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# Cost Saving Opportunities in Pakistan Foundries

ABSTRACT

There are a number of challenges facing the foundry industry in Pakistan today that will require facilities to adopt more efficient practices to remain competitive in the world market and ensure the sustainability of their operations. Increase in global demand and resource scarcity may result in unstable commodity prices. Ever increasing prices of energy, raw material and land makes it difficult to be a manufacturer, but fortunately, there are still endless opportunities to have a better profitability. This paper of fact sheets aims to assist Foundry operators in Pakistan with a positivity to identify and implement eco-efficient practices that will not just result in reducing cost of production as, but will also give a better understanding of utilisation of facilities through reorganising the management. This may not only help to reduce operating costs and improve profitability, but also assist to control measures to reduce rejection, wastage by increasing not just production but productivity, not just profits but sustainable profitability.

‘’ We expect all our business to have a positive impact on our top and bottom lines. Sustainable profitability is very important for us or we wouldn’t be in this business’’ Jeff Bezos, CEO of amazon.com

## Introduction:

There are countless areas and opportunities to reduce in house cost of manufacturing. One way is to achieve an energy efficient manufacturing system while other is process reengineering to optimize operations which reduce your input cost. The most important and the most brainstorming of all is to get to the right information to conclude which sector of your industry is contributing in higher cost of manufacturing ( Cost Raisers ) or which sector needs an up gradation or a reinvestment. The precise your target is the better is probability of success. A way to get hold on to true information for your industry is through authentic data entry to the system. Among other solutions one of it is up gradation in the IT system e.g. integrated ERP system in place of traditional management information system can help save cost from various different aspects by delivering you fast, authentic reporting for better decision making.

Knowledge of what you are doing, and getting as a result is very important. Foundry manufacturing business in Pakistan just not require your understanding of metallurgy, but it is like any other business, several different fields of study are practiced in it. Management and economics being one of the key role players to efficiently produce in a manufacturing environment, understanding of accounts and finance for managing your books to avoid paying any extra taxes or managing a better cash flow, organizational psychology to human resource to get the best from your employees and labor, supply chain to Information technology to know where you stand today and get authentic information from better IT reports hence resulting in better decision making, all have a role to play in a successful and sustainable foundry business.

This paper covers few of those various aspects that foundry men in Pakistan ignore, all of it is mostly managerial, but links to different fields of knowledge. The paper will put a light on reducing the in-house cost through better management, a better IT system, energy management and its implementation. All other various possibilities and aspects could not be covered within a paper.

To start with, all of us should agree upon one thing, that is

''To believe that every problem has a solution, and everything that happens has a reason, sometimes reason is our lack of knowledge, understanding and negligibility! ''

# 1 - Organizational Management

Two different foundries in Pakistan were analyzed over the period of time before delivering my analysis in this paper. Few of the common attitudes that were observed in those foundry managements are discussed below.

**Control of rejection:**

Among other reasons, main factor that contribute in higher rejection percentages was observed to be due to absence of skilled labor. Around 3 % out of 9 % rejection in 'foundry A' was caused by injection of inexperienced labor. In Pakistan foundries a trend was observed that holding experienced skilled labor is challenging due to various reasons. New labor are expected to perform as good as the experienced labor that was present before the replacement. In absence of any proper understanding of the process or workflows, the new labor results in producing rejection. The most effective solution for reducing human dependent rejection is by producing proper workflows, chart of duties and SOP's (Standard Operating Procedures) for whole foundry. The new labor should be given workshops or training under skilled supervision before they get hold on to a machine. In addition to it, it was acknowledged that with good quality control team foundry 'A' can reduce the rejection percentage to up to of 4.8 % in total. Further reduction in rejection could be achieved by replacement of old machinery with semi-automated machines e.g. CNC Lathe in place of conventional lathe as it reduces human intervention and human based errors.

**Process flow**

Poor layout of process equipment results in productivity & energy losses. Developing a simple process flow chart can help a new comer to easily understand process flows. It can also help to identify and highlight any duplication of effort and waste. A time and motion study can also help to pin point wastes such as poor timing sequences or excessive transport distance. For example, a proposal given to Foundry 'B', evaluated its foundry's layout and then reduced its transfer stations from nine to six cutting 186 kilometres of wasted travel a year from within the plant. Imagine the amount of productivity and time that it might have wasted. Ensure all materials, tools and equipment had a designated location and that all such locations are easy to access. The site can identify the need for tool shadow boards, additional racks and storage areas, cupboards for protective equipment, and notice boards for staff communication. Then handling procedures should be implemented and well-coordinated to avoid the crossover of activities. Handling should be kept to a minimum. If possible, handling should be automated, through the use of equipment such as cranes and conveyors, and materials standardised to reduce the variety of handling units and equipment required.

**Preventative maintenance**

The energy efficiency and life of equipment depends largely on the effectiveness of the maintenance program. Shut down of production because of equipment breakdown wastes energy as lines have to be kept on standby or molten metal held ready for casting waiting for the equipment to be fixed. Preventative maintenance is typically more effective than reactive maintenance in cost saving. A regular schedule of maintenance with inspection logs to follow up on repairs is a good management option. Systems should also be in place to encourage staff to identify and report maintenance problems such as leaks in compressed air systems (Discussed separately). Computer programmes are available that can help schedule maintenance activities from software providers.

**Transport and distribution factors**

The transport of raw materials and product to and from foundries is not only costly but time consuming. Purchasing materials close to foundry site can help save cost and time. In case of Foundry 'B' , the delivery cost on each Kg of sending a batch tractor Hubs weighing 5Kg to OEM is more than sending batch of 150Kgs of Axle wheels. Deliveries should be managed keeping cost incurred for deliveries. One should also look for combining deliveries to check what cost you bare for per kg of the metal while delivering it to the buyer, ensuring trucks are sized appropriately for the job.
It sound difficult at first but still possible to implementing just-in-time alike purchasing policy. It is a production strategy that strives to improve a business' return on investment by reducing in-process inventory and associated carrying costs. It may also reduce cost incurred by the dead inventories, warehouse costs and the disposal of out-of-date inventory, as mentioned below the ERP IT system can help with maintaining your inventory to the most optimum position hence benefiting a better cash flow.

## IT system:

Recently, much work has been done in the world on accumulating of authentic data to feed to the IT system. The correct information in field of work result in correct decision making hence more profits. It was thought to be extremely hard to overview various operations from the management information system before the birth of this new revolutionizing IT system known as Enterprise resource planning system or ERP system. It is integrated system giving you flows for inputs for sales, procurement, Production, supply chain and human resource in such a way that isn't duplicating and gives you excess to reporting as an output of all the departments. A foundry can use to collect, store, manage and interpret data from many business activities, including:

- Product planning, True activity based costing
- Manufacturing or service delivery
- Marketing and sales
- Inventory management
- Shipping and payment

ERP provides an integrated view of core business processes, often in real-time, using common databases maintained by a database management system. ERP systems track business resources—cash, raw materials, production capacity—and the status of business commitments: orders, purchase orders, and payroll. The applications that make up the system share data across the various departments (manufacturing, purchasing, sales, accounting, etc.) that provide the data. ERP facilitates information flow between all business functions, and can also manages connections to outside stakeholders in needed. It would not be wrong to describe it in a metaphor that this system can be called a foundry's brain where all the information can be fed in, and as an output calculated desired reports e.g. cost of each item produced in a particular day can be gained.

Knowing the true utilization of raw material and very actual cost of production of any particular day or any particular product, can help you manage your procurement or cash flow in a way to maximize your profits and target your cost raisers to redesign them in a way to reduce the in house cost.


## 2 - Energy Understanding and Management:

Cost of energy in Pakistan is very high in comparison to other countries .Metal casting is an energy-intensive process; in fact, it is one of the most energy-intensive industries. Almost 15-20 percent of the manufacturing cost is energy cost in foundries. Energy is also the second biggest purchase of any foundry, after Raw material scrap. As such, it is a prime candidate for energy analysis.

Melting involves heating metal into a liquid ready for pouring. The process involves a number of steps that incur 'material and energy' losses. Theoretically the minimum amount of electrical energy required to melt one tonne of steel to a temperature of 1600 C (ready for pouring) is 377 kWh. However, most steel foundries consume between 700- 900 kWh per tonne due mostly to energy (heat) loss during the process. When these losses are multiplied by yield losses in rework during casting and finishing, steel foundries can be using three to five times the theoretical energy requirement for melting.
'' I built a steel plant from the grassroots, so I learned all the nuts and bolts. When there was a problem, I would be able to guide them, though I am not a technical person. ''
-Lakhshami Mital

Sustainable energy management in a foundry is challenging due to the difficulty that arises from understanding the diversity of energy use – there are thousands of processes, each having unique energy consumption characteristics as well as different production requirements based on the product, product quality, and other business factors. Integrating the knowledge of the each process and operation of each facility is critical for achieving more sustainable manufacturing operations.

The main processes and consumption of energy of foundry are presented in table 1

| Equipment / process | Consumption of total plant energy, (%) | Area savings potential, (%) | Overall plant saving (%) |
|---|---|---|---|
| Melting | 78 | 30 | 22 |
| Lighting | 4 | 50 | 2 |
| Motors & pumps | 7 | 35 | 2.5 |
| Air compressors | 5 | 40 | 2 |
| Miscellaneous | 6 | 25 | 1.5 |

An estimated of 30% of the total energy is wasted in the foundry business which could be reduced to minimum with better understanding. As the paper could not cover whole sections, it goes through melting and compressed air with the analysis results from the both foundries. The study reveals that more than two thirds of the energy consumed in a foundry is used for metal casting and holding operation. Considerable energy saving can be achieved by proper attention to this process with proper energy management. Energy accounting is necessary to determine where and how energy is being consumed and how efficient is the energy management system.

In foundry the energy management may be define as the strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output. The energy tree of foundry 'B' is illustrated in figure 1:

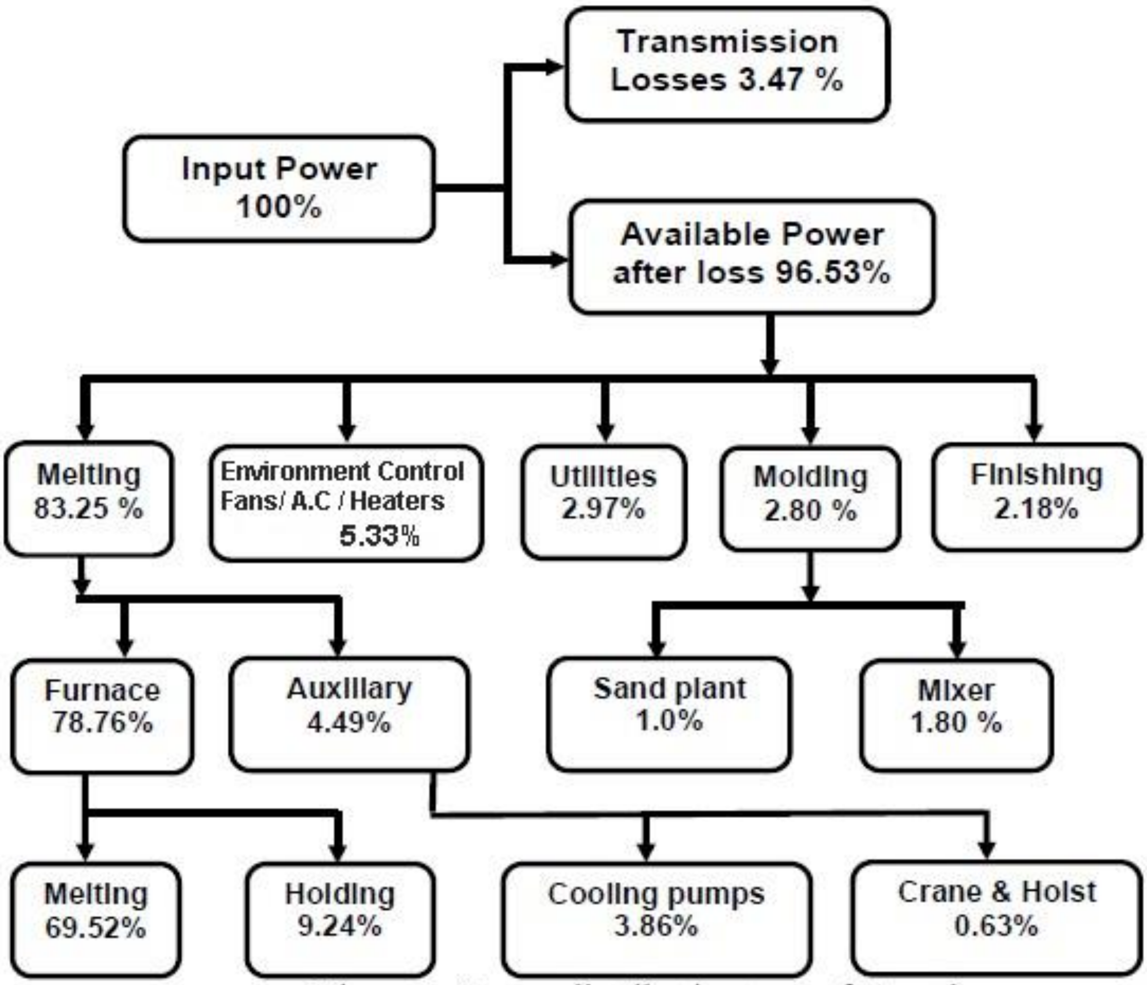
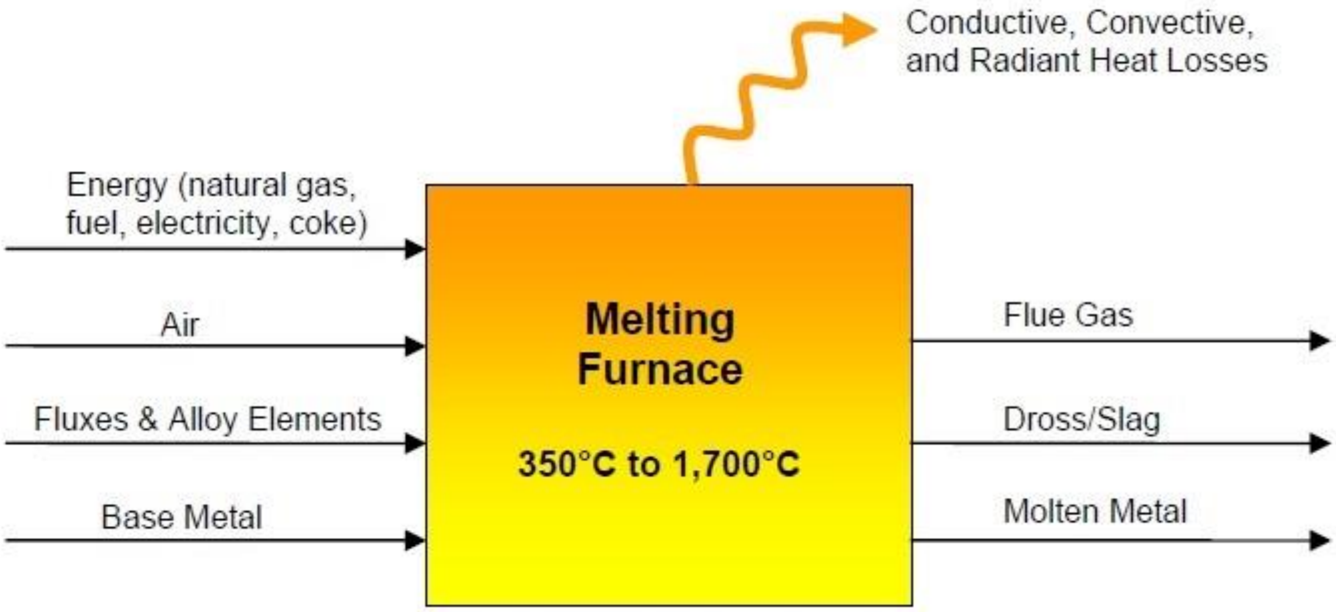



Figure1. Power distribution tree of Foundry

Evaluating energy performance of a production system requires accurate information on how, when, and where process energy is being used. We should attempt to formalize the collecting and tracking of process energy data. Process energy data is based on integrated measurements over time to determine power consumption, but may include peaks, spikes, and other cost-sensitive parameters that are out of scope for this paper. For this analysis, the key energy parameter is not only power consumed, but also correlating time-based energy readings to the underlying process state. Success of Energy management depends on a team effort starting with a firm commitment from the top executive and management team. The first assignment in energy saving activity must be the initial energy audit. It is a key step that establishes the baseline from which the future energy efficiency improvements can be measured. One of the main results of energy audit is the possibility of determination of the energy consumption pattern. The energy pattern is the key in understanding the way energy is used in a foundry and helps to control energy cost by identifying areas where waste can occur and where scope for improvement may be possible.

Few of the possibilities that were suggested to the foundries after observation were:

a) **<u>Energy Savings in the Melting Furnace</u>**




Schematic of melting process

1) **Cleaner charge preparation**, Dirty charge and the addition of oxides and non-metallic compounds to remove impurities significantly affects the type and quantity of slag formed. When slag makes contact with the refractory lining of the furnace it cools and adheres. The gradual slag build up increases the furnace wall's thickness (through which heat is transferred to the metal) which can greatly reduce the furnace's overall electrical efficiency and capacity. Dirty charge also wastes energy that could be utilised for melting the charge. Sand for example has twice the heat content of iron. Therefore every kilogram of sand in the charge heated with the metal uses the same amount of energy as it would take to melt two kilograms of iron.

2) **Preheating to reduce the melting time of the furnace,** Preheating charge cuts melt time and can reduce the energy required for melting by around 55-83 kWh per tonne. Preheating the scrap reduced the metal

melting time by 17 per cent which allowed the foundry to use its electric furnace more efficiently. This increased productivity by 18 per cent.

3) **Heat recovery from hot flue gases** is possible as hot flue gases from melting or holding furnaces can provide the energy for pre-heating systems. The operation of pre-heaters should be synchronized with the furnace so excessive temperatures or holding times do not lead to oxidation and energy losses.

4) **Melting process control** can manage the melt cycle by using load cell feedback on the charge weight in the furnace to calculate the energy required to bring the bath to pouring temperature and then turn off the power supply, or lower it to a holding mode, to reduce electricity charges and to avoid overheating. Overheating not only wastes energy but can damage the lining of the furnace and can cause quality problems as some alloys can burn out at high temperature or with time. A 10 % increase in molten-metal temperature results in a 33 per cent increase in radiated heat losses.

5) **Reducing the amount of metal in castings** despite the need to reduce production costs to stay competitive, foundries must also meet increased demands for high quality castings. Foundries must now investigate opportunities to reduce energy consumption for melting by reducing the amount of metal in their casting and gating (runner) systems without sacrificing quality. Increasing the yield would definitely result in increasing the energy efficiency per Unit of metal produced.

6) **Continuously operated furnaces can use less energy** as energy is not required to reheat the furnace for every load. However, savings can often be negated by heat loss from lids or doors opened for loading. The charging rates (the rate of loading charge into the furnace) can often be 20 per cent below optimum. This adds to heat loss as lids and doors are left open for longer. To reduce these losses, foundries should ensure that the charging rate is not unnecessarily slow.

7) **Well insulated furnace covers**, designed to be removed in sections, can reduce heat loss. Hydraulic swivel options can be used in situations where lids are cumbersome, heavy or hot. Lids should be tight fitting and not damaged or warped. Around 75 per cent of the heat loss in an induction furnace occurs when the lid is open.

8) Many foundries compensate for **radiation heat loss by superheating** the metal in the melting or holding furnace. If metal that could have been poured at 1510 °C (2,750°F) for example are allowed to rise to 1649 °C (3,000°F) (less than 10 per cent) then additional energy will be used by the furnace while the heat losses are boosted by 33 per cent.

9) Ways to reduce heat losses include **covering the ladle with a lid or lightweight ceramic-fibre cover** during transfers which can enable the dropping of tap temperatures by as much as 50°C

10) To lower the specific energy consumption, **Reduction in time taken for sample analysis** & communication was significantly reduced the heat time. Use of intercoms and alarms, pneumatic conveying and advanced logistical preparations helped to reduce the time for sample analysis.

11) Use of recently introduced **energy optimizer** for melting operation created a benchmark and enforced conscious practice to complete the job within the set goal.

**b) <u>Energy Savings in the Compressed Air System</u>**

Air compressors account for significant amount of electricity used in Pakistani industries. Air compressors are used in a variety of industries to supply process requirements, to operate pneumatic tools and equipment of tasks including blowing sand into or off moulds, pneumatic transport, spray coating and cleaning. Only 30% of energy reaches the point of end-use, and balance 70% of energy of the power of the prime mover being converted to unusable heat energy and to a lesser extent lost in form of friction, misuse and noise.

Air compressors were used in the machine shop for pneumatic equipment and machine tools. While visited the foundry compressor system had found some issues were presented below in table below.

Location of the compressor was near by the heat source that shown the reason of rise in inlet temperature may reduce power saving. Measured temperature of inlet air is about 45°C by contact thermometer. Regular checking of leak were not taken place that cause pressure drops that adversely affect the operation of air-using equipment and tools, reducing production efficiency

The relation between inlet temperature and relative air delivery and due to that power consumption can be analysed and summarised in the table below:

| Inlet Air Temperature (°C) | Relative Air delivery | Power Saved (%) |
|---|---|---|
| **43** | 100 | 0 |
| **38** | 101.6 | 0.9 |
| **32.0** | 102.9 | 1.9 |
| **26.6** | 105.1 | 3.4 |
| **21.1** | 106.9 | 4.5 |
| **15.5** | 108.8 | 5.9 |
| **10** | 110.8 | 7.2 |

Energy savings of up to 30% can be realized in a compressed air system by regular simple maintenance measures. The following points should be taken into consideration while deciding the location of compressors or combined compressed air systems.

The leakages in the distribution system for compressed air can result in compressors constantly working more to produce amount of pressure required for the use. The table below shows the calculated amount of money wasted annually due to leakages as per their sizes. The site in china analysed their daily energy consumption reports from their IT system. This daily monitoring alerted the site to a spike in energy consumption over a weekend when there was no production. When investigated it was found to be the result of several leaks in the compressed air system which when fixed resulted in a saving of 106.7 MWh or $10,000 annually.

Leakages plays a big role as a cost raisers in a foundry environment. Preventive maintenance is required to avoid such instances. Hence the leakages, the air lost due to the size of leakage and the cost incurred were calculated and summarised in the table below.

| Equivalent hole diameter (sum of all leaks) | Quantity of air lost per leak (m3/year) | Cost of leak (Rs/year) |
|---|---|---|
| Less than 1 mm | 6,362 | 15983 Rs |
| From 1 to 3 mm | 32,208 | 81261 Rs |
| From 3 to 5 mm | 117,633 | 226781 Rs |
| Greater than 5 mm | 311,738 | 686538 Rs |

Another experiment was done in order to audit for the energy efficiency of two compressors or the same manufacturer, of the same year of manufacturing and same rated power. The goal was to correlate production activity with the process/facility energy consumption. Cost functions for resource energy were based on resource and process properties (Cycle Time) collated with production schedule the results are shown as below:

| Time/ Hr | Compressor 1 | | | | | Compressor 2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Production (Tons)** | **Elec Units (KWh)** | **Cost (Rs)** | **Cost / Hr** | **Cost/Ton** | **Production (Tons)** | **Elec Units (KWh)** | **Cost (Rs)** | **Cost/ Hour** | **Cost/Ton** | Difference (%) |
| **4** | 13.7 | 265 | 3975 | 993 | 290 | 13.7 | 175 | 2625 | 656 | 192 | |
| **5.3** | 17.1 | 320 | 4800 | 905 | 279 | 17.1 | 210 | 2400 | 600 | 184 | |
| **8** | 22.4 | 425 | 6375 | 853 | 304 | | | | | | |
| **8** | | | | | | 25 | 280 | 4200 | 525 | 168 | |
| **10** | 27 | 560 | 8400 | 840 | 311 | | | | | | |
| **10** | | | | | | 23 | 270 | 4050 | 405 | 176 | |

During production days 1 and 2 the compressors were running simultaneously and the production was divided among two compressors. The Total running time of time if the compressors along with the unit consumed were measured. It was further used to calculate cost per hour of each compressors and cost per ton of production. The table vividly shows the difference between the energy utilisation of each compressor. On day 3 and 4 each compressor was used separately for 1 day while shutting down the other compressor. A full day average of each compressor reconfirms the results that compressor 2 was utilising 69% less energy input per ton to produce the same amount of compressed air used.

## <u>Energy Savings in the</u> auxiliary

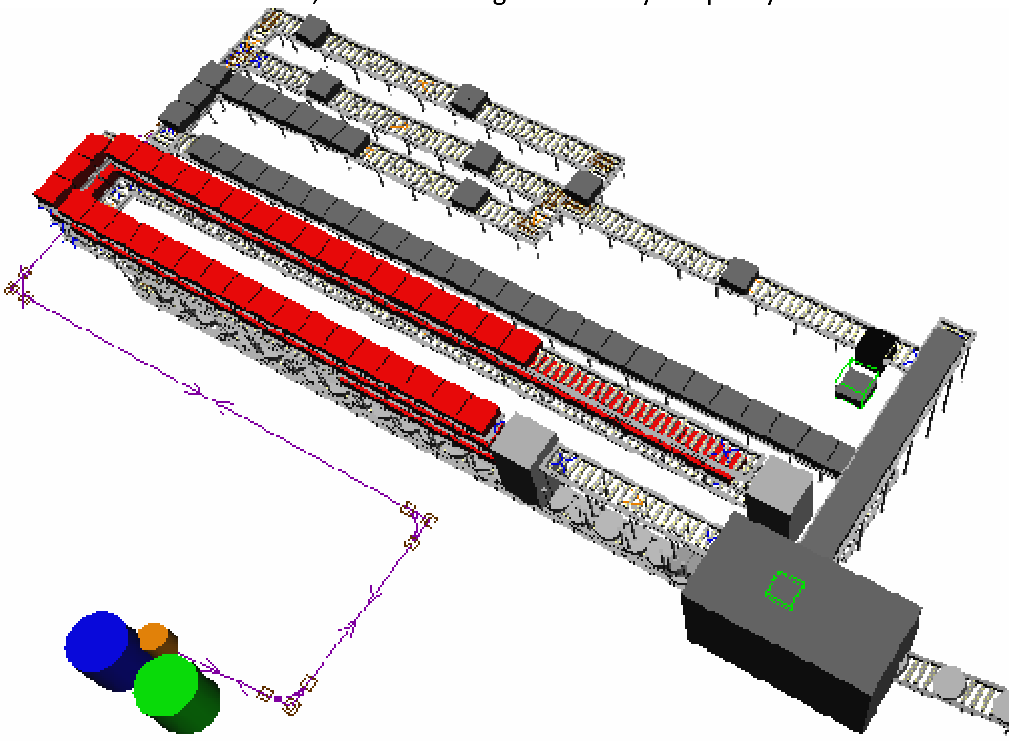
This section is not much covered in the paper but an introduction is written. Motors, pumps and fans are intrinsic to all foundry operations. However, they can incur significant running costs. For example, an electric motor uses 4-10 times its purchase price in electricity annually. Therefore careful selection and design is essential taking into consideration both operating and capital costs. While high-efficiency alternatives may be more expensive initially, energy savings often quickly recover the extra cost. Apart from melting and holding, energy usage in the supporting processes, such as ventilation, lighting, space heating and tap water, have often received less attention. Reasons for that are for example the history of low electricity prices limited access to capital, technical risks such as risk for production disruptions and lack of budget funding.

Balance the system voltage to reduce the distribution losses in the system. For every 1% increase in voltage imbalance, the efficiency of the motors decreases by 1%.

## Modelling the Production Schedule

The modelling concepts developed have the potential to significantly reduce manufacturing energy consumption, but still have many challenges. Collating the necessary information, filtering the raw data into statistical characterization, and resolving representation discrepancies in production system is time consuming. However, sustainability knowledge that could simplify the process, such as electric power distribution, plant layout, single line diagram for Energy mappings or equipment energy readings.

Increasing the yield (the total weight of good castings in relation to the total weight of metal melted) directly gives lower energy usage. To manage this focus should be on accurate production planning and good practice in general in key areas such as melting, pouring, molding and core making. The reduction of scrap is one important issue since it has a two-fold effect. Firstly, less energy is required for metal melting and secondly, materials, consumable items and labor are also reduced, thus increasing the foundry's capacity.



**Production planning**

Production plans are made manually by a production planner. The plans are based on the incoming orders. The production planner then decides good mix based on experience. The fact that there are several hundreds of models that can be arranged in almost an infinite number of ways makes the situation even more complicated. The exact plans and the mix of models are not decided until the production list reaches the mould line.
When modelling energy using equipment it is useful to divide them into groups. Generally there are two main categories of energy consuming equipment – production processes and support processes.

## RESULTS AND ANALYSIS

To use the results there is a need for an understanding of the results as well as a willingness to adopt the ideas and results into the company. Without the engagement of the workers it is impossible to create a more energy efficient plant.

Since there is a considerable lack of detailed production data and the fact that the models are arranged in the forms at the last minute by the shop floor personnel it is difficult to make an accurate detailed simulation model. The fact that there are several hundreds of models that can be arranged in almost infinite number of ways made the situation even more complicated.

**Conclusion**

There is a large scope of energy management in foundry industry sector in pakistan small and medium scale foundry industries considering the fact that the large amount of power is being wasted by many ways. As majority of these foundries are not aware of these facts.

From above case study we conclude that the better energy management program may save not only in terms of energy but also it may save money. Savings of at least 10% and up to 30 % may be realized by implementing some useful energy management techniques. The key to achieving savings is to take a strategic approach to managing energy use and giving importance to energy management techniques. While energy efficient technologies have a significant role to play in reducing energy use in foundry industry.

Most of the small-scale foundry units are family owned and managed. The general level of awareness among them about energy conservation and new technologies is low. Although some of the entrepreneurs are interested in energy efficiency and technological improvements they are constrained by lack of technical know-how and finances. Looking into today’s scenario, it becomes very essential for Foundry men to look for means which can bring down the energy consumption in melting operation significantly by efficient methods and techniques.

Hence it was concluded that there should be proper workflows, HR manuals so that the designated employee exactly knows his chart of duties and Standard operating procedures. One should also know whom to contact for a certain work type within the industry. Explanation of the work type and duties should be made simpler and the workflow should be properly defined for better response time hence this increases productivity.