"Development of automatic feeder system in cellular manufacturing to improve productivity of Traub machine shop."

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Abstract - *The purpose of this project is to investigate potential effects on manufacturing using the same conventional methods of production, where many issues, including low production, high labor costs, poor quality, and safety, are caused by its current working practices in an observed industry (Tuljai Engineering Works), which is located in Pune, Maharashtra. First, the study focuses on the line balancing methodology in order to address this current method. Line balancing is a useful technique for enhancing shop layout, which shortens the time it takes to produce a product. Additionally, there are several benefits to cellular manufacturing, including greater quality, increased productivity, and improved machine usage. The company is now dealing with issues including worker injuries, low productivity, excessive labor costs, poor quality, etc. The entire process must be automated in order to handle this issue.*

The effectiveness of automated high speed part feeding is crucial to the outcome of automated assembly in batch or mass production. For this task, a standard vibratory bowl feeder is practical under these circumstances. The goal of this project is to advance the implementation of a flexible vibratory bowl feeder. The rigidity of tool orientation is to blame for the issues incorporated. This study devised a strategy for uptime maximization and evaluated the total production downtime for each production line each shift. To emphasize some concerns with material circulation to the plant floor, the corporation also acquired a manufacturing layout. The business also utilized to compare cycle time, Takt time, and overall equipment effectiveness with downtime (OEE).

Key Words: Cellular Manufacturing, Productivity, Vibratory bowl Feeder, Overall Equipment Effectiveness

1Introduction

Manufacturing is a crucial business activity performed by businesses that offer goods to consumers. Manufacturing today entails a variety of interconnected tasks, such as product design and documentation, material selection, process planning, production, quality assurance, management, and product marketing. To produce products that are both feasible and competitive, these activities should be combined. In the conventional manufacturing process, the work item is manually fed onto the turning machine. To load the work item onto the machine collet, the operator holds it in his hand. There are safety risks as the work piece is put onto the machine and held in place by the collet for the simultaneous chamfering and grooving operations. Coolant circulates constantly while the turning operation is being completed to facilitate efficient machining. Following the completion of the turning operation on the work piece, the job is automatically ejected or unloaded by the machine, and additional work is placed in a storage bin. After the work piece has been unloaded, the operator feeds a new work piece into the machine's collet for turning. An action that happens sequentially. To clean and remove burr, the stored work components are submerged in LH3 grade oil for 10 minutes. Before being sent to the packaging department, the work items undergo random inspections. Thus, the company's old manufacturing method causes issues like operator injuries, low productivity, excessive labor costs, poor quality, etc. The entire process must be automated in order to deal with this circumstance. Manufacturing technology has undergone constant, incremental yet revolutionary change. The manufacturing industry has undergone a metamorphosis as a result of these technological breakthroughs. The single biggest cause of lost production time for the majority of manufacturers is downtime. Given how noticeable equipment breakdowns and failures are, it attracts a lot of attention.

1.1 Objectives

- To make loading and unloading of the work piece automatically i.e., process automation.
- Utilization of appropriate shop-floor by using cellular manufacturing Approach.
- To Compare the various automation for feeding system and choose the vibratory bowl feeder is technical viable than other feeding system.
- To compare the Productivity of machine shop before and after implementation of vibratory bowl feeder.

- To reduce the downtime of machine using Overall equipment effectiveness technique.

1.2 Problem definition and identification

A management at several of the businesses I've visited can detail every cent that goes toward an operator's cost (again, wages plus benefits). One business I went to even mentions the price of the parking place the employee uses to keep their vehicle. However, they are not nearly as aware and careful when it comes to machine prices. Once more, the key to making informed judgments about operator usage is having an accurate estimate of both the cost of the operator and the machine. Poor operator-utilization decisions are caused by inflated operator costs and depreciated machine costs. It will seem more cost-effective than past methods to use one operator for two or more machines Initially there were 24 machines, which were operated by 24 skilled operators along with 4 unskilled operators or helpers.

Problem in present are,

1. Manual operation hence less accuracy.
2. Skilled worker required.
3. Production time depends upon operator skill.
4. Tool break down problem due to misalignment of part.
5. Machining safety
6. Line balancing of the shop-floor.

1.3 Downtime

A system or machine is considered to be in downtime when it is not functioning properly. It describes the moment when a company's plant is not turning out goods in the manufacturing sector. Since unplanned downtime frequently happens while regular business operations—such as paying employees and ordering materials for product manufacturing—continue, this can negatively affect a company's bottom line and profit margins.

- Available Losses
- Performance Losses
- Quality Losses

1.4 Traub machine shop

A TRAUB machine is a tool that provides great precision at a reasonable price and is frequently appropriate for mass producing precision parts. Electrical, textile, electronic, and general engineering sectors frequently use these machines. TRAUB machines are available in a variety of models, including the C15, C-25, C-30, C-32, C-42, and C-60, to meet all of your industry's needs. These devices offer great returns on a small investment and are incredibly adaptable.

Fig 1 Traub machine

2. Cellular manufacturing

Cellular manufacturing is a method of producing goods that sets up workstations and equipment in a specific order to allow things to pass through the production process as quickly as possible while requiring the least amount of waste and logistical work. Cellular manufacturing, a subset of just-in-time and lean manufacturing, tries to set up machinery, tools, parts bins, and workstations to allow for an optimum flow of continuous production from one cell to the next. Cells are often made to process parts one at a time as opposed to simultaneously processing a batch of components in a workstation. This makes it possible to produce more similar goods more quickly since individual cells can be modified without rearranging the entire assembly line whenever a variation is required. Each cell has a distinct independent producing unit. Depending on the cell sequence, each cell may have a designated specialist or may have workers who have undergone cross-training to supervise the operation of other cells or the entire cell sequence. While a cell may generate finished products from beginning to end, most often, cells are set up in a flow where the output of one cell serves as the input for the following one.

2.1 Types of cell layouts

- Linear layout
- Cage layout

2.2Implementation process

There are various processes involved in the creation of a work cell. The first step is to classify the company's items into families. These product clusters could be components of one and the same design that simply differ in terms of size, shape, or functionality. They could also be Categorized According to the production process, such as by process step or order of operations. Second, families should be grouped using a production flow analysis (PFA). In this case, it is crucial to choose machines to cluster that complement the components of each family. It aids in estimating the quantity of raw materials and spare parts that will be needed. In many cases, combining family parts might help you reduce your parts inventory. With only a minor alteration, a single part might be found to be compatible with another finished product. By the cell's equipment. Finally, the cell's internal activities can be optimized .This may contain noticeable components like the number of steps between stations within a cell or the routing's distance from one cell to the next. Planning for material handling, station-to-station product flow, fixed manufacturing expenses, and labor costs may also be a part of it.

2.3 Line balancing in manufacturing

Line balancing is a production strategy that involves balancing operator and machine time to match the production rate to the takt time.

By combining people and machines into one work station for mass production, line balancing is done on the factory floor to save idle time. Because of the high rate of production in this layout and the need for effective machine and operator balance for increased efficiency, line balancing is employed in product designing. Takt time is the pace at which components or goods must be produced to keep up with demand from customers. Production time must match takt time precisely for a given production line to be properly balanced. If not, resources should be redistributed or reconfigured in order to eliminate bottlenecks or excess capacity. To put it another way, a new balance should be struck between the numbers of workers and machines allocated to each duty on the line.

2.3.1 Benefits of Line Balancing

- Reduce waiting waste
- Reduce inventory waste
- Absorb internal and external irregularities
- Reduce production costs and increase profits

2.3.2 Line Balancing Implementing

1 Calculate takt time
2 Perform time studies
3 Identify bottlenecks and excess capacity
4 Reallocate resources
5 Make other improvements

3 machine shop layout of traditional manufacturing and cellular Manufacturing

3.1 Traditional shop floor layout

24 machines were handled by 24 personnel in the traditional shop floor configuration (figure2), which resulted in the several drawbacks mentioned above. Additionally, the long product cycle time needed under the current circumstances led to low productivity and inefficient machine use. To overcome, we have created new or modified shop floor layouts using line balancing technique

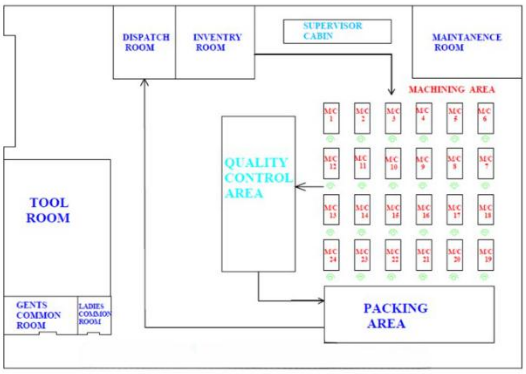

Fig 2 Traditional shop floor layout

3.2 Implementing shop floor layout

As was mentioned in the problem definition, this industry is having issues with shop floor line balancing and space usage. We have accomplished line balancing approach with the use of a redesigned shop floor layout (as shown in figure 3.7). Four machines can be operated in this modified layout by a single worker, resulting in a reduction in labor costs. Product cycle time has been shortened by applying a changed shop floor layout, leading to high productivity, a reduction in space, and improved equipment usage**.**

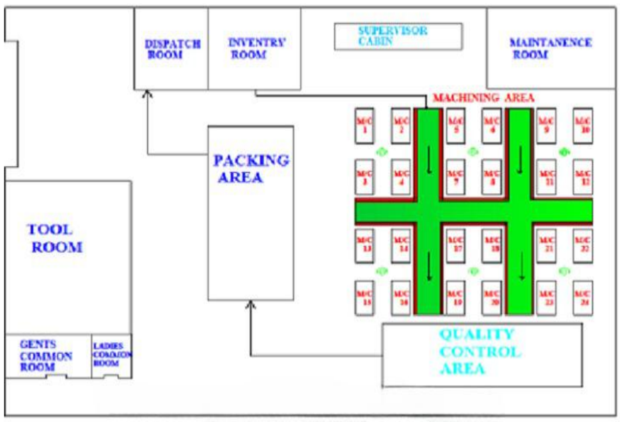

Fig 3 Implementing shop floor layout

4 Automatic feeder system in traub machine

Today, every manufacturing sector must work to develop efficient production processes while also reducing production costs. This pushes every business to adopt smart manufacturing, wherein the company leverages the technology of the tools they already have to create the best possible manufacturing environment, but still relies on the role of humans who still have control over these equipment. This is due to the fact that the manufacturing industry relies heavily on its machine technology and the caliber of its human resources, which can be referred to as the role of humans. In this post, we'll talk about an equipment or technology called a feeder machine that isn't often discussed in the industrial industry. a This time, we'll talk about a machine that is really helpful in the manufacturing industry: the feeder machine. A feeder machine is, by definition, a device that is used to "load" or "feed" a product or object in order to increase production and make it more efficient. In other terms, a feeder machine is described as a device that feeds items, packing, or containers one at a time before directing them along a conveyor. Depending on the intended function, this machine can be integrated with other machines. In order to control the flow of bulk materials into the machinery for additional processing or another operation, a feeder is a piece of material handling equipment. Essentially, a feeder is a conveyor used when a uniform rate of dispersion is required over short distances. Depending on how they operate, there are many different types of feeders to suit many different industries.

4.1 Parts Feeders Function

The crucial tasks of locating pieces and controlling flow rate are performed by all parts feeders, regardless of whether they rely on centrifugal force, mechanical vibrations, or gravity. Centrifugal feeders are recommended for packaging tasks or handling fragile parts, while vibratory feeders are typically better suited for production process. The following are the top two services that feeder systems offer:

1 Feeding
2 Orienting

.4.2 Types of automatic feeding system

1 Robotic arm
2 Linear feeder
3 Stepper feeder

4.3 Technical Comparison of Automatic feeder system

Technical Comparison of feeder system

Parameters	Gntry robot	linear feeder	stepper feeder	Vibratory bowl feeder
Particle Size	16 mm	80 mm	150 mm	200 mm
Feeding Speed	1000 pieces/hr	400pieces/hr	2700pieces/ hr	400pices/hr
Feeding capacity	100gm	100-150gm	50-60gm	100gm
Lifting Capacity	100 gm	0-2 ton	40 kg	2 ton
Usage/Application	Part feeding	Part feeding	Part feeding	Part feeding
Power	1HP	2HP	2HP	2HP
Phase	Single	Single	Single	Single
Warranty	1 year	1 year	1 year	1 year
Payback period	9.6 year	7.6 year	11.2 year	4.4 year
Automation Grade	Manufacturing	Manufacturing	Manufacturing	Manufacturing

Fig 4 Technical Comparison of Automatic Feeder system

4.4 Comparison of proposed automation

Manufacturing industries must replace their outdated infrastructure with one that is more adaptable and dynamic. These shifts have given rise to several new ideas, supported by tactics designed to handle problems brought on by international marketplaces. We sought to use process automation, such as a robotic arm and vibratory bowl feeder, to get around the conventional manufacturing method. When compared to the other two technologies, the robotic arm has several limitations and is very complex. Robotic arm assembly requires a lot of mechanisms, electrical parts, sensors, and microprocessor control units. It requires more labor and possibly uses more space. As there are 24 machines in this industry, 24 automatic feeders must be installed for process automation, and high precision, accurate programming is also required with a skilled programmer to develop an appropriate program. Thus in case of small scale industry automation by robotic arm linear feeder stepper feeder is not affordable

Parts must be accurately reoriented for feeding into an assembly line in manufacturing, where component feeding for automatic assembly is a critical issue. In this sector, vibratory bowl feeders are used to feed and realign pieces into a specific arrangement. Vibratory bowl feeders have various benefits, including being energy-efficient, relatively inexpensive, of sturdy construction, portable, etc. Manufacturers can save time and money by using vibratory feeders instead of manual labor. When a set number of work components are waiting in line on an inclined rail, it also reduces power usage. When comparing automation by robotic arm versus automation by vibratory bowl feeder, it is clear that the latter is more practical and cost-effective. In light of this, this report recommended automation using a vibrating bowl feeder

5 Working setup of automated mechanism

A vibrating bowl feeder is the most frequent tool used to feed industrial parts. The internal wall of the basin is climbed via a helical track. If the bowl is vibrated in a circular motion, parts dumped into it will climb the helical track in a single file. As they ascend the track, the pieces encounter a succession of obstacles that either reorient them or lead them back into the middle of the bowl. Stepper motor operated wiper blades and programmable track width are utilized in place of welded passive orienting devices, such as wiper blades, and permanently constructed orienting devices on the track to make the bowl feeder adaptable and programmable to accommodate pieces of different sizes. An electromagnet placed on the base of a bowl causes vibrations, and The support system limits the range of motion. The vibratory motion that occurs when parts are introduced into the bowl causes them to climb the track to the exit at the top of the bowl. Figure 6 of the schematic for the vibrating bowl feeder is shown below.

The work piece moves progressively along a predetermined helical route as soon as the feeder is powered up and starts vibrating with a certain amplitude. As soon as a job arrives at the wiper blade station, it is rejected or wiped off if it is stacked on top of another one or exceeds the wiper blade's predetermined height limit. a common passive orienting device used in the vibratory The wiper blade station is in the vibratory bowl feeder and is used to reject or wipe off operations. After passing the temporary wiper blade station, the work item moves on to the deflector station. Here, a deflector station at a 90-degree angle deflects the jobs before they continue along a slanted track in the direction of the machine collet. Similar to this, when there are lots of available positions A precise spot inside an inclining rail houses the proximity switch sensor. The sensor on the inclined rail will complete the close loop. A sensor will turn off the power to the vibrating hopper when the workload exceeds the sensor's threshold. By disabling the vibrating hopper's power source when it isn't in use, we may cut power consumption in this way.

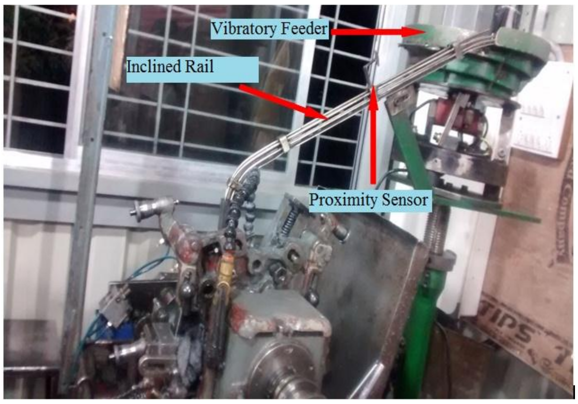

Fig 6 Working setup of automated mechanism

6 Overall Equipment Effectiveness (OEE)

Overall equipment effectiveness is a gauge of how successfully a manufacturer runs its business (OEE). In other words, total equipment efficacy helps us identify operational issues, determine how much of the production time is actually productive, and solve them. It also gives you a reliable yardstick for measuring progress. The goal of OEE measurement is continuous improvement.

6.1 Overall Equipment Effectiveness (OEE) to Measure Manufacturing Productivity

An impressive number is the equipment efficacy overall. OEE is used to quantify manufacturing productivity in a variety of ways since it gives a lot of information in a single value. It can greatly increase your production if estimated and understood correctly. When comparing a specific production to industry standards, internal equipment, or other shifts using the same piece of equipment, overall equipment effectiveness is utilized as a comparison. These are the typical OEE benchmarks:

- Perfect production is defined as having an OEE score of 100 percent, which indicates that the business produces only high-quality items as soon as possible with no downtime.
- For discrete manufacturers, an OEE score of 85% is regarded as world class and is a long-term objective.
- Discrete manufacturers often have an OEE score of 70%, which indicates there is much opportunity for improvement.
- While considered low, an OEE score of 40% is not unheard of for manufacturers just starting to monitor and enhance performance. In most circumstances, a low score can be quickly raised by taking simple actions.

6.2 Overall Equipment Effectiveness: Terms

Before we discuss overall equipment effectiveness further, there are some important terms to be aware of.

- **Quantitative Efficiency** - This refers to manufactured parts that don't meet quality-control standards, including ones that need to be reworked. It is calculated as

$$\text{Quantitative Efficiency} = \frac{\text{Actual Production}}{\text{Target Production}}$$

- **Performance Efficiency** - This takes into account the number of times there are slowdowns or brief stops in production. A perfect performance score in OEE terms means your operation is running as quickly as possible. It is calculated as

$$\text{Performance} = \frac{\text{Actual production}}{\text{Maximum Production Possible}}$$

- **Availability Efficiency -** This takes into account planned and unplanned stoppage time. A perfect availability score means your operation is constantly running during planned production times. It is calculated as

$$\text{Availability} = \frac{\text{Net Production time} - \text{Down time per shift}}{\text{Total time available}}$$

OEE Calculation based on earlier factors

OEE=Availability efficiency ×Performance efficiency×

Quantitative efficiency

7 Important Definitions

1TAKT time:

TAKT time is derived from German word TAKTZEIT which means meter. TAKT time is the rate at which the product must be produced in order to meet client demands. TAKT time synchronizes the manufacturing process' speed with customer demand. Each manufacturing process works to TAKT. It is the ratio of total time available for manufacturing of any product to the total demand of that product to the customer. All the activities that are necessary for the completion of any product must be completed within the TAKT time of line otherwise it will lead to fabrication of bottleneck at the line. It is also called the cycle time of line.

$$\text{TAKT Time} = \frac{\textbf{Total time available for production}}{\textbf{Total demand}}$$

2 Cycle time:

Cycle time is the amount of time for operator spends actually working on producing on a product. It is the average time

$$\text{Cycle time} = \frac{\text{Net Production time}}{\text{No of unit Produced}}$$

8 Cost distribution of old process

Cost details of 24 machines for one month are shown in table 1 Here The most contributing parameter is labor costing which is 75% of total production expenditure. So, project mainly focus to optimize labor cost

Table 1 Old Process Cost Distribution

Sr. No.	Parameter	Unit Cost (Rs)	Unit	Total Cost (Rs)
1	Skilled Operator	12000	24	288000
2	Machine Maintenance	950	24	22800
3	Tool Break Down	220	120	26400
4	Electricity	8.25	2150	17737.5
5	Helper	6000	4	24000
			Total Expenditure	378937.5

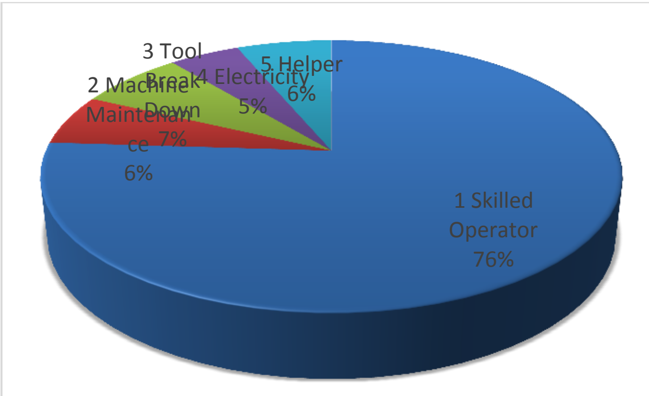

Fig 7. Pie Chart 1 Old Process Cost Distribution

9 RESULTS

9.1 Total Production data before and after implementation

9.1.1 Pre-implementation Production data

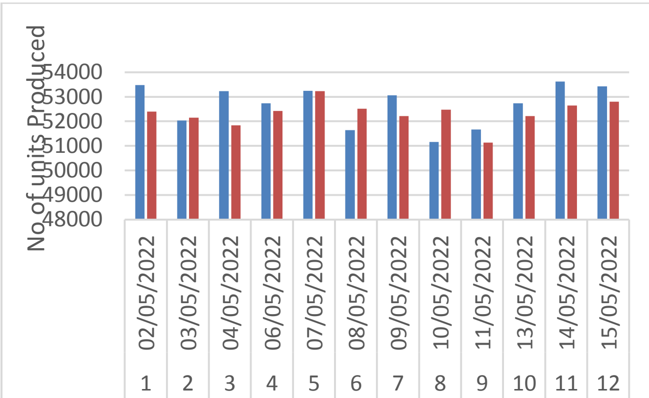

Fig 8 Bar chart Pre-implementation Production data

9.1.2 Post-implementation Production data

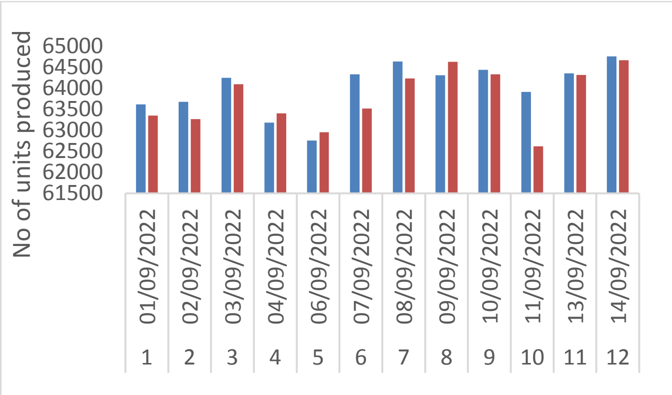

Fig 9 Bar chart Post-implementation Production data

9.2 Down time before and afterimplementation

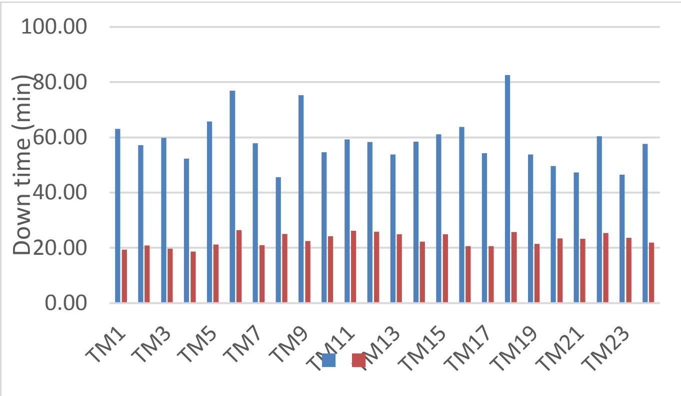

Fig 10 Bar chart Downtime before and after Implementation

9.3 post implementation Expenditure

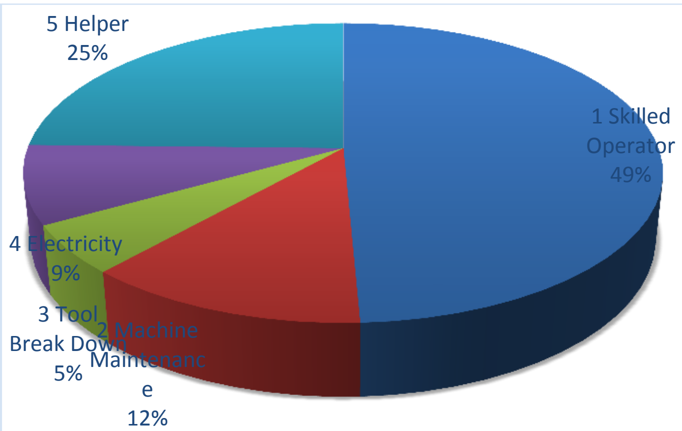

Fig 11 Pie chart 2 modified cost Expenditure

9.4 CALCULATIONS

1 TAKT Time

TAKT Time = $\frac{450\times 60}{3000}$ = 9 sec

2 Cycle Time

Cycle Time = $\frac{440\times 60}{3000}$ = 8.8 sec

Ideal OEE = $\frac{440-\text{Down time}}{450} \times \frac{\text{Actual production}}{3200} \times \frac{\text{Actual production}}{3000}$

$= \frac{440-0}{450} \times \frac{3000}{3200} \times \frac{3000}{3000}$

Ideal OEE = 91.66 %

Net Production time available = 440 min.Target for the production = 3000 units.

The total time available = 450 min per shift.

Actual Production (before implementation) per machine = 2290 units

Actual Production (after implementation) per machine = 2760 units.

Performance Efficiency (before implementation) = $\frac{2290}{3200}$ = 71.56%

Performance Efficiency (after implementation) = $\frac{2760}{3200}$ = 86.25%

Quantitative Efficiency (before implementation) = $\frac{2290}{3000}$ = 76.33%

Quantitative Efficiency (after implementation) = $\frac{2760}{3000}$ = 92%

9.5 Calculated OEE for work-station

Table 2 Calculated OEE for work-station

MACHINE	OEE	
	BEFORE Implementation	AFTER Implementation
TM1	0.406702	0.732103
TM2	0.443638	0.719218
TM3	0.426448	0.728785
TM4	0.476276	0.738433
TM5	0.390881	0.715937
TM6	0.327874	0.671011
TM7	0.43906	0.717904

TM8	0.522367	0.683022
TM9	0.336742	0.704531
TM10	0.460763	0.690038
TM11	0.430468	0.673213
TM12	0.436184	0.675736
TM13	0.465981	0.683658
TM14	0.435467	0.707128
TM15	0.419178	0.684294
TM16	0.402142	0.720861
TM17	0.462499	0.720861
TM18	0.298179	0.677315
TM19	0.465483	0.714301
TM20	0.493923	0.696455
TM21	0.510129	0.698066
TM22	0.423155	0.680482
TM23	0.515959	0.694847
TM24	0.440984	0.709405
Average	0.434603	0.701567
	0.4346 43.46%	0.7015 70.15%

10 CONCLUSION

1. The rise in Production clearly seen as for 1st Shift is 17% and for 2nd Shift is 18 %
2. The rejection of jobs is reduced by72%
3. The reduction in downtime is 60%.
4. Availability of machine is increased by 8%.
5. Average overall equipment effectiveness increased 43.46%To70.15%.
6. The production expenditure is reduced by 22.90%

11 REFERANCES

1. Negahban, A., & Smith, J. S. (2020). Simulation for manufacturing system design and operation: Literature review and analysis. Journal of Manufacturing Systems, 33(2), 241-261.
2. Askin, R. G. (2019). Contributions to the design and analysis of cellular manufacturing systems. International Journal of Production Research, 51(23-24), 6778-6787.
3. Nouri, H. A., Leman, Z., Moghadam, H. P., & Sulaiman, R. (2014). Literature review on machine reliability in cellular manufacturing system. Am J Appl Sci, 11(12), 1964-1968.