# Improving Operating Methods in a South African Foundry Company - A Case Study

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## Abstract

South African foundry companies experience a number of production constraints due to lack of application of Industrial Engineering tools. The lack of application of these tools leads to poor production planning, poor plant utilization, and incorrect lead times. All these factors contribute highly to foundry companies not able to improve productivity and thereby improve profits. The proper application of these tools is important to reduce production constraints and bottlenecks. The study was undertaken at a South African foundry company. The company's current operations and production processes were studied over a period of ten months. Observations, interviews with production managers and support services managers were conducted, and historic data in company reports was used. The production constraints were then identified and a series of projects to assist improve operations were conducted. These projects include calculation of plant capacity, labour efficiency, standard times, and lead time. This paper discusses three of the conducted projects: labour efficiency, plant capacity and lead time.

## Keywords
Operations Management, Engineering Management, and Quality control and Management.

## 1. Introduction

### 1.1 Background
Company ABC uses die casting and sand casting processes to produce its castings for electrical components. The dies are already designed for all the castings to be produced, and is changed according to the type of casting to be made. When it comes to sand casting, a pattern has to be designed for each casting order placed by the customer. The company has a wide variety of patterns designed each year. Some of these patterns are only used once if the order was a once-off. After the pattern has been deigned, a mould is made. A mould is simply a mixture of green sand and binders. The process of mould making is done in parallel with metal melting, which requires an accurate desired temperature.

When the mould is ready and the metal has been molten, the metal is then poured into the mould. This process also requires an accurate desired pouring temperature as the metal might cool down and solidify before the pouring is completed, causing defects. Once the metal has cooled; solidified; the casting is then shaken off the mould and fettled. It then goes for machining if required and is sent for inspection, which after it is ready for shipping.

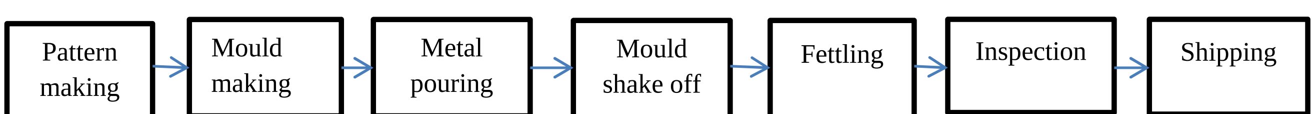


Figure 1: Sand casting process flow

The methodology employed follows a problem solving technique. This methodology can be used by any foundry company or organisation. The challenge could be the lack of relevant skilled personnel who can apply these techniques.

### 1.2 Problem statement

The company's productivity was low hence they were using a lot of overtime to meet their production targets. This resulted in high input costs. High input costs directly affect productivity. Also, there was a low customer return rate due to long lead times.

### 1.3 Objective

The aim of the study is to improve operating methods by applying problem solving techniques to identify constraints leading to low productivity.

## 2. Literature Review

A foundry is a factory that produces metal castings from either ferrous or non-ferrous metals including copper, brass, bronze, aluminium, zinc, lead, nickel, and all their various alloys (Beely 2001). Casting is a manufacturing process where a solid is melted, heated to proper temperature; and is poured into a mould (Henderson 2009). A pattern is required to make mould as it is a replica of the casting to be made.

Productivity measures the effective and efficient use of the available resources. There are many factors that affect productivity. These include methods, quality management, and technology. Operations methods can have a major influence on the competitiveness of an organization (Stevenson 1999). If not properly designed, it may hinder the production process. According to a study by National Foundry Technology Network (2009), smaller foundry companies that employ less than 100 people comprise 80% of the South African foundry industry, and they find it difficult to compete due to their lack of access to technical and financial resources. Implementation of cheaper improvements can enhance their competitiveness and improve their financial resources.

There are a number of operations improvement methods that have been developed over the years. These include kaizen, theory of constraints, business process re-engineering, total quality management (TQM), and lean manufacturing. These methods follow the same phases which include preparation, planning and goal setting (Grunberg 2003). The implementation of these methods can be costly for a small company as they require a certain level of skill.

Continuous improvements are then conducted to keep the organization current with its operations and to constantly identify constraints in production. The improvement process which is used in all improvement methods includes:

- Identifying the problem.
- Data collection.
- Describing the current and revised processes.
- Generating ideas for process improvement.
- Achieving consensus among team members.
- Evaluating and monitoring results.

A number of tools can be used to improve the process, included amongst these are flowcharts, brainstorming, Fishbone diagram, and control charts. The Fishbone diagram gives causative factors into layers of categories (Johnson 1984). Sugimori and Kusunoki (1977) used Toyota Production System which included 'just-in-time production' and the 'respect-for-human' system to improve labour productivity at Toyota Motor Company, Japan. Grunberg (2003) in his study mentions that although the methods follow the same phases, their focus is different. Some focus on waste reduction, while others focus on human activities and productivity improvements. He states that theory of constraints focuses more on production bottlenecks, while total preventive maintenance deals more with improving machine availability and equipment efficiency improvements.

In this paper, Fishbone or Ishikawa diagram is used to identify problems and causes. Furthermore, the paper presents and discusses some of the identified problems.

## 3. Methodology

### 3.1 Identifying factors contributing to constraints

The production operations were studied after which the Fishbone diagram or the Ishikawa diagram was used to identify and analyse the factors leading to low productivity. There were a number of factors identified but the study concentrated on only six which were more significant to low productivity. The diagram defines the factors contributing to low productivity and the causes thereof.

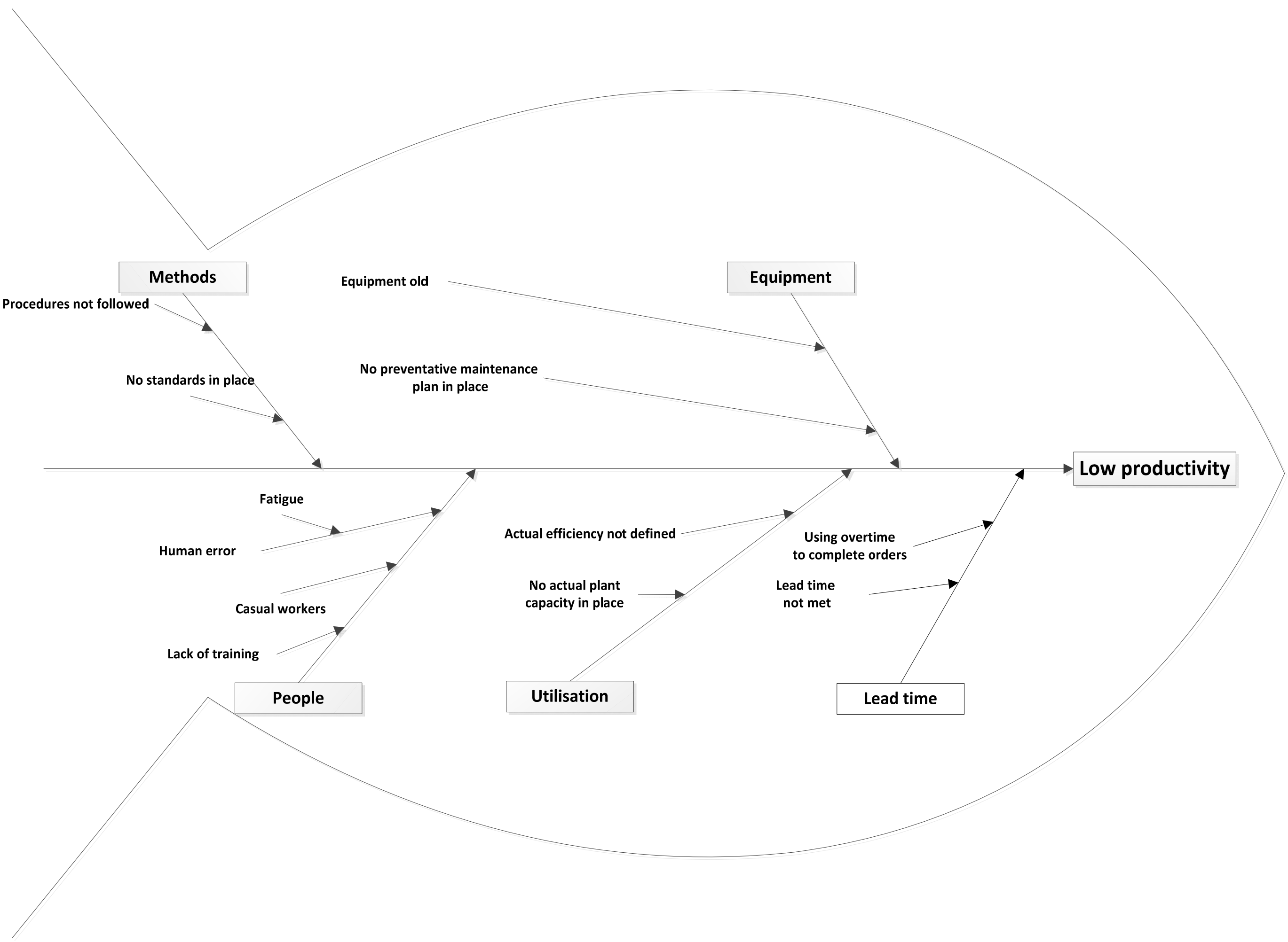


Figure 2: Fish bone diagram

The factors identified included methods, equipment, people, poor utilisation of resources, and lead time. This paper presents three of these factors, being: labour efficiency, plant capacity and lead time.

## 4. Results and discussion

### 4.1 Labour efficiency

This exercise determined whether the hours worked in the foundry production section are equivalent to the amount of weight produced, which is termed efficiency. This will assist in determining the number of employees that should be allocated in each shift. It will also assist the company in eliminating unnecessary overtime hours. This was done by calculating the total number of hours worked by all operators for each month and the total amount of weight produced in kilograms for that month, and the actual production excluding defects.

Table 1 shows sand casting data of normal hours, overtime and total hours worked as well as number of people working. It also shows monthly total weight produced in kilograms.

Efficiency was calculated using the formula:

$$Average\ production\ weight\ per\ hour = \frac{Total\ production\ weight}{Hours\ worked} \tag{1}$$

$$Labour\ efficiency = \frac{Average\ production\ weight\ /hour}{Actual\ production\ weight} \times 100$$

Where:
Average production weight per hour = total production divided by hours worked including overtime
Total production weight = production including scrap
Actual production weight = production excluding scrap
Efficiency = labour effectiveness

Table 1: Efficiency table

| | Normal time (Hrs) | Overtime (Hrs) | Total Hours worked (Hrs) | Number of people working | Total production weight (kg) | Actual production weight (kg) | Labour efficiency (kg/hrs) |
|---|---|---|---|---|---|---|---|
| January | 2427.75 | 213.5 | 2641.25 | 23 | 7129.62 | 6090.6 | 0.044 |
| February | 3764 | 689.5 | 4484 | 23 | 29474.49 | 21966.65 | 0.029 |
| March | 4230.5 | 551.75 | 4782.25 | 23 | 19864.26 | 17048.51 | 0.024 |
| April | 3498 | 705.75 | 4203.5 | 26 | 10893.80 | 10167.32 | 0.025 |
| May | 4573 | 872.75 | 5445.75 | 26 | 23969.22 | 21684.64 | 0.020 |
| June | 4511.5 | 718.25 | 5235.25 | 26 | 23540.71 | 23218.15 | 0.019 |
| July | 2197.25 | 156.75 | 2453.75 | 26 | 12135.21 | 10048.35 | 0.049 |
| August | 4769 | 450.75 | 5216.5 | 26 | 25992.17 | 25821.97 | 0.019 |
| September | 4502.25 | 379 | 4881.25 | 26 | 22103.10 | 20391.44 | 0.022 |
| October | 4311.75 | 1439.5 | 5751.25 | 26 | 37348.47 | 35191.99 | 0.018 |

Looking at Table 1, it can be seen that in January the month started on the 10th and 23 people worked only 264, 25 hours, therefore the production was low at 7129.62 kg. If we compare February and March we can see that hours worked in February are less by 298, 25 than hours worked in March but the total weight produced is higher in February compared to March by 9610.23 kg. The cause of this variance is erratic due to production procedures not consistently being followed, which results in rework. The table shows that the company used a total overtime of 6177.5 hours. The number of people working is also high considering the high labour costs in the industry.

In months like April, holidays can be taken into consideration as one of the contributing factors. July was affected by the strike as can be seen that the hours worked are also low which is equivalent to units produced, but if the July results are compared with April, the hours worked in April are more than those worked in July, but production in April lower with a difference of 1241.41 kg.

If we look at the efficiency graph in Figure 3, July has the highest, with 18%. This is because the hours worked are the lowest and the overtime hours are also the lowest at only 156.75. The total production weight though does not make any significance factor as it is the second lowest following January. Although the actual production weight of January is the lowest, the labour efficiency results show that it is 16% which is the second highest; closely following July. March and April both have an efficiency of 9%. This is due to that if the hours worked and the production weight produced is compared for both months, they have the same proportion. It can be concluded that the good efficiency results will lie above 0.049, which will indicate more than 50% labour efficient. If the efficiency is low, it indicates higher hours worked and lower production weight produced. Figure 3 gives a summary of efficiency results obtained from the calculations while Figure 4 shows the comparison between hours worked and total production weight produced.

The calculated efficiency was used to determine the number of workers per shift. This reduced overtime hours by 20%, which is a huge saving in terms of labour costs.

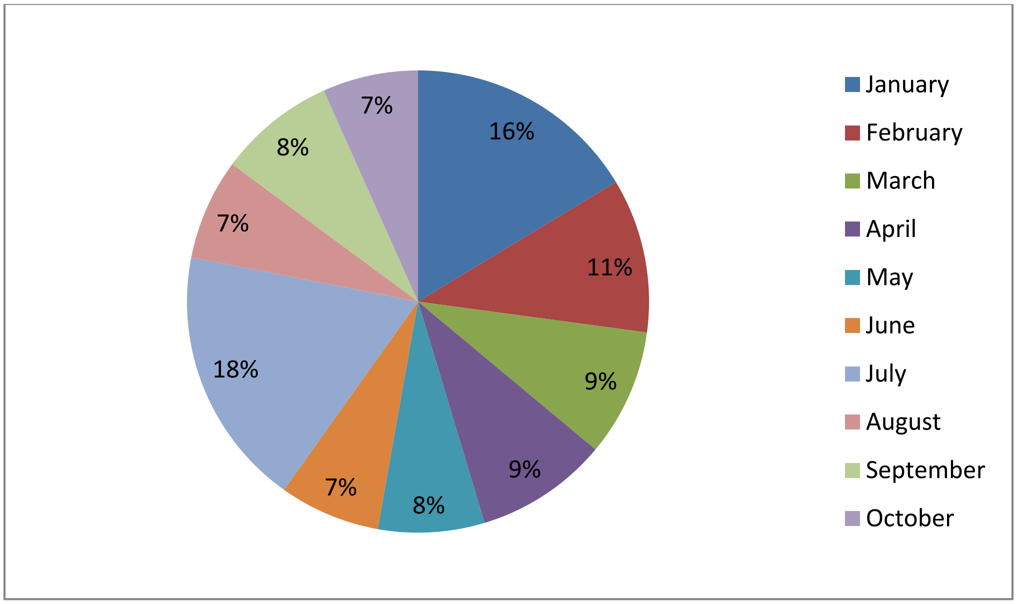


Figure 3: Efficiency graph

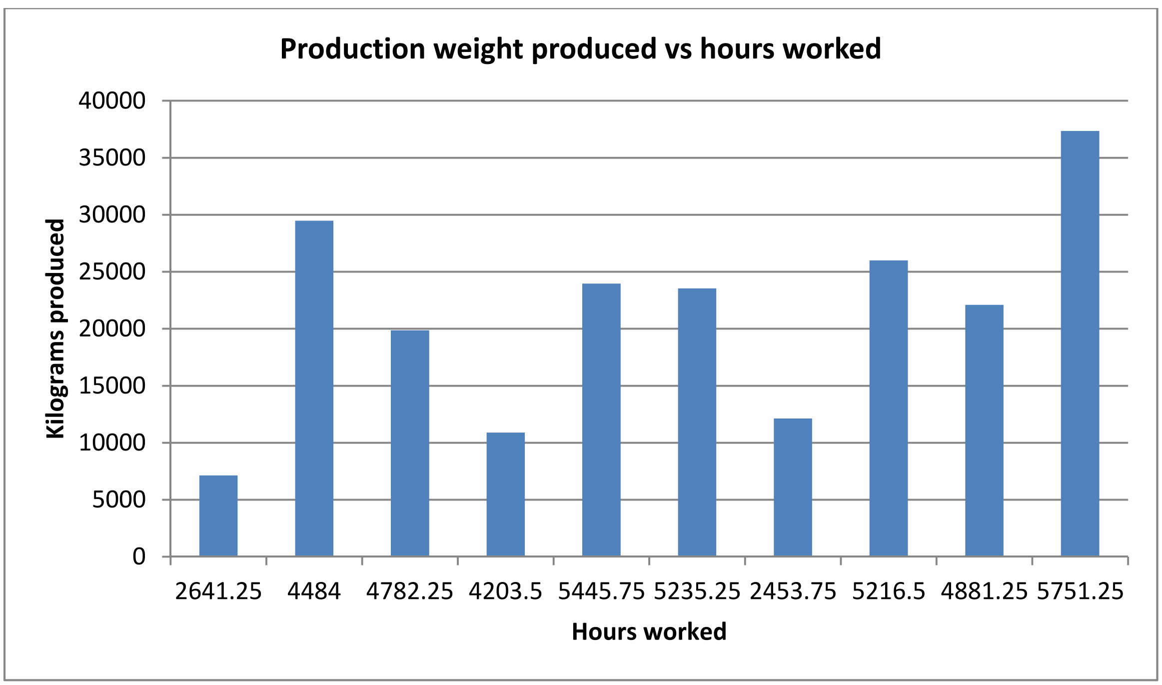


Figure 4: Unit weight vs hours worked

**4.2 Plant capacity**

To eliminate the costs associated with not producing to full capacity, actual plant capacity was calculated. From calculating the capacity of how much metal each furnace can melt, the amount of melted metal that can be poured from each melt was then calculated. There are four furnaces that feed the sand casting.

Furnace 1 has a capacity of 520 kg, furnace 2 a capacity of 170 kg, furnace 3, 4 and 5 have a capacity of 270 kg each. Furnace 1 takes approximately three hours to melt therefore can only melt twice in a day. Furnace 5 is a copper melting furnace and can take up to six hours on the first melt and approximately another three hours on the second melt and therefore can also only melt twice in a day when the furnace is started at six o'clock. If not started up at six o'clock in the morning the time will only allow for one melt in this furnace. Furnaces 2, 3 and 4 can each melt three times a day. This tells us that the full running capacity of the furnaces and total amount of melted metal poured in a day can be calculated to an amount of 3710kg.

Hypothetically speaking, if all furnaces are running to their full capacity then it would be possible to calculate or at the very least, estimate the number of castings that can be produced per day. This would in turn allow for the correct amount of orders to be accepted in a month and avoid taking on work that could not possibly be completed which leads to customer dissatisfaction and has a negative impact on the lead times. When extra orders need to be taken, the amount of overtime can then be calculated through the knowledge of the capacities of the furnaces.

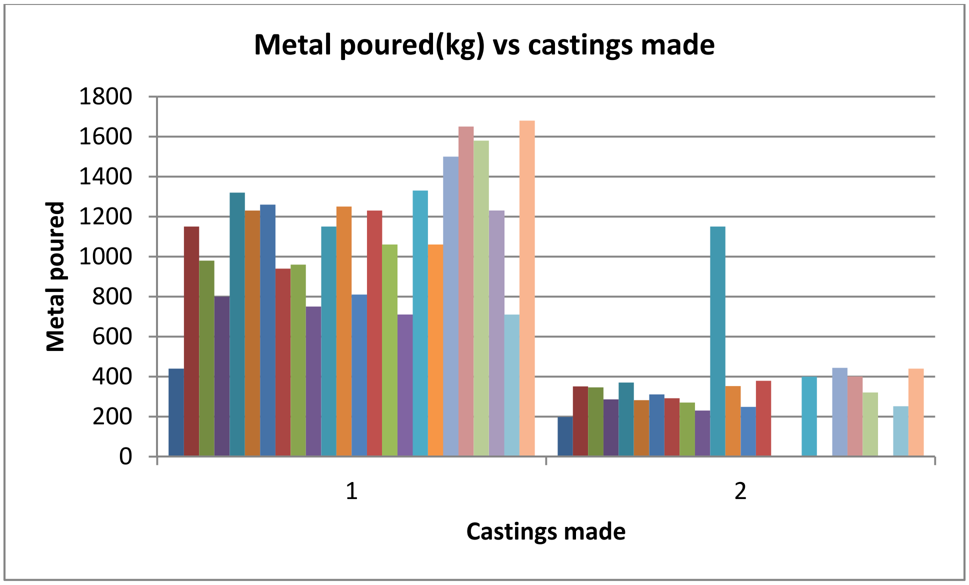


Figure 5: Metal poured vs castings made

**4.3 Lead time**

Lead time is the time from date of order to delivery date, that is, the time a customer is promised to receive the order. The company's lead time is set at four to six weeks. To measure lead time, we identified orders that have been delivered late since between 2011 and 2012, and investigate reasons behind the late delivery. Table 2 below shows the late deliveries; and the reasons for late deliveries.

In the lead time section of table 2, it indicates that the main reason given for most of these late deliveries is the supplier not delivering the raw material on time, specifically the insulators. The biggest obstacle with the insulators is that there is only one supplier in South Africa. In the interview conducted on the 17th of April 2012 with the production department manager, he mentioned that the other suppliers from China have been tried but this requires a long lead time. This was validated by the procurement manager again in the interview conducted with him as the person responsible for sourcing suppliers.

The other suppliers from other countries could be looked into but there are costs involved. The trade-off then becomes the higher raw material costs, which might end up in product prices being up. It is therefore up to the management what they decide to make a trade-off. The other option would be for the company to use historical data to calculate the number of orders that required insulators. This information can then be used to forecast the quantity of insulators to be ordered that will last for a long period of time. Most products are made to order, and therefore the company does not hold inventory but a priority could be made for scarce raw materials. This will assist to reduce the lead time.

The other reason for late deliveries indicated in the table was due to an order being a 'cash on delivery' which would require the customer to pay before goods are released, until this happens the goods will still show on the company's system and be considered a late delivery.

Table 2: Late deliveries

| Part name | Customer required date | Delivery date | Reason for late delivery |
|---|---|---|---|
| Frame, mounting, vertical | 08/03/12 | 19/04/12 | Cash on delivery |
| | 26/03/12 | 16/04/12 | |
| Frame, mounting, horizontal | 01/02/12 | 09/03/12 | Cash on delivery |
| Isol rock 33kV | 26/03/12 | 16/04/12 | Awaiting insulators |
| Isol rock, 33kV | 31/10/11 | 31/01/12 | Awaiting insulators |
| | 04/11/11 | 30/01/12 | Awaiting insulators |
| | 31/01/12 | 13/02/12 | Awaiting insulators |
| | | | |
| MK5 Mount BRK | 18/11/11 | 31/01/12 | Waiting for insulators |
| Isol ROCK 33kv | 01/01/12 | 12/03/12 | Awaiting insulators |
| Isol rock, 33kV | 13/01/12 | 23/04/12 | Awaiting insulators |
| Isol, 4 pole changeover | 15/03/12 | 30/03/12 | Awaiting insulators |
| Isol, rock, 11 kV | 04/04/12 | 17/05/12 | Awaiting insulators |
| Isol , rock, 33 kV | 30/04/12 | 15/05/12 | Awaiting insulators |
| MK5 SW disc | 06/07/12 | 15/06/12 | Awaiting insulators |

It was noticed during the study that some of the late deliveries are caused by the furnaces not running to full capacity. These reasons though are never recorded by production managers. When the pressure is too much on the production managers to deliver the job, they then use casual workers and overtime. The problem with the casual workers is that they are not given adequate training due to time constraints. These problems can be avoided if the production managers monitor labour efficiency as calculated above, and utilise the furnace capacities.

## 5. Conclusion

The calculated efficiency was used as a guideline to decide on the number of employees to assign per shift. This assisted in shortening lead times while saving labour costs. This also encourages for proper production planning and scheduling of jobs which the company lacks. Foundry industry is very competitive and by keeping the unit costs down, the company will remain competitive. The well- defined plant capacity assists in utilising the available resources, while making sure that lead times are met. Shorter lead times lead to customer satisfaction which is important for business growth. Satisfied customers are likely to place orders in the future and also give referrals. The company can plan well in advance and be able to take on more orders based on the calculated capacity and lead time. This will in turn improve profitability and create more employment opportunities. The calculated amount of melted metal that can be poured in a day is 3710kg, amounting to 18550 kg a week. Running at 100% capacity will not exert any pressure on the current labour allocated to the furnaces as it is sufficient. Although there were six factors identified during the problem identifying phase, this paper only presented three of these factors. It was discovered that there are no working standards in place, equipment is too old, and the company uses a lot of casual works. Most of the time casual workers are not given adequate training, resulting in errors during the production process. These errors also have a negative impact on quality of the final product which results in losses.


## Acknowledgements

National Research Foundation (NRF), University of Johannesburg, Metal Casting Technology Station (MCTS), Council for Scientific and Industrial Research (CSIR).


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## Biography

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