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Improving Productivity by Reducing Waste Material in Sheet Metal Fabrication Industry in Maharashtra, India

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Abstract - *An almirah lever is a product installed in an almirah door for locking purposes. It is connected to the lock and key mechanism of an almirah. Almirah lever was produced in a factory with an annual production of 15,000 units, and research was carried out to minimize the scrap for producing the same. Restrictions were provided by the company to execute the solution on the work; those were – no resources should be utilized from the company's side, and the new process should have minimal changes. This research was conducted at an Industry in Maharashtra, India. We were committed to the above parameters and applied the trial-and-error methods, then iterations were formed to find the best possible production method. In this study, demand forecasting, process planning, inventory control, and formulation methods were used. The proposed process was implemented by the company. It resulted in their annual cost savings of Rs. 1,05,300, as large amounts of scrap were reduced, and it further resulted in reduced costs of traveling, work in process inventory, and labor.*

Key Words: **Almirah Lever, Sheared, Punching, Demand Forecasting, Process Planning, Inventory control, Formulation, Work in process inventory, Hot Roll Sheet (HR Sheet).**

1.INTRODUCTION

Techniques to improve productivity can be applied effectively in organisations of all sizes, from sole proprietorships to corporations with thousands of employees. The techniques are used in mass production, batch production, and so on to reap the benefits and to become agile manufacturers of customized products. (J.C. Chen et al 2001) studied the importance of productivity improvement techniques in industries and the emerging need to adapt those using the kaizen technique. They suggested that in this competitive era the designing should follow kaizen in industries for designing cellular manufacturing systems to reduce the cost and working space. They conducted a study and concluded that the lean thinking approach in kaizen for designing a flexible, controllable, efficient, and unique manufacturing process is a success for a company in terms of space optimization, cost reduction and improved worker satisfaction. (Joel James et al 2013) performed an experiment to see the importance of kaizen for safety purposes. They analysed results before and after kaizen and realized that high reliability for all safety experts, ratings showed were not only having a significant reduction in risks but also productivity was increased. A.M. Borkar et al (2021) evaluated the overall equipment effectiveness in the sheet metal parts manufacturing industry. In this study root cause analysis, six big losses, kaizen, were used. They evaluated results from overall equipment effectiveness and observed that the availability rate has increased from 76.69% to 80.01%. They concluded that more kaizen should be conducted for further improvements as kaizen is a never-ending process.

2. CASE STUDY

An Almirah lever was a part produced in a company where some previous calculations were given for producing that part. HR sheet was used of dimensions 1500x2500x3. Those sheets were further sheared in 150x1500 respectively. Then further, the sheared sheets were transported to the power press for producing the almirah lever. Here the operation on the sheet was performed, that is the sheet is only entered on time in the power press, and the part was developed. Later the part is ready for other processes that are bending, welding, notching, and others. Now, some parameters are given for increasing productivity. The company is not ready to change the die. The company is demanding that the work should be done with same process. Only one part is to be produced at a time because the machine works at 50-ton pressure anything above that would lead to failure of the machine.

2.1 PRODUCT DESCRIPTION

- Name: Almirah Lever

- Description: It is the main component of lock-and-key system installed in the door of the almirah.
- Material used: Hot Rolled sheet.

Fig-1: Almirah Lever

Fig-2: Hot Rolled sheets, 1500mm X 2500mm.

2.2 MACHINES USED:

1. **Shearing Machine**: Cutting metal bars and plates into structural shapes of the different cross-section are being done by this machine. This machine comprises a plunger (movable cutting member) that can have one or more cutting or shearing plates and are arranged with the corresponding number of stationary plates by face-to-face contact.

Fig -3: Shearing Machine

Fig- 4: Sheared Sheets (Planks)

2. **Punching Machine:** Punching out the lever from the plank is done through this machine. In the punching process, the mechanical force is applied by a die (tool) to punch blank sheets. Now, the material that is removed is the new metal work piece or blank.

Fig -5: Power Press Machine

Fig -6: Closed view of Power Press Machine

3. **Notching Machine**: Notching is a metal cutting process used on sheet-metal, thin bar-stock or angle sections. In notching the cutting line of the slug formed must touch one edge of the plank or strip and operation of removal of metal to desired shape.

4. **Bending Machine:** A hydraulic bending machine is a tool in the machine shop used to bend the workpiece. The workpiece is bent for locking purposes.

Fig -7: Hydraulic Bending Machine

5. **Welding Machine:** Welding is used for joining the different metal parts by heating the surface. High adaptability and speed for automation in high-rate production processes.

Fig -8: Assembled lever

2.3 MANUFACTURING PROCESS

2.3.1 Initial Process:

1. 1500x2500 Hot rolled Steel sheets are sheared through a shearing machine into 16 planks, each of dimension 1500mm X 150mm.
2. One side of the plank is inserted into the punching machine, and 18 metal workpieces are punched out from that plank.
3. Then, bending of the lever is done for locking purposes.
4. Finally, the lever is then assembled to the almirah lock-and-key mechanism through welding.

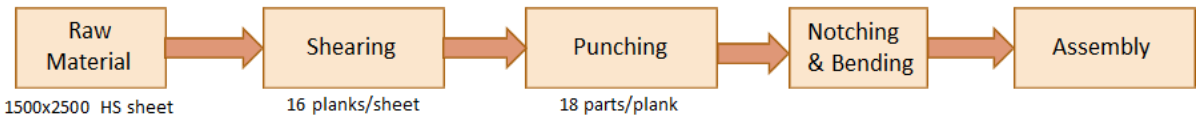

Fig -9: Initial Manufacturing Process of the lever

Fig -10: Arrangement of punching of the levers in the initial process.

2.3.2 IMPLEMENTED PROCESS:

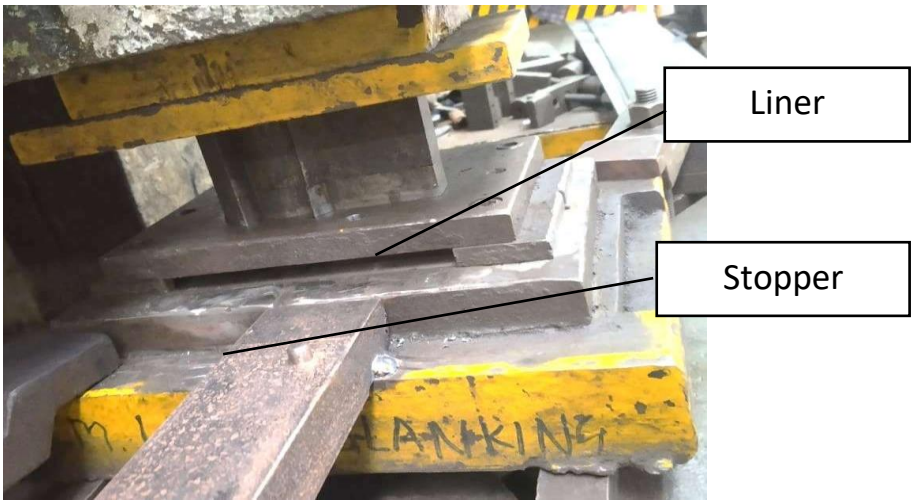

Fig -11: Die after suggestions

(A stopper was installed on the die base for perfect judgement of punching. Also, a new liner of 137 mm was introduced in the die base)

1. 1500x2500 Hot rolled Steel sheets are sheared through a shearing machine into 18 planks, each of dimension 1500mm x 137mm.
2. One side of the plank is inserted into the punching machine, and 11 metal workpieces are punched out from that plank. The punching is done at a new distance which is defined by the stopper installed so that the inverted alignment of the lever can be accommodated with efficiency.
3. Then, 11 more invertedly aligned metal workpieces are punched out after inserting the same plank into the punching machine.

4. Then, bending of the lever is done for locking purposes.
5. Finally, the lever is then assembled to the almirah lock-and-key mechanism through welding.

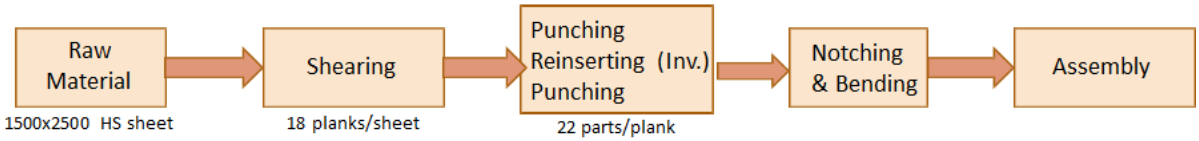

Fig -12: Implemented Manufacturing Process of the lever

Fig -13: Arrangement of punching of the levers in the implemented process.

3. ANALYSIS

3.1 Data

- Part (Almirah Lever) – 3mm thickness
- HR sheet – 1500x2500x3mm
- Cost/kg of HR sheet – Rs. 90
- Max 50 tons pressure at power press

3.2 INITIAL CONDITION

A study was conducted to observe the ongoing process and find out the specifications concerning these processes. Many working trials and reading were noted for the understanding purpose and the data collected is as follows.

Each sheet was sheared in 150x1500 and in total 16 planks were produced. After that further process was carried out that is performed on a power press and 18 metal work pieces were produced on a sheet. Each plank weighed 5.3 kg respectively and the amount of scrap produced was 3.2 kg. From the above parameters, we have noted that the total material productivity is 33% and 288 parts were produced from a single sheet.

Now by using demand forecasting we have seen that 15000 parts were needed yearly and to produce the required parts 53 sheets are required. The cost of the HR sheet per kg is 90 rupees respectively.

3.2.1 Given:

- Parts produced/year – 15000 units
- Sheared sheet dimensions – 150x1500mm
- Total planks produced – 16 units
- Total parts/plank – 18
- Planks weight – 5.3kg
- Scrap weight – 3.2kg
- Cost/kg of HR sheet – Rs. 90

3.2.2 Calculations:

(Actual Weight is measured of the part manufactured, Gross Weight is the actual material required for producing a certain part)

- Actual Weight – 0.1kg
- Gross Weight – 0.296kg
- Production cost for 15000 pcs Actual =15000*0.1*90 = 1, 35, 000
- Production cost for 15000 pcs Gross = 15000*0.296*90 = 3, 99, 600

- Total parts produced in one sheet = 16x18 = 288 parts
- Sheets required for 15000 pcs = 15000/288 = 53

3.3 IMPLEMENTED PROCESS

Further study is conducted to find the solution which is more feasible than the ongoing process. First, the hypothetical book study was made for an assumed study which consists of some rough figures on the development of new processes. The study was carried out by a slight change in the liner of the die. The liner was fixed at 150 mm but it was modified to 137 mm to conduct the study. The 137 mm was decided by considering tolerance, and allowance. Clearance was also settled up for the process to be efficient and to ensure that no unnecessary scrap is produced. Certain changes in the production process were also done at first the sheet was entered only once but now the sheet is entered in the power press twice to perform inverse press of the part. A stopper was also introduced to get the exact position of the simultaneous part which was inversely pressed.
Now for the updated process, each sheet is sheared into 137x1500 mm. The number of planks produced is 18 and the metal workpiece (Almirah Lever) produced are 22 respectively. The weight of each plank produced is 4.8 kg. The amount of scrap produced for the improved process is 2.2 kg respectively. The above parameters are considered and a conclusion is made that the material productivity is increased from 33% to 56%. It is seen that a 23% increase in material productivity has been there. Now 396 parts are produced from a single sheet.

3.3.1 Given Condition

- Parts produced/year – 15000 units
- Sheared sheet dimensions – 137x1500mm
- Total planks produced – 18 units
- Total parts/plank – 22 units
- Planks weight – 4.8kg
- Scrap weight – 2.2kg
- Cost/kg of HR sheet – Rs. 90

3.3.2 Calculations

- Actual Weight – 0.1kg
- Gross Weight – 0.218kg
- Production cost for 15000 pcs Actual = 0.1x15000x90 = 1, 35,000
- Production cost for 15000 pcs Gross = 0.218x15000x90 = 2, 94,300
- Total parts in one sheet = 18x22 = 396 parts
- Sheets required for 15000 pcs = 15000/396 = 38

4. RESULT

Specifications	Previous	Implemented	Benefits
Sheet size	1500 X 2500 X 3	1500 X 2500 X 3	No change
Plank size	1500 X 150	1500 X 137	more planks sheared
Plank weight	5.3 kg	4.8 kg	easier to handle
No. of planks	16	18	more parts punched
No. of parts	18	22	productivity improved
Scrap weight per plank	3.2 kg	2.2 kg	scrap reduced

Scrap Cost/year	Rs. 3,99600/-	Rs. 2,94300/-	scrap cost reduced
Sheets Required/year	53	38	Requirement reduced
Productivity	33%	56%	Increased
Parts produces/sheet	288	396	Increased

A total savings of 1,05,300/- is estimated in the production of 15000 units of Amirah Lever. Moreover, the savings by the scrap reduction is much more beneficial to the company. As the sheet requirement is reduced, so, less money will be out in the market for certain sheets to be purchased and in relation to that less material handling is required as the desired amount of material to be transported is less. Labor costs will also be reduced as the certainty of working is reduced.

Now, after processing the raw material then also the effects will be observed as less scrap is generated and more resources are utilized so it will help in increasing the overall profit of the industry by means of material handling, labor required for the work, reduction in work in process inventory, the tool life of the shearing machine is also increased as fewer sheets are to sheared, less time is required for the same process. The scope of increase in productivity is depicted and how productivity results in enhancing the efficiency of working, and optimization of material and resources is observed.

5. KAIZEN SHEET

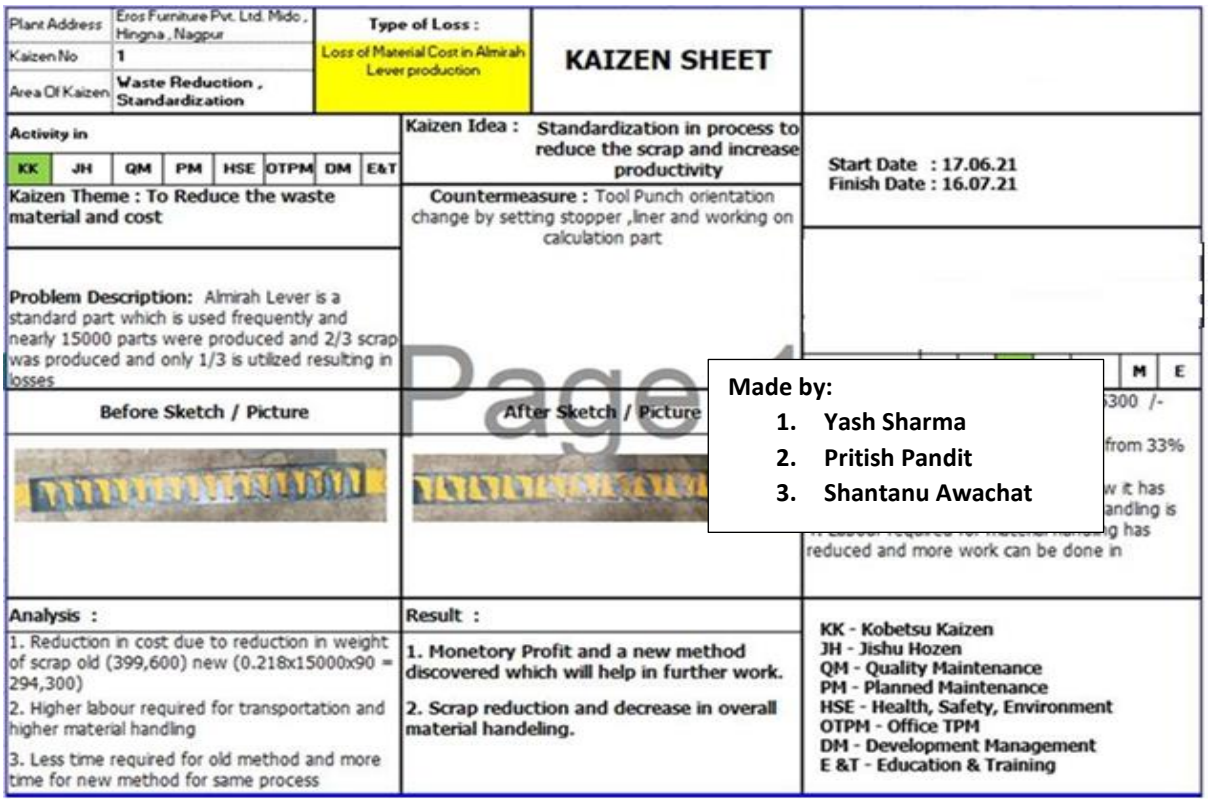

Fig -14: Kaizen Sheet

6. CONCLUSION

The purpose of this case study is to understand the importance of designing and optimizing the work pieces that are to be produced and how a difference is created with minor changes in it. It has been observed in the study in a well explanatory way. For this, we developed a theoretical framework of the study and understand the formulae behind them and their

findings respectively. The trial-and-error method was used to get to the solution and the framework was generated and tested. After that also we need some modifications to improve utility. Taking the complete analysis, we implemented kaizen and found the best suitable way to perform the operation and how it redefines the way to perform the study.

A well-planned study can change the perspective of the work, this has been observed in the above study. Some changes are done like stopper, liner, and method to perform the operation and a huge difference is observed that is 1,05,300 Rupees of savings annually. Moreover, various productivity-increasing parameters are observed that are market capital, labor cost, tool life, material handling, work in process inventory, scrap quantity and so on.

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