STUDY ON VARIOUS LOSSES IN PROCESSES & TO REDUCE THE WASTAGE-CASE STUDY OF STEELCO GUJARAT LTD.

MAYANK DEV SINGH, NISARG SUTHAR, RITESH PATEL, PRADIPSINH VAGHELA, RONAKSINH MAHIDA

Abstract- There are numerous industries dealing with sheet metal production, hot rolling, cold rolling of sheets, galvanizing, and subordinate processes like cutting, trimming, cleaning etc. on steel sheets. Steelco Gujarat Pvt. Ltd. is one of such industries, which is dealing with finishing of raw steel sheets, reducing gauge and producing annealed, galvanized and corrugated sheets. During these processes large losses occur resulting in loss of precious metal, energy and time, ultimately leading to large economic losses to company as well as nation. Our attempts are based to study and reduce such losses occurring in production as well as processes of production by use of advanced production techniques compared to conventional methods. This will lead to better product quality with minimum possible losses, help in reducing processing cost and support energy conservation.

Keywords- Sheet Metal Processing, Hot Rolling, Cold Rolling, Galvanizing, Trimming, Pickling, Losses.

I. INTRODUCTION

There are thousands of industries that deal with processes like sheet metal production, hot rolling, cold rolling of sheets, galvanizing, and subordinate processes like cutting, trimming, cleaning etc. working on steel sheets. Our study is based on observing the each process occurring during production in detail and study the data related to losses occurring. Optimizing the losses occurring in small or large process and minimizing them to lowest possible levels. Hence, attempts have been made to achieve predefined goals and loss norms set by the industry. Comparison of conventional techniques and advanced techniques that will have effect on the yield as well as the quality of product. Some of the suggested methodologies like advanced production techniques may lead to energy conservation and help in environmental and social issues. Use of modern techniques and process improvement will result in loss reduction to large extend ultimately leading to more economical benefit and improved quality of product. In this firm the raw sheets are generally supplied from ESSAR Pvt. Ltd. These sheets are Trimmed, Pickled and its gauge is reduced. Then galvanized and heat treated according to requirement of customer and dispatched. There are various processes carried out like annealing, cut to length, pickling, rolling, acid cleaning, galvanizing, corrugating of sheets etc. During every process carried out in the entire journey there is wastage of material like scrap losses, pickling losses etc. Firm has put on some norms for the losses occurring in every processes, so here we got few data and by analyzing the data we thought that number of process do not match firm’s norms ,so we found reasons of wastage and methods to reduce it to predefined norms.

1.1 Company Profile:-
Skinco Gujarat Ltd. Industry is located at Palej, Bharuch. Steelco Gujarat Ltd., an ISO 9001-2000 & ISO 14001 certified company is the Indian Chapter of the $2.5 billion Comcraft Group having presence in 45 countries across the globe with 250 establishments in Steel, Aluminum, Plastics, Chemicals, Non Ferrous metals, Engineering and Industrial components. Backed by Comcraft's managerial expertise and technological support from Hitachi of Japan, Steelco Gujarat Ltd makers of paper thin steel stands as a force to reckon within the Indian scenario. Vision of the Firm is: “To achieve excellence in our product service process system environment upgradation and above all customer satisfaction, that goes beyond contractual obligation” - Steelco

1.2 Company products:-
The products manufactured in the company are Cold Rolled Steel Coils/ Sheets (Full Hard and Annealed), Hot Dip Galvanized Steel Coils and Plain / Corrugated Sheets, Cold Rolled Sheets and Coils in the thickness range of 0.12mm to 2.5mm and width range of 100 mm to 1300mm. Galvanized Sheets (plain and corrugated) and Coils in the thickness range of 0.12 mm to 0.70 mm and width range of 600 mm to 1000mm. The raw material generally used for the products is steel coils.

[Figure1:Photographs of Steelco]
II. LITERATURE REVIEW

According to Yan Ping Sun et al, there was horizontal vibration problem in strip rolling which was studied and dynamic model was established. The mechanism of self-excited vibration was analyzed.

The main reason of surface quality of strip is self-excited vibration. A vertical natural frequency and vibration mode of the rolling mill are obtained by finite element method. It lays the theoretic foundation for future researches on rolling mill vibrations.

According to Yoichi Haraguchi et al, there is certain apparatus that for manufacturing that comprises a final stand, with standing side members, and a cooling apparatus. The cooling apparatus comprises rows of upper surface cooling nozzles, rows of lower surface cooling nozzles, and an upper surface guide on the upper surface side of the sheet. An end portion of the cooling apparatus on a side of the final stand is arranged between the standing side members of the housing.

When defining a width of a uniformly cooled region, an average gap distance (W) between the end portion of the width of the uniformly cooled region and the standing side member of the housing; a gravity acceleration rate, an average water volume density of the width of the uniformly cooled region, and a value determined Weight and average distance between the upper surface guide and the upper surface of the sheet, a specific relation is satisfied.

According to M. Geiger et al, when the laser cutting experiments were studied using an industrial laser cutting system including a 1 kW CO₂- laser and a two axis CNC cutting table. Oxygen assisted cutting was carried out with a laser beam in fundamental mode focused by a 5 inch ZnSe lens. The materials investigated include deep drawing steels, mild steels and stainless steels.

The influence of beam polarization and cutting mode on the cut quality and the development of the heat affected zone is demonstrated. Lateral accuracy, micro geometry of the cut and mechanical properties of cut samples are reported as function of process parameters. As was shown earlier, laser cut samples exhibit finished product quality and mechanical properties that fulfill the requirements of DIN and ASTM standard values. Examples of 3D cutting applications for automobile industry are given.

III. PROBLEM STATEMENT AND OBJECTIVE

3.1 Layout of processes:

The layout of processes which is currently in industry is shown below:

As the raw material which a rolled aluminum sheets having average weight of 15-20 tons are firstly trimmed in a trimming machine where sheets are cute in desired length and width, edges of the sheet are trimmed out here, then it is loaded to pickling line of 90 meters length having number of rolls and chemicals spraying continuously on sheet, which cleans up the dirt of sheet, then it comes to heart of the company, 6- high rolling machine , where the gauge of sheet is reduced to desired requirement of customer, machine having 6 rolls, 2 working rolls and other 4 supporting rolls, if the sheet has to made with thin gauge then it is passed again through 6-high rolling mill to reduce its thickness up to 0.12 mm, other processes like annealing, galvanizing, cut to length etc. are carried out according to the need of customer and then finally it is packaged and wrapped into aluminum foils and then dispatched.

3.2 Main processes of the company:-

3.2.1 Cut to length:

It is a process of trimming out the excess of material from the sheet rolls, it reduces the width according to the requirement, in these a trimming machine is used which cuts the sheet into different width, and then the sheet is further exposed to pickling process. As in trimming there is loss of excess material, which is also called scrap loss, material from both edges are trimmed out.

3.2.2 Continuous pickling lines:

Its primary function is to remove the oxidized iron, or scale, that forms on the surface of the steel. The unit is capable of pickling 1.2 million tons per year up to ¼ “thick and 62” wide. This includes all cold roll and galvanize products, as well as pickled and oiled hot roll (P&O) purchased by customer who desire surface quality more conductive to painting or plating.

The heart of pickling line, its acid bath, consists of four tanks in a row containing HCL in concentrations ranging from 2% to 10% at temperature between 180 and 200 degrees Fahrenheit. Chemical inhibitors are added to discourage the acid from attacking the steel.
beneath the scale. Here some amount of reduction in weight is measured which includes in the list of scrap losses.

3.2.3 Six-High rolling mill:
A machine for the pressure shaping of metal and other materials between rotating rolls. In a broader sense, a rolling mill is an automatic system or line of machines that performs both rolling and auxiliary operation: transport. The wide range of products able to be rolled by these mills includes low, medium and high carbon steels, along with copper, brass and a number of alloys. Additionally, a very wide range of strip widths can be treated, and output thickness can be as thin as 0.12 mm. And with mill speeds of up to 1400 meters per minute, high level of productivity and cost effectiveness are guaranteed. In 6 high rolling mill, 2 main rolls are the working rolls which actually reduces the thickness of the material other rolls are the supporting rolls which helps to compress the material to a greater extent.

Hot rolling of large ingots is the dominant method of producing plate, sheet, and foil aluminum products. Hot rolling has typical recovery rate of about 82%, which means 18% of the original material is lost as planned end cut and scalping, or as incidental (unplanned) scrap. Generally, scrap generation is due to edge cracking of hard alloys and surface defects of soft alloys.

IV. PROBLEM STATEMENT
During sheet metal processes in the firm, large losses occur resulting in loss of precious metal, energy and time. Ultimately leading to large economic losses to company as well as nation. Our attempts are based to reduce such losses occurring in production as well as processes of production by use of advanced production techniques compared to conventional methods. This will lead to better product quality with minimum possible losses, help in reducing processing cost and support energy conservation.

4.1 Objectives:-
• To observe all the processes minutely & detail analysis of the available data.
• To identify all the scrap losses occurring in the processes and there reasons.
• To reduce the maximum losses by alternative remedies, to match the predefined norms set by the company.

V. PROPOSED METHODOLOGY
5.1 Methodology:-
The current technology and machines used for the entire process line of steel sheet right from the uncoiling of raw material to packaging of final product used are conventional methods. There are several modern techniques and machinery that can be used for reducing wastage and loss to appreciable levels in particular processes and stages.

5.2 Modification Method:-
After detailed analysis of the techniques and machinery used in the processes of the plant layout, the processes where losses are up to greater extend and where they can be reduced are selected. The innovative and applicable genuine ideas which can help in reducing waste within limits of cost can be applied. The layout can be thus modified with new techniques.

VI. INTRODUCTION OF NEW TECHNIQUES
- Trimming:
  - Water jet Cutting
  - LASER Trimming
- Pickling:
  - Improved guiding path
  - Advanced uncoiling to prevent end cut loss
- Cut to length:
  - Mechanisms producing width spread/variation, edge-drop and shape
  - Implementation of portable edge-drop and width measurement systems
  - Development of intelligent soft-sensors

6.1 Water jet cutting:
Water jet cutting is a process used to cut materials using a jet of pressurized water as high as 60,000 pounds per square inch (psi). Often, the water is mixed with an abrasive like garnet that enables more materials to be cut cleanly to close tolerances, squarely and with a good edge finish. Water jets are capable of cutting many industrial materials including...
Advantages of water jet cutting are as mentioned:
Light weight, even a small weight reduction translates into major cost saving. No delamination, it eliminates the potential for the delamination of composite materials that can occur with conventional cutting techniques. Near-net shape, the composite part is made to near final shape, so forming and conventional machining operations are minimized. No hard tooling, Water jet cuts use a single tool (cutting head) moved under computer control. No hard tooling is needed for some individual part as in conventional machining. About 95% of the water jet machining involves edge trimming, hole making, and creating openings in the surface such as maintenance access ports. It pays for itself very quickly if you can keep the work flowing.

### 6.2 Comparison Of Laser Cutting And Water Jet Cutting:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Laser Cutting</th>
<th>Water Jet Cutting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method of imparting energy</td>
<td>Light 10.6 µm (far infrared range)</td>
<td>Water</td>
</tr>
<tr>
<td>Physical machine set-up</td>
<td>Laser source always located inside machine</td>
<td>The working area and pump can be located separately</td>
</tr>
<tr>
<td>Typical process uses</td>
<td>Cutting, drilling, engraving, ablation, structuring, welding</td>
<td>Cutting, ablation, structuring</td>
</tr>
<tr>
<td>Materials able to be cut by the process</td>
<td>All metals (excluding highly reflective metals), all plastics, glass, and wood can be cut</td>
<td>All materials can be cut by this process</td>
</tr>
<tr>
<td>Cutting materials with limited or impaired access</td>
<td>Rarely possible due to small distance and the large laser cutting head</td>
<td>Limited due to the small distance between the nozzle and the material</td>
</tr>
<tr>
<td>Common applications for this process</td>
<td>Cutting of flat sheet steel of medium thickness for sheet metal processing</td>
<td>Cutting of stone, ceramics, and metals of greater thickness</td>
</tr>
<tr>
<td>Initial capital investment required</td>
<td>Comparatively lower</td>
<td>Comparatively Higher</td>
</tr>
<tr>
<td>Parts that will wear out</td>
<td>Protective glass, gas nozzles, plus both dust and the particle filters</td>
<td>Water jet nozzle, focusing nozzle, and all high-pressure components such as valves, hoses, and seals</td>
</tr>
<tr>
<td>Cut surface appearance</td>
<td>Cut surface will show a striated structure</td>
<td>The cut surface will appear to have been sand-blasted, depending on the cutting speed</td>
</tr>
<tr>
<td>Degree of cut edges to completely parallel</td>
<td>Good; occasionally will demonstrate conical edges</td>
<td>Good; there is a &quot;tailed&quot; effect in curves in the case of thicker materials</td>
</tr>
<tr>
<td>Degree of only partial burring</td>
<td>No burring occurs</td>
<td></td>
</tr>
</tbody>
</table>

| Thermal stress of material | Deformation, tempering and structural changes may occur in the material | No thermal stress occurs |

### 6.3 Mechanisms producing width spread/variation, edge-drop and shape:
Mechanisms producing width spread/variation, edge-drop and shape as well as the mutual interaction between these phenomena in cold rolling for different materials and mills (4-high, 6-high, cluster mills). Implementation of portable edge-drop and width measurement systems to be used at different locations and mills where no such facilities are available. Strip-edge position measurement will also be included. Use of the gathered data to calibrate and validate the models.

For the detection of the strip edges, a light-section system has been selected and tested. This measurement system delivers 2-dimensional measuring values. That means, besides the regulation of the edge determination in horizontal position, the vertical position is collected at the same time.

**Portable width measurement system:**

**Characteristics:**
- Width: 820-1700 mm
- Strip Deviation: +/- 50mm
- 4 Telescopic Cameras with overlapping
- Field of 440 mm
- Laser Telemeters with distance of 310 mm
- Not sensible to temperature variations

The investigation of the specific local situation at the four-stand cold rolling mill and the decision of the position to install the measuring system for the edge-
drop were done. Figure above in shows the first possible position in the entry and exit area of the tandem mill. After further investigations about the installation a new place for temporary installation of the gauge and first measurement campaigns. For that reason, the original location mentioned above was temporarily given up for a better accessible location at stretch-leveling machine. The main advantages of the new location are, on the one hand, the better accessibility and, on the other hand, the possibility to wrap round strips, so that both sides of the strip can be measured with just one gauge. Therefore the measurement device had to be revised constructively to fit the new installation location. It supported the integration into the mill instrumentation by preparing the installation location.

6.4. Sensors:

Instead of measured data, the soft-sensor simulates the strip condition, mainly edge-drop. For achieving this, the values mentioned in previous measured data manually are used to simulate the actual rolling condition and, concerning to the project, edge-drop can be predicted. With this strategy, it should be possible to compute the edge-drop according to specific kind of materials/dimensions, which can be classified and, if possible, with existing actuators, even reduced.

The main disadvantage of model-based soft-sensor is its complexity and the difficulty of tuning the many parameters involved. The alternative solution for the estimation of edge-drop is using a data-driven approach (used here).

The correlation of rolling force is very high. The correlation of bending on edge-drop is reciprocally proportional and lower compared to the roll force. The entry strip thickness and the exit thickness are good correlated with the edge-drop. Instant strip tensions between stands are correlate positive with edge-drop.

The influence is less than roll force or thicknesses, but significant. Only the last tension between stand 4 and the coiler’s correlated negative. Entry strip width does not have an influence on edge-drop.

6.5. Strip edge cooling:

Thermal control is a well-known technique to influence the roll shape through locally different cooling. Therefore, an actuator that as suggested is used in strip edge cooling. The idea is to cool down the strip edges before rolling to make them harder which will decrease the reduction at the strip edges. This has been tested at the pilot plant rolling mill. Steel strips with a width of about 50 mm were used during the trials. First, three thermocouples were mounted on one side of a 1.26 mm thick strip where the distance from the strip edge was 1.5, 4 and 19 mm, respectively. Cans with cooling spray where the spray is around ~50°C were used for cooling. Cooling was applied on one side and the thermocouples were mounted on the other side. There was no logging of the temperature but after cooling during a few seconds the measured temperature was very low. After these first trials were done, a cooling device was constructed where six cans with cooling sprays could be mounted and where a lever could be used to start the cooling of all six cans simultaneously; see Figure . In this cooling device one of the strip edges could be cooled down. The cooling nozzles could be adjusted to come close to the strip surface.

VII. DATA COLLECTION & DATA ANALYSIS

7.1 Plant Layout

1- HRS Hot Rolled Slitter
2- CPL Continuous Pickling Line
3- 6-High Rolling Mill
4- Annealing Furnace
5- CGL Continuous Galvanizing Line
6- Corrugated Sheet Making Process
7- Packaging
8- Admin Department
9- Dispatch

7.2 Number of scrap losses in operations:

There are numerous losses which occurred in process line; which are described below:

HR trimming loss, HR sheet cutting, Pickling loss, HR coil end loss, HR coil end loss, CR trimming loss,
CR coil end loss, Baby coils (CPL, CRM, CRS), ECL loss, SKP loss, CTL loss.
Out of these we have taken only those losses or waste that can play a major role.

7.3. Reasons For The Rejection:
These are the following commonly reasons we found in survey and through data study that may cause a heavy rejection. Heavy fold marks, Unload due to strip, Edge crack, High loaded, Gauge variation, Break line, Scratch line, High hardness, Heavy skidding marks, Untrimmed.

7.4. Overall Yield Analysis Report (CRM Division):

<table>
<thead>
<tr>
<th>SCRAP LOSSES</th>
<th>CUMULATIVE</th>
<th>INTERNAL NORMS</th>
<th>TO BE ANALYSED</th>
</tr>
</thead>
<tbody>
<tr>
<td>HE Trimming Loss</td>
<td>1.999</td>
<td>1.54</td>
<td>1.40</td>
</tr>
<tr>
<td>HE Sheet Cutting</td>
<td>0.000</td>
<td>0.00</td>
<td>0.45</td>
</tr>
<tr>
<td>Rolling Loss</td>
<td>0.999</td>
<td>0.67</td>
<td>0.05</td>
</tr>
<tr>
<td>BR- CR Coil End Loss</td>
<td>4.571</td>
<td>3.06</td>
<td>2.50</td>
</tr>
<tr>
<td>CR Trimming Loss</td>
<td>7.126</td>
<td>4.77</td>
<td>4.75</td>
</tr>
<tr>
<td>CR Sheet Cutting</td>
<td>3.241</td>
<td>2.17</td>
<td>1.00</td>
</tr>
<tr>
<td>CR Coil End Loss</td>
<td>6.208</td>
<td>4.19</td>
<td>4.00</td>
</tr>
<tr>
<td>CR Baby Coils</td>
<td>1.075</td>
<td>1.14</td>
<td>0.50</td>
</tr>
<tr>
<td>ECL Loss</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Ship Loss</td>
<td>0.050</td>
<td>0.44</td>
<td>0.25</td>
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<tr>
<td>TOTAL SCRAP LOSSES</td>
<td>24.737</td>
<td>17.93</td>
<td>15.00</td>
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</tbody>
</table>

7.5Comparatively Defect-wise Diversion
Summary (Galvanizing)

<table>
<thead>
<tr>
<th>DIVISIONS</th>
<th>APR 2013</th>
<th>MAY 2013</th>
<th>JUN 2013</th>
<th>JUL 2013</th>
</tr>
</thead>
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<tr>
<td>AT COILS INPUT QTY</td>
<td>45.721</td>
<td>13.981</td>
<td>6.439</td>
<td>7.126</td>
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<tr>
<td>QTY %</td>
<td>3.79</td>
<td>10.44</td>
<td>5.90</td>
<td>11.313</td>
</tr>
<tr>
<td>AT COILS OUTPUT QTY</td>
<td>37.927</td>
<td>23.884</td>
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<td>13.304</td>
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As stated our objectives, we studied all the processes minutely and analyzed different losses occurring in processes and we collected the norms of company for that following losses that are found in processes. We observed processes and found fewer reasons for the occurrence of the losses, then using literature papers, integrating modern methods and study of other similar modern industries; we defined few methods and techniques that can be implemented to reduce wastage. The process layout of company is so compact and rigid, that implementing any new proposed techniques will lead to change numbers of things, as Steelco is not an automated company; its still leads the works manually, so to reduce greater wastage is only possible through strong and rigid supervisions over each and every process. The suggested techniques can applied over conventional method to reduce waste up to large extent on long run, though the initial cost of investment are high but can prove effectively for longer run.

REFERENCES