Enhancing Overall Equipment Effectiveness (OEE) in Compressor Manufacturing Industries

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Abstract
This paper focuses on the methodology of improving the productivity through overall equipment effectiveness (OEE) with the help of lean manufacturing techniques in compressor manufacturing industries. For a good manufacturing plant, the most recommended things are quality and efficiency. These two parameters depend on the function of equipment used in the industry. In the current global competitive environment, it is of immense importance for manufacturing companies to keep track of, and improve the production performance of their production systems. Production failure includes many reasons, among them improper maintenance and equipment performance are the eye-catching reasons. Lean manufacturing techniques help significantly identify the waste and eliminate it from the manufacturing processes. The OEE calculation is one of the ways to improve the performance. This work has been carried out in a 2 hp air compressor manufacturing unit for improving OEE with the help of 5s techniques using a systematic approach. The project has been addressed in three aspects; namely Availability, Performance and Quality which quantify OEE. The investigation result shows that the OEE has been improved from 45.9% to 55.8%.

Keywords: 5S; Overall equipment effectiveness (OEE); Standard operating procedure and Productivity.

Introduction
The manufacturing and process industry use Overall Equipment Effectiveness (OEE) as an important Key factor to monitor and control their performance effectiveness. At present, the level of competition between firms is increasingly demanding, and levels of demand by the customer are more stringent so that only the companies that have the ability to adapt easily to these needs are protruding in the market. Maintenance plays a very important role in the industry, since to be able to produce goods of quality and quantity, and to deliver at the right time according to customer needs; machinery and equipment must operate efficient and accurate. Although it is not always recognized as an important area, maintenance has been widely regarded as a support function that is not productive, since it does not generate cash directly and sometimes relegated for that reason. OEE is a measure used in Total Productive Maintenance (TPM) to indicate how efficiently the machines are working. With the proper implementation of lean tools, the problems can be solved effectively and the productivity can be increased. The paper discusses about the analysis and implementation of lean tools for improving the overall equipment effectiveness and to meet the customer demand by using standard operating procedure and 5S techniques. 5S is a system which helps to organize a workplace for efficiency and optimizes quality and productivity via monitoring an organized environment.

Problem Definition
Data collection is done based on 2 hp air compressor manufacturing unit. The results show that while the setup time is more. Further observation revealed that they are not meeting the customer demand, because there is no proper assembly of workstations, it increases the manufacturing lead time. Another observation is the machine downtime is more due to improper maintenance. This will cause less productivity. In machine shop, there is no proper handling of 5S activity, this causes for more tool searching time for operators. It will also increase the non-value-added activity for operators in machine shop. Machine utilization also poor because of improper operating procedure. It will cause for less production.

Objectives
- To reduce the non-value-added activity for operators in machine shop
- To improve the overall equipment effectiveness
- To meet the customer demand

To attain the above objective proper time study has been conducted and observations are noted down. Takt time is calculated which is the time required to produce one unit of product with the given customer demand to meet the market competition.
and time study is done for each and every activity details are in Tables 1 & 2 [1,2]. The time study is done for each and every activity. Table 2 gives the details about the data collection. This data is tabulated based on average values noted.

Table 1: Takt time calculation.

| Time Per Shift          | 8.5hrs=510min |
|-------------------------|---------------|
| Break and Clean Up Time | 60min         |
| Total Available Time Per Shift | 450min |
| Customer Demand Per Shift(Average) | 8  |
| Takt Time=Available Time/Customer Demand | 450/8=56.25min |

Table 2: Time study observations.

| Activity                  | Cycle Time (mins) | Value Added Time (mins) | Non Value Added Time (mins) |
|---------------------------|-------------------|-------------------------|----------------------------|
| Compressor head machining | 08                | 6.3                     | 1.7                        |
| Crankcase machining       | 45                | 29.6                    | 15.4                       |
| Cylinder machining        | 33                | 26                      | 07                         |
| Connecting rod machining  | 6.3               | 3.3                     | 03                         |
| Valve plate grinding      | 10.5              | 7.5                     | 03                         |
| Shaft coupling machining  | 05                | 03                      | 02                         |
| Inspection                | 13                | 00                      | 13                         |
| Assembly                  | 26                | 20                      | 06                         |
| Testing                   | 15                | 00                      | 15                         |
| Painting                  | 11                | 05                      | 06                         |
| Packaging                 | 20.5              | 16.5                    | 04                         |

Results and Discussion

After implementing lean tools OEE is improved 17.7% and productivity also increased from 35 products per shift to 40 products per shift details are in below.

Implementation Of Lean Tools

Different lean tools are identified to improve the OEE and productivity. After identification of lean tools, each tool is implemented as given below [3-6]:

Table 3: Implementation of lean tool.

| Activity | Before                                                                 | After                                                                 |
|----------|-------------------------------------------------------------------------|-----------------------------------------------------------------------|
| 1S       | There was unwanted material on shop floor. Proper sorting was not done at any stage | Unwanted material is removed from shop floor. Proper sorting is done to remove unwanted material |
| 2s       | There was no proper tool arrangement                                      | Tool is arranged in proper way                                         |
| 3S       | There was no provision for disposable bins                               | Disposable bins are introduced                                         |
| 4S       | No writing of hourly report by operator                                   | Hourly report is being written on time                                 |
| 5S       | Responsibility was not assigned                                          | Responsibility is assigned properly                                   |

Figure 1: Implementations of lean tool.
5S: 5S encourages workers to improve their working conditions and helps them to learn to reduce waste. In this paper 5S is one of the most important lean tools used. By using 5S as a tool lot of time is saved. The Table 3 and Figure 1 shows the details of before and after implement of lean tools.

**Overall equipment effectiveness:**

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OEE = \text{Availability} \times \text{Performance} \times \text{Quality} \\
\text{Availability} = \frac{\text{Operating time}}{\text{Total available time} - \text{Planned downtime}} \\
\text{Performance} = \frac{\text{Ideal cycle time} \times \text{Total cycle time}}{\text{Operating time}} \\
\text{Quality} = \frac{\text{Total Parts run} - \text{Total defects}}{\text{Total parts run}}
\]

**Overall equipment effectiveness for before implementation**

An experimental result shows the compressor manufacturing unit having 45.9% of overall equipment effectiveness before implementation of lean tools details are in Table 4 & 5 and Figure 2. An experimental result shows the compressor manufacturing unit having 55.8% of overall equipment effectiveness before implementation of lean tools details are in Table 6-8 and Figure 3 & 4. After implementing each tool step by step the suitable results are found out and results are discussed as follows. Figure 4 shows the tool searching of operator after the implementation of 5S. By implementing lean tools suitable results are found out. There is reduction in setup time is found out. Table gives the clear picture of how much time is reduced (Table 9 & 10).

**Table 4: Production data for before implementation.**

| Description               | Production data |
|---------------------------|-----------------|
| Shift length              | 8 hours + 30min=510min |
| Short breaks              | 2*15min=30min   |
| Meal break                | 1*30min=30min   |
| Downtime                  | 148.1min        |
| Ideal run rate            | 6.3min/piece    |
| Total pieces              | 35              |
| Reject pieces             | 2               |

**Table 5: Calculated data for before implementation.**

| OEE Factor | Calculated Data | %  |
|------------|-----------------|----|
| Availability | 301.9/450     | 0.67=67% |
| Performance | (35*6.3)/301.9 | 0.73=73% |
| Quality     | (35-2)/35      | 0.94=94% |
| OEE %       | 0.67*0.73*0.94 | 0.459=45.9% |

**Table 6: Downtime calculation for after implementation.**

| Observation | Down time (min) | Time Reduction (min) | Actual Production | Increased Production |
|-------------|-----------------|----------------------|-------------------|----------------------|
| Day 1       | 103             | 45.1                 | 35                | 7                    |
| Day 2       | 122             | 26.1                 | 35                | 4                    |
| Day 3       | 131             | 17.1                 | 35                | 3                    |
| Day 4       | 118             | 30.1                 | 35                | 4                    |
| Day 5       | 112             | 36.1                 | 35                | 5                    |
| Day 6       | 126             | 22.1                 | 35                | 3                    |
| Day 7       | 99              | 49                   | 35                | 7                    |
Day 8  |  128  |  20.1  |  35  |  3  
Day 9  |  115  |  33.1  |  35  |  5  
Day 10 |  109  |  39.1  |  35  |  6  
Day 11 |  102  |  46.1  |  35  |  7  
Day 12 |  122  |  26.1  |  35  |  4  
Day 13 |  112  |  36.1  |  35  |  5  
Day 14 |  104  |  44.1  |  35  |  7  
Day 15 |  106  |  42.1  |  35  |  6  
Average| 113.9 | 34.16  |  35  |  5 products

Table 7: Production data for after implementation.

| Description                  | Production Data                      |
|------------------------------|--------------------------------------|
| Shift length                 | 8 hours + 30 min = 510 min           |
| Short breaks                 | 2 * 15 min = 30 min                 |
| Meal break                   | 1 * 30 min = 30 min                 |
| Downtime                     | 113.95 min                          |
| Ideal run rate               | 6.3 min/piece                       |
| Total pieces                 | 40                                   |
| Reject pieces                | 0                                    |

Table 8: Calculated data for after implementation.

| OEE Factor   | Calculated Data | %     |
|--------------|-----------------|-------|
| Availability | 336.05/450      | 0.747 = 74.7% |
| Performance  | (40 * 6.3)/336.05 | 0.749 = 74.9% |
| Quality      | (40 - 0)/40     | 1.00 = 100%  |
| OEE %        | 0.747 * 0.749 * 1.00 | 0.558 = 55.8% |

Table 9: Comparison OEE.

| OEE Factor   | Before (%) | After (%) |
|--------------|------------|-----------|
| Availability | 0.67       | 0.747     |
| Performance  | 0.71       | 0.749     |
| Quality      | 0.94       | 1.00      |
| OEE %        | 0.459      | 0.558     |

Table 10: Results comparison.

| Tool Operating Procedure | Before | After |
|--------------------------|--------|-------|
| Downtime                 | 148.1 min | 113.9 min |
| Productivity             | 35 prod's/shift | 40 prod's/shift |

Conclusion

This paper was aimed to improve the influences of the overall equipment effectiveness in compressor manufacturing unit. To this purpose, Tool Searching time, Downtime, Productivity and OEE are implemented and analyzed. Investigated results are compared before and after implementing the lean tools. The end results shows that 75% reduction of tool searching time, 23% down time reduction, productivity has increased 12.5% and 17.7% increasing the Overall Equipment Effectiveness.

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