heat treatment line, the components of axle like gear, pinion have been loaded in to the furnace and kept inside the furnace for the specified time (varies with respect to model) and specific temperature. By raising the temperature of material, the metallurgical properties of the components have varied. Then the product /component has been unloaded and kept in the

quenching press for quenching by the SAF oil. The quenching is carried out for 2 to 4 minutes. After that the component is unloaded and moved towards the assembly line. By means of sudden quenching (oil), the hardening of material will be occur. It will result with change in metallurgical properties, especially, hardness to strength ratio increases. The important aspect to be considered is the heating time and amount of heat being transferred to the components. The amount of heat consumed by the component depends on the amount of energy / input feed to the furnace.

By theoretical analysis, the heat input required has been estimated based on the number of components being loaded, and specific heat of material being loaded. The detailed specimen calculation is shown below in Table 1.

Table 1: Theoretical heat requirement

	Description	Quantity/ Consumption	Unit
Theoretical (Mass * Sp. Heat * Temp.)	No of gears / day	400	Nos/ day
	No of Pinions / day	475	Nos/ day
	Wt. of gears @ 27kilograms/Gear	10800	Kilogram
	Wt. of Pinions @ 15 kilograms/Pinion	7125	
	Sp. Heat of Material (SAE8620)	0.108	K cal/ kg/°C
	Furnace temperature(930-30)	900	°C
	Total heat energy required/ day	1742310	K cal/ day
	Enrichment & Pilot burner LPG @ 200kilogram/day	2380000	K cal/ day
	Endo Gas LPG @ 475 kilogram/day	5652500	K cal/ day
	Pre Heat & Post Wash	580760	K cal/ day
	Total K cal/ day	10,355,570	K cal/ day
	Theoretical LPG Reqd.	870.2	Kilogram/day

If there is no loss, then the input feed energy (LPG) will be fully (100 %) converted as heat energy applied on the components (output) being loaded. It can be well understood by the input output diagram (given in Figure 9) of the furnace.

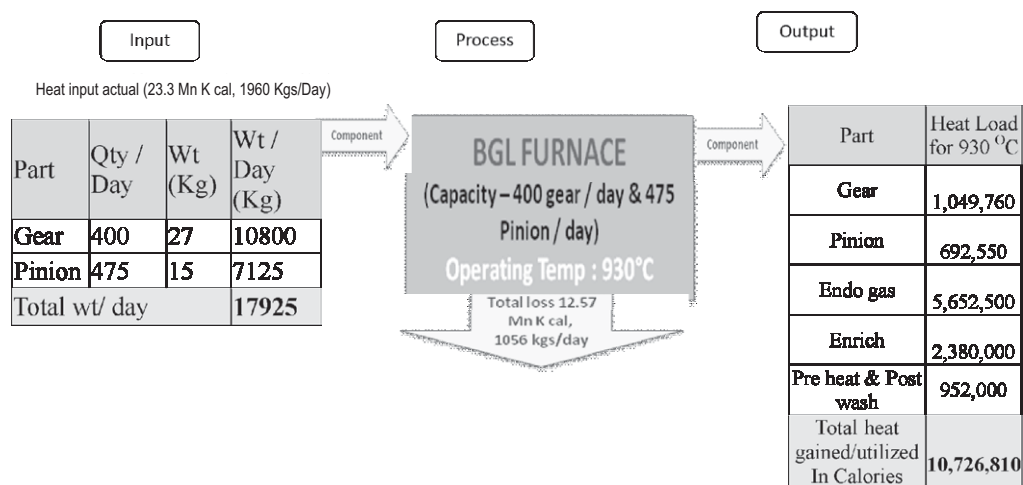


Figure 9. Furnace Input – Output Diagram

Loss #	BGL Furnace – Major Loss element	K cal/ day	Loss in %
1	Flue gas losses after recovery in Preheat & Post wash	2348720	18.67%
2	Endo gas Utilization loss	2167940	17.23%
3	Minor stoppages (Operator Fatigue loss)	1684640	13.39%
4	Change over (Scrap push) losses	1558600	12.39%
5	Insulation/skin temp losses	1494880	11.88%
6	Tray absorption losses	1399600	11.12%
7	Door operation	747440	5.9%
8	Down time losses	629160	5.0%
9	Door leakages	321720	2.5%
10	Radiant tube heat transfer	223720	1.7%
	Total – calories loss Per day	12576420	
	Total – Kilograms of LPG loss per day	1056	

From the Figure 9, the actual input (LPG) energy is 1960 kilogram (temperature inside the furnace being maintained at 930 degree and the amount of heat generated will be around 23.3 Mn. K. cal., but the heat consumed by the component is around 10.72 Mn. K.Cal., the remaining 12.57 Mn. K. Cal. of heat generated has not been utilized. By analyzing the input output processes diagram shown in Figure 9, around 1056 kilograms/day has been lost due to ineffectiveness in the process of heating the components. The heat loss has been quantified under 10 different categories of losses. In order to eliminate the losses, the following listed projects are given in Table 2. It has been planned to implement these projects within one year duration.

Table 2: List of Projects

Project No.	Project Title	Proposed methodology
1	Furnace opening time reduction	<ul style="list-style-type: none"> Eliminate the involvement of manpower in open the furnace and material transfer to quenching process Adopt robot to transfer the material Furnace mouth opening time reduction- heat loss reduction by 33% - due to faster rate of transfer from furnace to the quenching press, the heat loss will get distributed to 8 gears instead of 6 gears (during manual transfer) Optimize the scheduling machines
2	Optimization of endo gas	<ul style="list-style-type: none"> Convert fixed volume type into variable load type using variable frequency drive (VFD) Adopt separate controlling device Required quantity is generated and used
3	Heat recovery – recuperator for BGL furnace	<ul style="list-style-type: none"> Improve heat recovery using recuperator Shell type for heat recovery
4	Optimizing the material (loading) being heated inside the furnace chamber	<ul style="list-style-type: none"> Calculate the unutilized gap inside the side wall of the furnace Frame the unit loading system and load more quantity in one slot

The summary of kaizens related to these four projects (project -1 to project -4) and the benefits are shown from Figure 10 to Figure 13 respectively. In these Figures, by looking on clock wise direction, the first quadrant (top left corner) in each Figure shows the summary of that work (improvement activity) done towards the loss reduction and the second quadrant (top right

corner) shows the benefits by adoption of specified countermeasures / activities. The third quadrant (bottom right corner) shows the photo graph after inclusion of counter measures and the fourth quadrant of the Figure (bottom left corner) shows the image of the old system (before implementation of countermeasures). The robot implementation includes many tiny activities which are illustrated in Table 3.

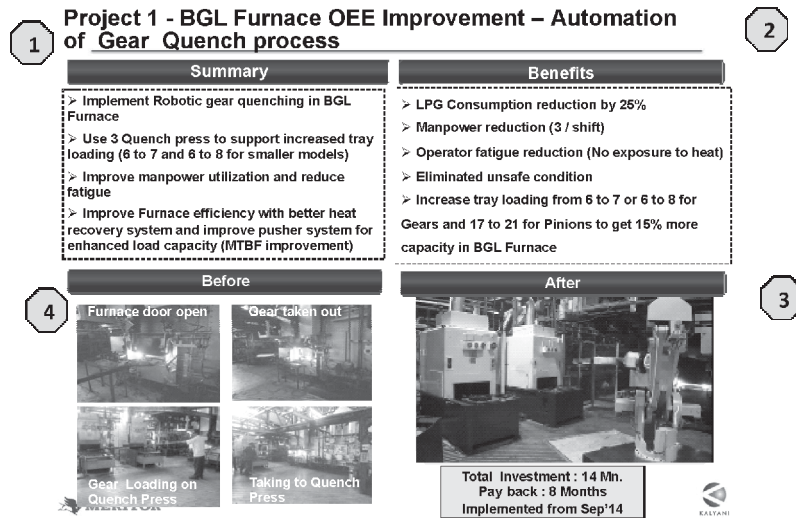


Figure 10: Project-1 of Robot installation

Table 3: Modules involved in implementation of Robot

Module	Part / Assembly	Actions taken
Furnace	Front Slot door	Increase height of the door to accommodate 8 gear/ tray
	Push / Pull Chain	Changed take increased load from 250 Kg to 400 Kg by replacing link type chain to roller type
	Empty tray transfer conveyor	Conveyor modified to drop empty tray near to Robot and ground conveyor provided to take it to post wash
	SCADA up gradation	Upgrade SCADA for tray number positioning, zone wise temperature indication and to integrate with Robot sequencing
Quench Press	Make Quench press controls compatible with Robot	PLC conversion to communicate with Robot controls
	Standardization of height	All quench press in same height for Robot repeatability
	Reduce distance between quench press	Quench press to be re-laid to align with Robot arm reach
	Quench Press uptime	Correction of all abnormalities to improve uptime of Quench press
Robot	Sequence optimization	Robot sequencing to ensure maximum utilization of Robot, to support 8 gear quenching and reduce push time
	Gripper design	Optimal gripper design to 3 grippers to accommodate maximum variety of gears so as to reduce set up time from model to model
	Gripper - Quick change over	Gripper change over within 10 minutes per set up

By incorporating robot in the product flow especially in between furnace, quenching machine

and assembly line (stage -1 to stage – 8) as shown in Figure 11, the material handling time is reduced.

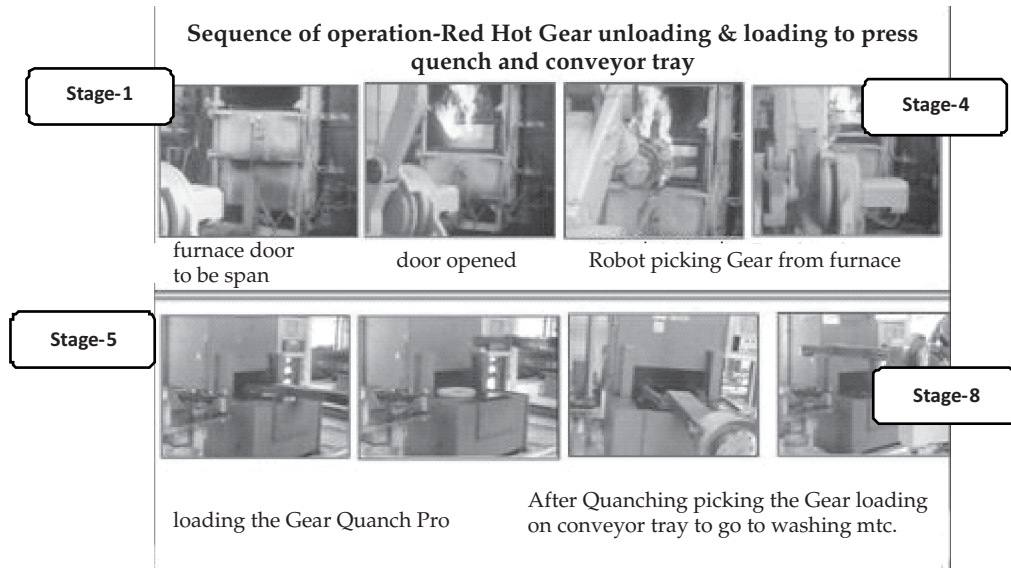


Figure 11. Project-1 of Robot operation

Also the fatigue reduction and operator safety will lead to team involvement in adopting the project successfully

Project 2– Optimization of Endo Gas Consumption

Summary		Benefits	
1	<ul style="list-style-type: none"> > With below 20K volume, average LPG loss is 23-25% in existing Endo gas generation system > Reason being it is of fixed volume generator – cannot be control based on actual endo gas requirement . After usage the remaining quantity is burnt and vented out > Need an Endo generator with controllable volume to meet varying production requirement. 	2	<ul style="list-style-type: none"> > Saving of LPG required by 75%. > LPG Cost Saving / Annum is Rs 3.24 Mn. > Improved Quality of Endo Gas. > Skin temp will be less by 2 degC > Improved reliability & easy maintenance. > Space Saving by 75SqM. > Improved safety & Morale.
Before		After	
4	<p>Excess Endo Gas venting out</p> <p>Frequent failure of Endo coolers / Retort / Nickel catalyst</p> <p>Existing Endo Gas Generators – Fixed volume type. Not designed for variable Endo Gas generation.</p>	3	<p>Investment : Rs 4.00 Mn. Pay back : 15 Months Implemented from Jul'14</p>

Figure 12. Project-2 of Endo gas utilization

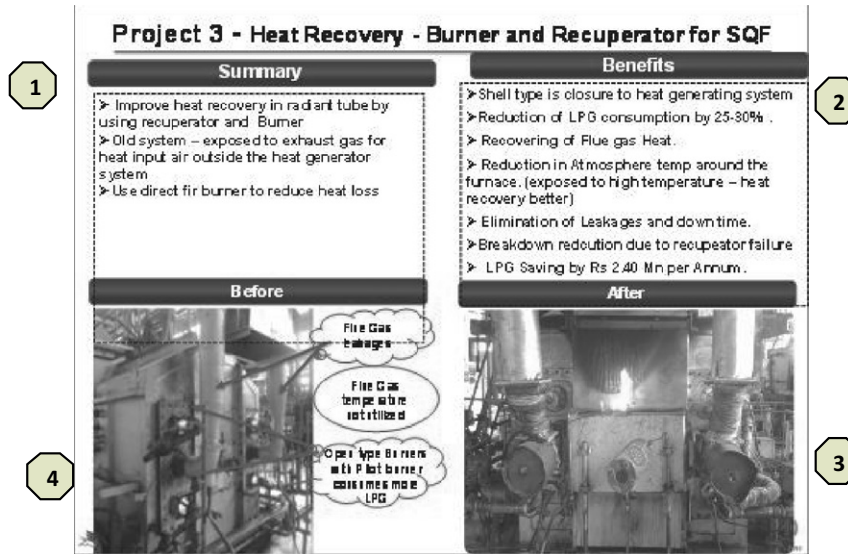


Figure 13. Project-3 of burner heat effective utilization

After completion of implementation of projects-1, 2, 3, project-4 has been implemented towards utilizing the capacity of the furnaces effectively. Here the same amount of heat is utilized by incorporating additional components (in one lot). The important aspect is the LPG fuel as the input to obtain the necessary heat. This will be same for the additional components being loaded. The additional space available inside the furnace which has been ideally heated will now be consumed by loading this additional component into the furnace. The capacity to be loaded inside the furnace at a time will be contributed by (i) size of the components, (ii) inside area of the furnace chamber and (iii) the weight capacity of the loading tray that travels inside the furnace.

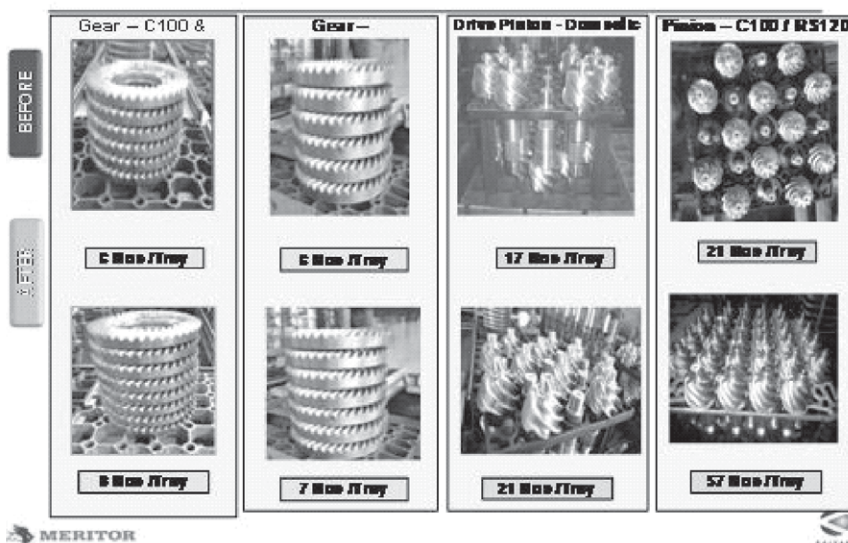


Figure 14. Project-4 productivity improvement of component loading per slot in heating chamber

For this BGL furnace, the weight capacity of tray inside furnace is only 200 kilogram (based on furnace supplier specification). The operating time of furnace is also not increased due to the additional components being loaded. Every 18 minutes, the furnace operation is completed and the output is delivered out by the furnace. The 18 minutes of heating is carried out for all the components being loaded in the tray of the heating chamber. The feeding machine (or) next machine in the line, quenching press has a processing time of 3.5 minutes (3 minutes for quenching and 0.5 minutes for loading/unloading). The only constraint is that the quenching press can be loaded by only one gear (at a time) for quench.

By adopting a system of manual loading in the heating chamber, up to 6 gears at a stretch comes out from heating chamber (for every 18 minutes), and available to be loaded in the quenching press. Because of the robot, it is possible to un-load 8 gears (adding 2 gears) from the heating chamber in the specified opening time of 18 minutes. By this, the robot not only increases the output of heating chamber but also improves the quenching press's utilization. The process can be understood by seeing the utilization chart of manual loading (Figure 14) of gears from heating chamber to quenching press. The robot loading is shown in Figure 15. By manual loading (6 gears output), the quench press utilization varies from 51.29% to 55.18% which is shown in Figure 15. By adopting the robot (8 gears output), the quench press utilization varies from 76.85 % to 79.22 % which is shown in Figure 16.

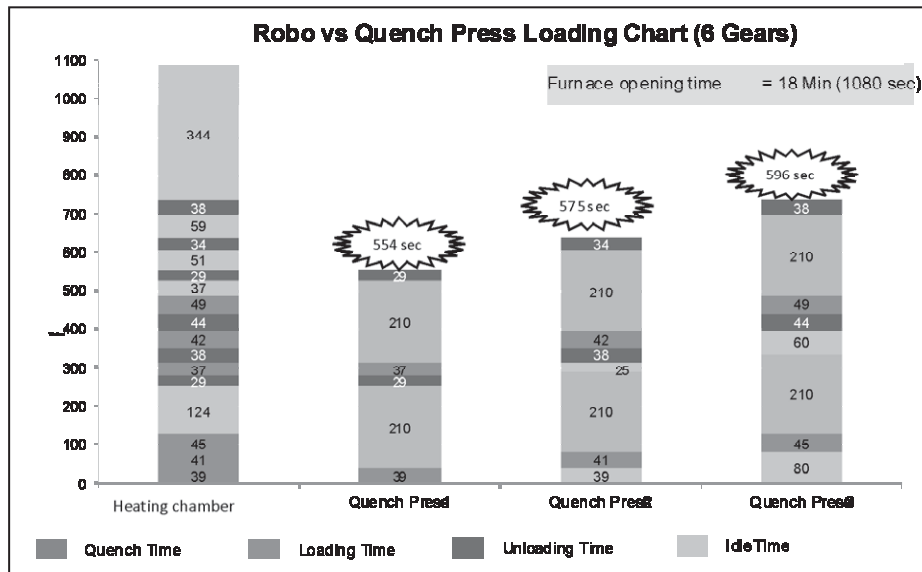


Figure 15. Quenching press utilization (Manual loading of gears)

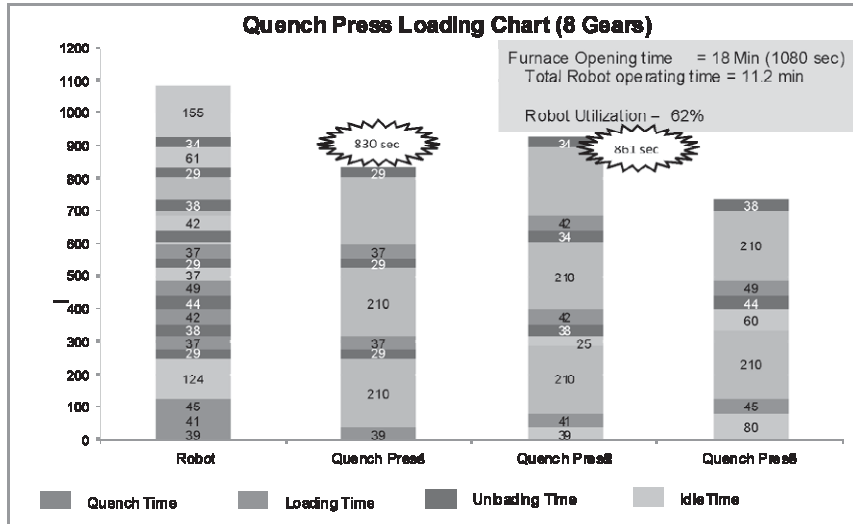


Figure 16. Quenching press utilization (Robot loading of gears)

Result & Discussion

By adopting conservation, the furnace heat utilization has been increased from 46 % to 62 %. The trend of improvement with respect to LPG consumption is shown in Figure 17. From Figure 17, it is inferred that LPG consumption during September-2013 was 0.32 kg/kg input and by implementing the projects 1 to 4, it reduced by 0.25 kg/kg input. In order to achieve the framed target of 0.23, it is necessary to do implement counter measures, which are being listed in Figure 17. The progress of implementation of countermeasures is also given.

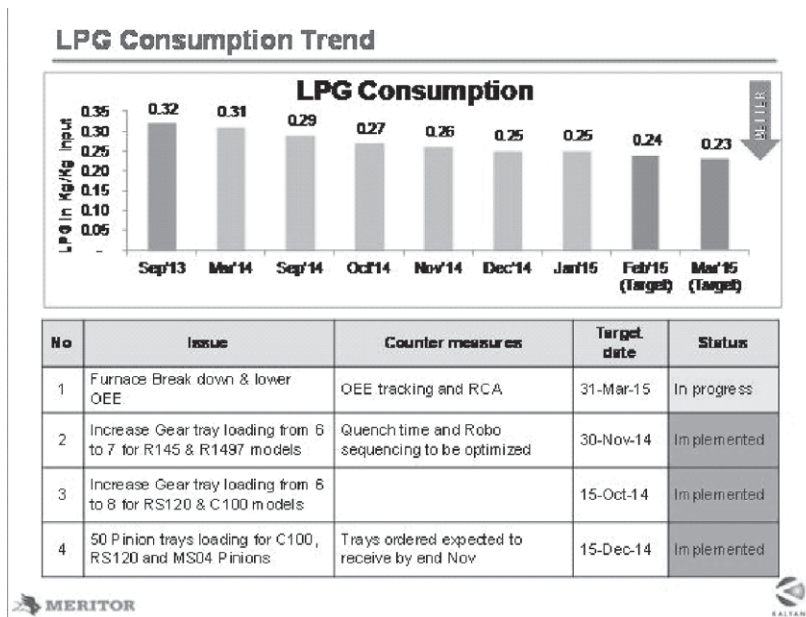


Figure 17. LPG consumption trend

The LPG cost is reduced from Rs.217 to Rs.147. It resulted in the reduction of the overall product manufacturing cost of the axle. Overall, the saving to the company is Rs 5.7 million per annum by adopting energy savings measures of LPG reduction. The summary of the project cost saving is shown in Table 4.

Table 4: Expected cost benefits by adopting four ESM projects

Project	Savings list	Cost implication (Rs in Million / month)
1	Manpower reduction	
	0.002	
2	LPG consumption reduction – LPG cost	0.270
3	LPG consumption reduction – LPG cost	0.200
4	Production cost	0.006
	Total	0.478

The financial implication of the result of implementing the project has been shown in Figure 18. After implementing the improvements, the energy cost reduced by 26% compared with previous year (2014).

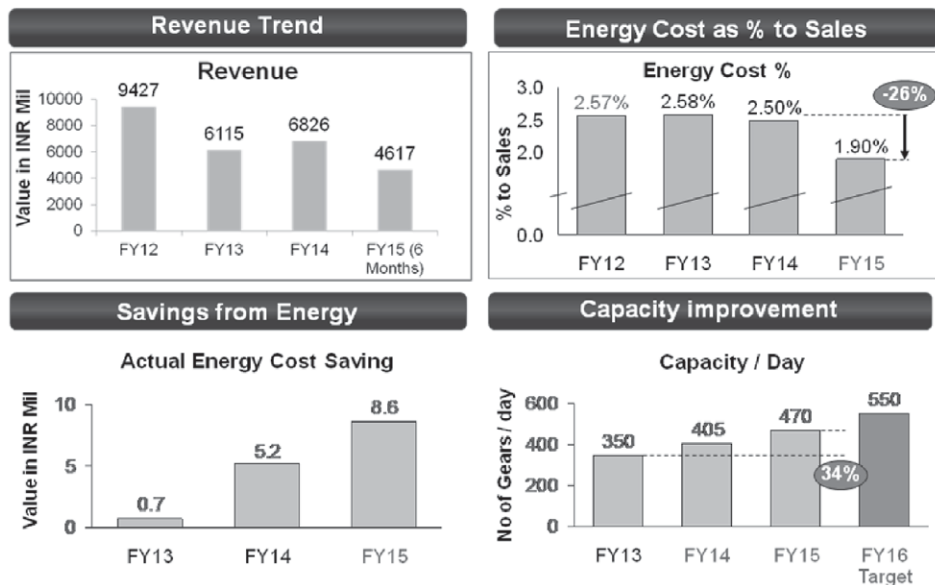


Figure 18. Financial Implication

Now the regular project team under the leadership of energy manager in that company will look after the stabilization of improvements being carried out. The check list has been framed so that regular routine maintenance team will carry it out on a day-to-day basis. The energy efficiency improvement will lead to improved organization efficiency including improvement in productivity and competitiveness (Hannes, 2014). The above mentioned projects are carried out as a continuous improvement process, in order to survive in this competitive world and to improve further the other improvement projects have been identified which are: a) direct fuel injection in to

the furnace, and b) no separate endo gas processes. By these improvements, the expected saving of LPG will be approximately around 300 kg per day. The current level of conversion cost split up has been shown in Figure 19. Here, the component of energy cost is the highest, but by adopting the project -1 to project 4, its contribution has reduced from 45% to 36%.

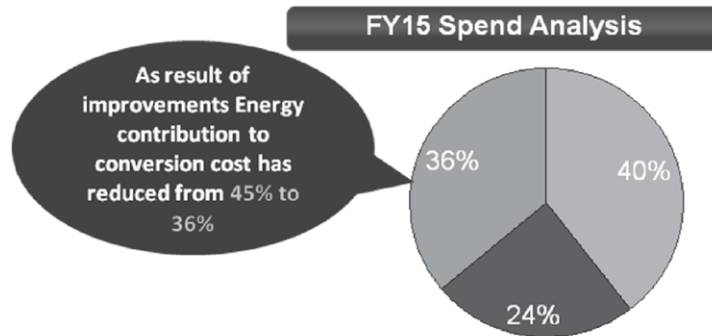


Figure 19. Current level of cost split up in the case study organisation

Conclusion

Energy Management System (EMS) is a comprehensive and systematic approach for energy efficiency efforts in an organization. As a result of EMS project, 25% of reduction in total energy consumption has been achieved in the case study organization. The methodology implemented has been applied to other components with necessary modifications. In this project, the suggested/implemented kaizens are not exclusively related to this automotive organization; they may be adopted by all manufacturing / process / assembly industries with minor modifications. Adopting these kinds of energy saving measures will not only improve organization's profit but also result in improvement of national economic policy. The success of EMS implementation is purely based on the involvement of all levels (in the organization) and all functions of the organization need tireless continuous commitment of top management. This ensures that the motivation of employees continue which is the key factor towards the effective functioning of EMS frame work. For sustenance of the achieved result (Hannes, 2014), linking the activities with PDCA continuous improvement frame work, is important.

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