# Evaluation of Waste Minimization Alternatives for the Galvanizing Production Process: A case study of Uganda Baati Ltd.

Adam Kalanzi[1], B. Kariko-Buhwezi[2], Luca Cellesi[3]

[1]Graduate Student, Faculty of Technology, Makerere University, P. O. Box 7062, Kampala, Uganda
Corresponding author email: akalanzi@tech.mak.ac.ug
[2]Senior Lecturer, Faculty of Technology, Makerere University, P. O. Box 7062, Kampala, Uganda
[3]Senior Lecturer, Dipartimento di Energetica “S. Stecco”, University of Florence, Italy.

**ABSTRACT**
Uganda Baati Limited is one of the largest manufacturers of metal roofing products in East Africa. It is faced with a large amount of waste from the production process of the galvanizing line in terms of defects and scrap which amounts to approximately 646 metric tons a year out of 50,544 metric tons of prime sheets. The aim of the study was to investigate the possibility of minimizing waste generation in the production process in order to propose technically feasible and economically practical alternatives to be employed by Uganda Baati. The study focused on analyzing the production processes of the galvanizing plant with an interest of identifying the causes, which lead this waste. Measurements of parameters such as temperature and flow were taken and compared with the standard operating parameters. The identified major factors leading to waste included: frequent stoppages, poor storage of Cold Rolled (CR) coils and use of operating parameters which are beyond the required standard. Stoppages are caused by factors such as: the sheet getting broken at various points, electrical faults, sheet getting damaged and stuck at various points on the production line. The study concluded from the measurements taken at various points on the production line and statictical analysis, that waste is due to inexact operating parameters, human factors, frequent stoppages, improper materials handling and storage. As such, a Manual Guideline containing some Cleaner Production (CP) options has been developed which will help to address how to minimize these wastes and improve on the efficiency of machines and equipments.

**Key words**: Cold Rolled Coils, Prime sheets, galvanizing, cleaner production

## 1. INTRODUCTION

The total Production at Uganda Baati in Constant Galvanizing Line (CGL) department is based on the total number of prime sheets produced per day. The daily target is approximately 130 metric tons with day shift taking a high percentage of about 51.6% and night shift taking the remaining 48.4%. However, uncertainties as well as general machine breakdowns leading to severe stoppages further lowered production figures. Steelmakers are facing an ever-increasing demand to improve product quality, to not only minimize scrapping and increase productivity but also to ensure customers satisfaction (Demurger et al, 2008). Concerning the latter, measures can be taken to ensure final product quality. The most common procedure consists in ensuring absence of unwanted defects through a variety of non-destructive testing methods, repairing defects when possible and scrapping when not. While this allows for defects detection and guarantees the final product conformity, it does not affect defect occurrence and therefore does not help reduce scrapping. Defect formation may happen at different stages along the steel manufacture route. To reduce defect occurrence, it is therefore important to understand the mechanisms of formation of the different kinds of defects, and quantify the influence of the processing parameters. At the constant galvanizing line of Uganda Baati, the sheet getting broken, electrical faults and the sheet getting stuck at various points are some of the major causes of stoppages due to failure of machinery. This leads to downtime presenting a major loss to the company. While there is little that can be done about obsolescence, something can be done about reducing stoppages in the production process through the use of cleaner production technologies. Causes of stoppages such as feed roll failure, repairing shaft on galvanizing roll, looper failure, nozzle cleaning, run out conveyor problem, replacing new stabilizers, boiler failure, change stamp, blower failure e.t.c, do not occur frequently and their effect on production performance is minimal since the number of their occurrence is very small. Whenever there is a stoppage, there is a reject or scrap produced because the sheet will be stopped and the part of the sheet in contact with the zinc bath will be spoilt. It is there fore important to know the real causes of stoppages so that they can be minimized. The causes of stoppages on the production line were traced using the methodology below.

## 2. METHODOLOGIES EMPLOYED

The papers presents the findings aimed at minimizing rejects and scrap from formation the production process of the constant galvanizing line at Uganda Baati Ltd. The specific objectives were to carry out an in-depth study of the current production processes in order to derive means for waste minimization; to identify and document the various input, output and waste streams in the process and develop the relevant characteristics; to develop a cleaner production manual guideline for waste minimization at Uganda Baati. The following were done to achieve the mentioned objectives:

i. An in-depth study of the current production processes was carried out and this involved taking measurements for various parameters such as temperature of baths, voltage and current flow. This helped to know the various causes of stoppages on the production line. Visual inspection of equipment and machinery plus raw material storage was done as illustrated in figure 1 and 2 below,
ii. Identification and documentation of the various inputs, output and waste streams in the process and developed the relevant characteristics in form of waste production and prime sheet production monthly,
iii. Development of a cleaner production manual guideline for waste minimization after ascertaining the root causes of the waste. The manual contains cleaner production options to be employed.

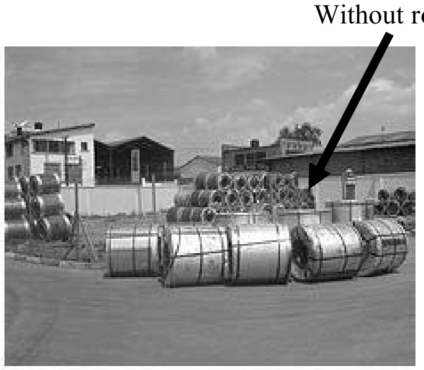


**Figure 1:** CR Coils Storage in bond


**Figure 2:** Raw material Storage inside

## 3. FINDINGS

The following paragraphs summarize the findings of the investigation. From a visual inspection of the current situation at the plant and measurements taken, the following were found;

### 3.1 Improper raw material storage

As indicated in figure 1, it was observed that most CR Coils are kept outside without roofing which leads to rusting of the coils especially when it rains. Figure 2 shows improper storage of zinc ingots.

### 3.2 Unplanned maintenance schedules

It was observed that electrical motors on the production process fails frequently leading to various electrical faults. This causes stoppages on the production line hence leading to formation of rejects. There was lack of proper maintenance schedule for electrical motors, barrel corrugators and the galvanizing kettle.

### 3.3 Improper monitoring of parameter conditions

Standard operating parameters such as temperature of different baths on the production line where clearly indicated on charts. However, after measurements, the values obtained where not tallying with the standard values. These were at pickling point, zinc bath and at the dichromate tank.

### 3.4 Weakness by management

Since the company has a policy of selling its rejects at a relatively low price as compared to prime sheets, little effort is put in to trace the root causes of rejects and scrap formation in order to curb them.

### 3.5 Human factors

The department has a large number of casual workers whose technical know-how is low as far as the operation of the galvanizing plant is concerned.

## 4. ANALYSIS OF RESULTS

### 4.1 Measurement Analysis: Electrical motors

The values of current readings taken for a few electrical motors (Root air blower motor, Bridle roller motor) on the three phases are illustrated in the table 1 below.

**Table 1**: Current and voltage readings for electrical motors

| Motor type | Voltage (V) | Current (A) |
|---|---|---|
| Root air blower motor | 417 | 40.5 |
| | 419 | 42.6 |
| | 417 | 43.8 |
| Bridle roller motor | 413 | 7.7 |
| | 411 | 8.0 |
| | 412 | 7.9 |

These values taken for current and voltage were fluctuating and the most probable cause of current unbalance on any induction motor is voltage unbalance. Current unbalance rises sharply with a small voltage unbalance. Therefore, in any current unbalance problem, the suspect source is voltage unbalance. The maximum allowable voltage unbalance from winding to winding is 2% (Taylor, 2006). The voltage and current unbalance were calculated to determine whether the unbalance was with in the acceptable limits or not as shown below.

#### 4.1.1 Root air blower motor

The voltage readings between phases were;
$L_1$ to $L_2$ = 417V,
$L_2$ to $L_3$ = 419V,
$L_3$ to $L_1$ = 417V

The average voltage = $\frac{17+419+417}{3}$ = 417.67V

By calculating the unbalance for each phase through getting the difference between the voltage reading and the average, we shall have;
$L_1$ to $L_2$ = 417.67V − 417V = 0.67V
$L_2$ to $L_3$ = 417.67V −419V = -1.33V
$L_3$ to $L_1$ = 417.67V − 417V = 0.67V
It is seen that 0.67V is the unbalance.
Using the formula;

$$\% \text{ unbalance} = \frac{Maximum\ unbalanced}{Average\ voltage} \text{ x } 100\%$$
$$= \frac{0.67}{417.67} \text{ x } 100\%$$
$$= 0.16\%$$

This voltage unbalance is less than 2% hence acceptable as seen in figure 3 below.
The current readings between phases were;
$L_1$ to $L_2$ = 40.5A,
$L_2$ to $L_3$ = 42.6A,
$L_3$ to $L_1$ = 43.8A

The average current= $\frac{0.5+42.6+43.8}{3}$ = 42.3A

By calculating the unbalance for each phase through getting the difference between the current reading and the average, we shall have;
$L_1$ to $L_2$ = 42.3A- 40.5A = 1.8A
$L_2$ to $L_3$ = 42.3A-42.6A = -0.3A
$L_3$ to $L_1$ = 42.3A-43.8A = -1.5A
It is seen that 1.8A is the unbalance.
Using the formula;

$$\% \text{ unbalance} = \frac{Maximum\ unbalanced}{Average\ current} \text{ x } 100\%$$
$$= \frac{4.8}{2.3} \text{ x } 100\%$$

= 4.26% this current unbalance is 4.26%.

The effect of voltage unbalance on current unbalance for any type three-phase induction motor is shown in figure 3.

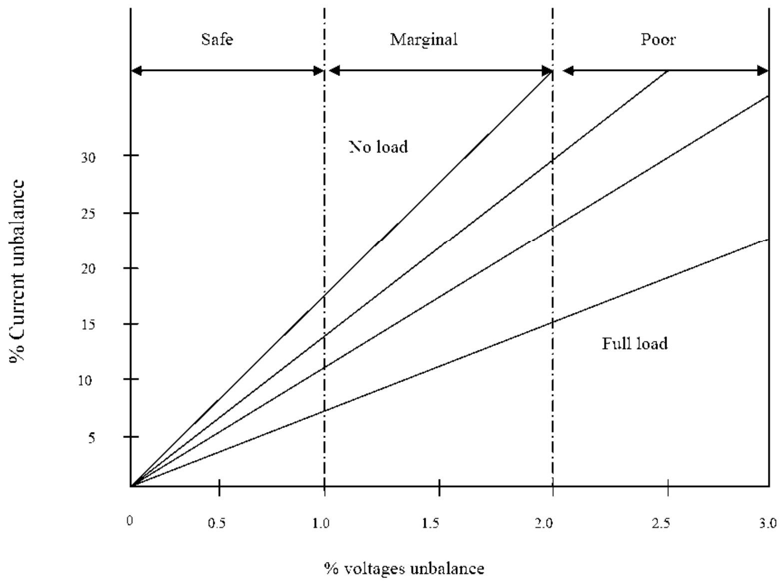


**Figure 3**: Effect of voltage unbalance on current unbalance (Taylor, 2006)

Voltage unbalance will cause a current unbalance, but a current unbalance does not mean that a voltage unbalance necessarily exists. The high variations in current for a root air blower whose current unbalance is 4.26%, causes it to flow in a winding of least resistance. This leads to increased current flow in other windings leading to more generation of heat (Taylor, 2006). It can there fore be concluded that one of the factors leading to stoppages due to electrical faults is motor overheating which in turn causes frequent motor failures on the production line.

**4.2 Measurement Analysis: Pickling point**

The values of the readings taken were 54.5°C, 55.2°C, 54.2°C and 55.5°C. These values were not within the required temperature ranges of 40°C-50°C.

**4.3 Measurement Analysis: Zinc bath**

The preset temperature values on both day one and day two was 490°C. The reading taken at the control panel was 475°C on day one while on day two; the readings taken were 498°C, 499°C and 493°C. However, according to information displayed at the plant, the standard operating parameter for zinc bath temperature is 455°C-475°C. Steel galvanizing baths are relatively resistant to attack by molten zinc in the temperature range of 440ºC (825°F) to 470°C (880°F) but are severely attacked at higher temperatures as illustrated in figure 4 (Teckcominco, 2009).

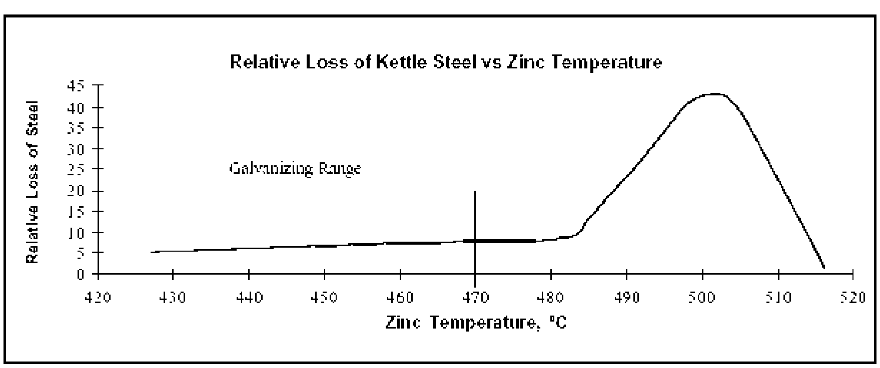


Figure 4: **Kettle life versus heat input (Teckcominco, 2009)**

**4.4 Measurement Analysis: Dichromate tank**

The optimal temperature ranges for this solution is between 45°C-50°C. However, the readings taken were 58.2°C, 57.9°C, 60.3°C, 66.2°C, 56.5°C, and 51.5°C. These values were not within the required temperature ranges.

**4.5 Measurement Analysis: Degreasant**

Since the optimal temperature value for this mixture (degreasant) is between 60°C-80°C and the values of readings taken were 72.6°C, 70.7°C, 70.4°C, 70.1°C, 70.3°C, and 71.2°C for day one and two, the values were within the required limits.

## 5. CONCLUSIONS

The study demonstrates from the measurements and statictical analysis that waste (rejects and scrap) at CGL is due to;

i. Inexact operating parameters, human factors, frequent stoppages, improper materials handling and storage,
ii. According to machine operators, application of some processing material such zinc ammonium chloride in the zinc bath had no standard quantity to be put in but only estimates. However in case of little/high application of some processing materials, the end result is poor appearance of the sheet. Responses on dross removal showed that it was not done regularly,
iii. Materials handling and storage in general was not proper especially at the bond where there is no roofing for the CR coils,
iv. About cleaner production technology training and knowledge, the employees admitted that they had some training on kaizen but have never had any Cleaner Production training. It is important to further note that management has little concern about the rejects and scrap produced at CGL since the company has a policy of selling rejects and scrap at a lower cost than prime sheets.

## 6. RECOMMENDATIONS

Basing on the above conclusions, a Cleaner Production Manual Guideline for waste minimization at CGL department was designed which can minimize the waste production if management implements recommendations in it. A summary of the key Cleaner Production options in the manual is explained below.

**i. Good housekeeping**

Take appropriate managerial and operational actions to:

- Avoid incomplete surface cleaning of the sheet,
- Keep the temperature parameters to standard,
- prevent leaks (steam),
- prevent damage of raw materials during transportation with in company premises,
- prevent machine failure by employing preventive maintenance techniques,
- enforce existing operational instructions,
- Control bath's temperatures to the required standard.

**ii. Input/raw material substitution**

- substitute input materials e.g. use of Sulphuric acid instead of HCL at pickling point,
- consider the use of dry fluxing instead of wet fluxing,
- consider using antimony alloy other than lead in the zinc bath due to environmental safety concerns,
- consider using other grades of steel sheet such as Advanced High Strength-Low Alloy Steel and Forming Steel other than Commercial Steel sheets,

**iii. Better process control**

- Constantly removing dross,
- Avoid using excessive aluminium,

- Modify equipment instructions by following standard parameters set,
- Modify process record keeping in order to run the processes more efficiently and at lower waste and emission generation rates,

**iv. Equipment modification**

Modify the existing production equipment and utilities by:

- running the processes at higher efficiency,
- installing new motors for most machines,
- Improving welding/mechanically remove the welding slag/ joints to avoid zinc overflow,
- Lowering waste generation rates through equipment monitoring, maintenance and servicing to avoid stoppages during production.

**v. Technology change**

- Replacement of the technology especially obsolete machines,
- Replacement of processing sequence in order to minimise waste and emission generation during production,
- Consider using zinc jumbos.

## 7. ACKNOWLEDGEMENTS

The authors would like to acknowledge the financial support they received from The Italian Cooperation Project that enabled them carry out the research.

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