Analysis and Optimization of Aluminum Foil Winding Base Structure

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***Abstract* - The recent tread of technology requirement of automation, as part of industrial development which is developed in automation. This project will work on analysis and optimization of cost of aluminum foil winding machine as per market requirement. The first step is to analyze existing design as per core components concern then find out factor of safety is as per design requirement or over by using a theoretical and practical approach to the identified route cause of cost optimization. By using CAD tools like Solid work which is easy to modeling and analysis each component then concluded.**

***keywords* - Base Structure, Aluminum Foil Winding Machine, CAD, Analysis, Optimization**

I. INTRODUCTION

Aluminum is the most abundant metal found in the Earth’s crust (approximately 8%) and is the third most abundant element found on Earth, after oxygen and silicon. Due to its reactive behavior, aluminum is never found as a pure metal in nature but combined with hundreds of minerals. The chief source of commercially manufactured aluminum today is bauxite. Bauxite is a reddish-brown clay-like deposit containing iron, silicates and aluminum oxides, the latter comprising the largest constituents. At present, bauxite is so plentiful that only deposits containing a content of aluminum oxides greater than 45% are selected to manufacture aluminum. Bauxite derives its name from a small French town called Les Baux, where bauxite was first discovered in 1821. Today, the largest bauxite mines are in North America, the West Indies, Australia and Northern Europe.

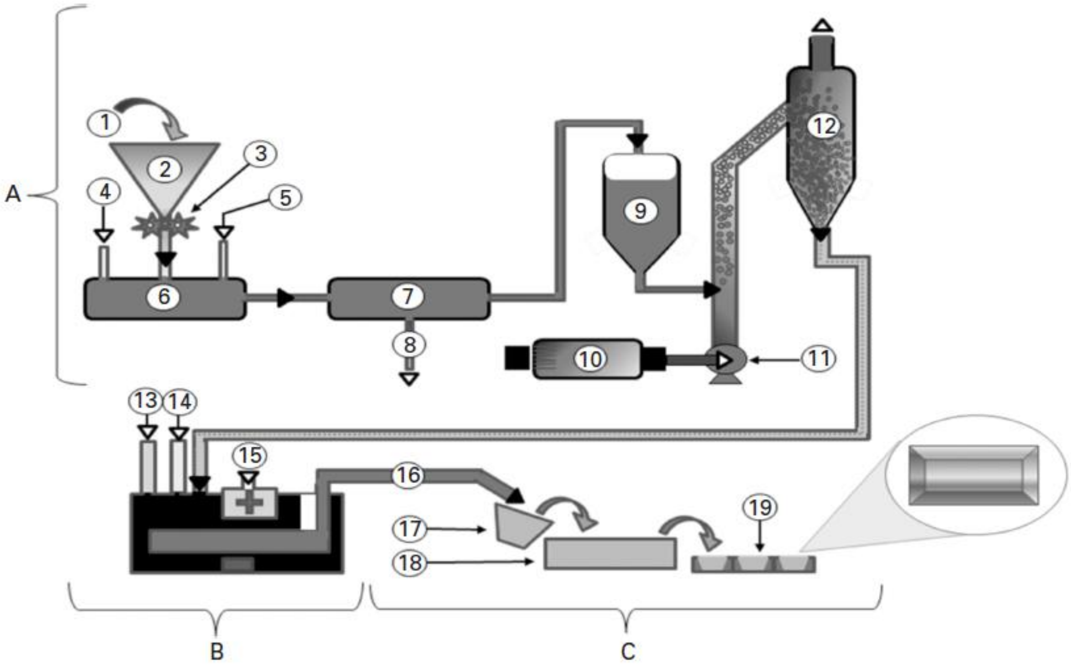

Figure 1 The aluminum manufacturing process

Fig. 1 Illustration of the aluminum manufacturing process encompassing the chemical extraction process (A), electrolysis (B) and alloy casting (C) operations (1. Raw material (bauxite) is processed into pure aluminum oxide (alumina) prior to its conversion to aluminum via electrolysis. This primary step is achieved through the ‘Bayer Chemical Process’. Four tones of bauxite are usually required to generate two tons of finished alumina which ultimately produces approximately one tons of aluminum at the primary smelter. 2. Bauxite feed hopper. 3. Mechanical crusher employed to reduce bauxite particle size and increase surface area for chemical extraction. 4. Input chemical (sodium hydroxide). 5. Input chemical (lime). 6. Aluminum oxide is effectively released from bauxite in the presence of caustic soda solution within the primary reactor (digestion) tank. 7.

The aluminum hydroxide is then precipitated from the soda solution. 8. Spent solids/ tailings discard a red mud residue generated as a byproduct of the process. 9. Precipitation tank: aluminum hydroxide is precipitated from the soda solution. The soda solution is recovered and recycled within the process. 10. Drying system (air heater system). 11. Drying system (hot air blower system). 12. Drying system (cyclone fines recovery system): post calcination, the anhydrous end-product, aluminum oxide (Al_2O_3), is a fine grained free flowing, white powder. 13. Input chemical (aluminum fluoride – AlF_3). 14. Input chemical (cryolite – Na_2AlF_3). 15. Fuel source (e.g. coke, petroleum and pitch). 16. Molten aluminum: the reduction of alumina into liquid aluminum is operated at around 950°C in a fluorinated bath under high intensity electrical current. The electrolytic process. 17. At regular intervals, molten aluminum tapped from the pots is transported to the cast house crucible. 18. The aluminum is alloyed in holding furnaces by the addition of other metals (according to end user needs), cleaned of oxides and gases. 19. The liquid metal is then cast into ingots. These can take the form of extrusion billets, for extruded products, or rolling ingots, for rolled products, depending on the way it is to be further processed. Aluminum mound castings are produced by foundries which use this technique to manufacture shaped components.)

II. DESIGN ANALYSIS OF ALUMINUM FOIL WINDING MACHINE

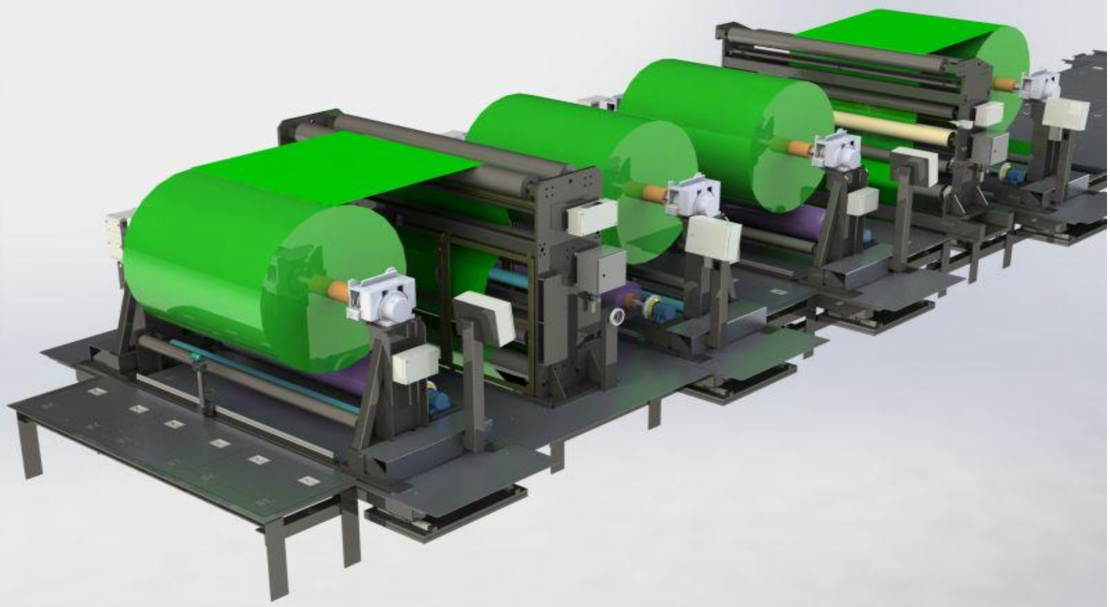

Figure 2 Aluminum Foil Winding Machine

Winding and unwinding station front of a continuous running operation like unwinding, cutting and winding process. It is possible to wind and unwind release aluminum foil. Maximum weight of the batches is 3000kg.

III. BASE STRUCTURE DETAIL FOR WINDER AND UNWINDER

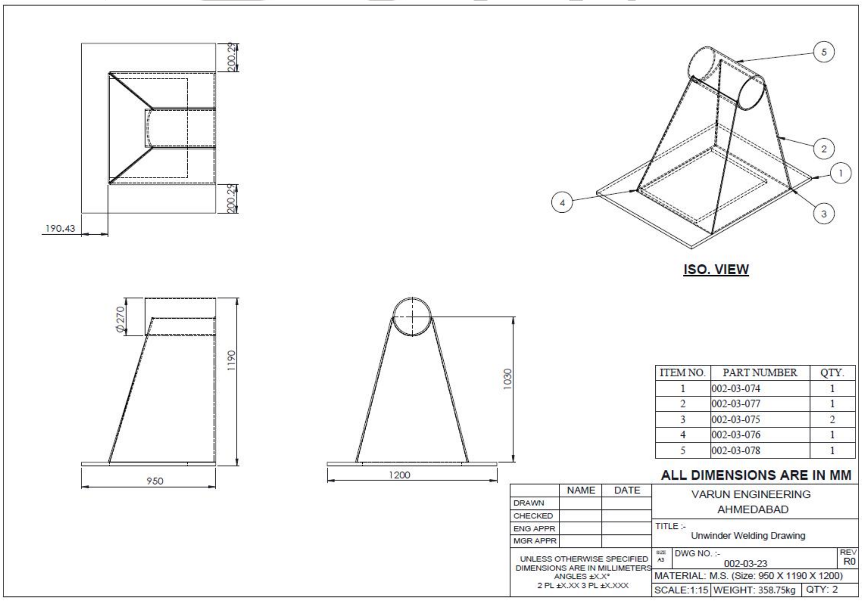

Figure 3 Base Structure detail for Winder and Unwinder

Figure 4 Real Snap-3 of Base Structure of Aluminum Foil Winding Machine

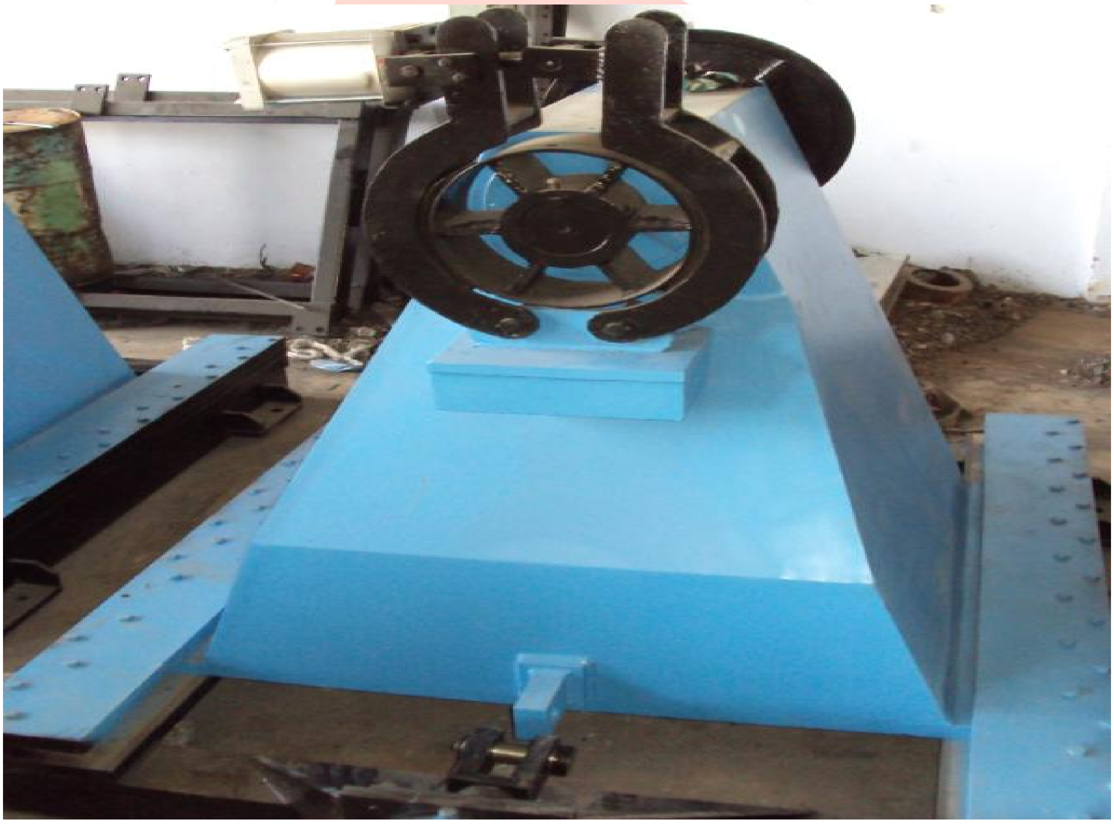

Figure 5 Unwinder Base Structure

IV. JOHNSON'S METHOD OF OPTIMUM DESIGN

In Johnson's method, the design equations are categorized into three types, namely,

1. The primary design equation,
2. The subsidiary design equation and
3. The limit equations

In the optimum design of a mechanical element, the primary design equation is the most important design equation which expresses the most significant functional requirement to be maximized or the most significant undesirable effect to be minimized.

The primary design equation expresses the quantity upon which the optimum design is based. It is designated by P.D.E.

The primary design equation is expressed as,

$$DE\left[\begin{array}{c}\text{Most Significant}\\ \text{Functional Requirement}\\ \text{or Most Significant}\\ \text{Undesirable Effect}\end{array}\right] = f\left\{\left[\begin{array}{c}\text{Functional}\\ \text{Requirement Parameters}\\ \text{Including Undesirable}\\ \text{Effects}\end{array}\right]\left[\begin{array}{c}\text{Material}\\ \text{Parameters}\end{array}\right]\left[\begin{array}{c}\text{Geometrical}\\ \text{Parameters}\end{array}\right]\right\}$$

In the optimum design of the mechanical element, the design equation other than the primary design equation is known as subsidiary design equations. The subsidiary design equations are designated by S.D.E. The subsidiary design equation expresses either functional requirements or undesirable effects.

For example, stress equations in any optimum design are generally subsidiary design equations.

The subsidiary design equation is expressed as,

$$SDE = g\left\{\left[\begin{array}{c}\text{Functional}\\ \text{Requirement Parameters}\\ \text{Including Undesirable}\\ \text{Effects}\end{array}\right]\left[\begin{array}{c}\text{Material}\\ \text{Parameters}\end{array}\right]\left[\begin{array}{c}\text{Geometrical}\\ \text{Parameters}\end{array}\right]\right\}$$

In optimum design, the satisfactory ranges are available for the values of certain parameters. These ranges are expressed mathematically by equations known as limit equations. They may be rigid or loose.

For example,

$$\sigma_t < \frac{S_{ut}}{N_f}$$

Problem statement for optimization support plate of the base structure of aluminum foil winding machine.

A simple tensile plate is subjected to constant tensile force F. Design the design plate to minimize material cost under the factor of safety Nf. The following limitation is specified design

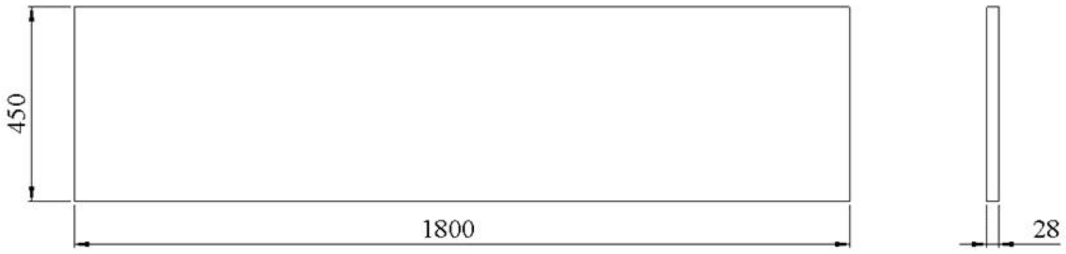

Figure 6 Detail Drawing of Support Plate

Cm = Material cost of Support Plate (Rs.)

C = Cost per unit mass for material (Rs/Kg)

ρ=Mass density of Support Plate material (Kg/m3)

A = Crossectional are of Support Plate (N)

Nf = Factor of Safety

σt = Tensile stress-induced in Support Plate (N/mm2)

Sy = Yield strength of Support Plate Material (N/mm2)

Primary Design Equation,

The most significant undesirable effect to be minimized cost of the support plate.

$$C_m = \text{Cost per unit support plate X mass of support plate}$$

$$= C \text{ X } \rho \text{ A L}$$

$$C_m = C\,\rho\,A\,L$$

Subsidiary Design Equation,

Tensile stress-induced in support plate given by

$\sigma_t = F/A$

This is S.D.E.

Limit Equation

$\sigma_t < S_y/N_f$

and

$$L_{min} < L < L_{max}$$

Classification of Parameters

Table 1 Classification of Parameters

	Specific	Limited	Unspecific & Unlimited
Functional requirement parameters	F, N_f		
Undesirable effect parameters		σ_t	C_m
Geometric parameters		L	A
Material parameters		C ρ S_y	

Combining S.D.E. and P.D.E.

By combining with P.D.E. by eliminating the unspecified and unlimited parameter

$$C_m = C\,\rho\,F\,L / \sigma_t$$

Combining the limit equation with P.D.E.

Include the effect of the limit equation in P.D.E.

$$C_m \propto \frac{1}{\sigma_t}$$

and

$$C_m \propto L$$

By substituting this limit value equation can be written as

$$C_m = \frac{C\rho\,F}{S_y/N_f}\,L_{min}$$

$$C_m = \frac{C\rho\,F\,N_f}{S_y}\,L_{min}$$

or

$$C_m = [F\,N_f]\,[L_{min}]\,[{}^{C\rho}/{}_{S_y}]$$

This is final P.D.E. to minimized Cm, material selection factor $[{}^{C\rho}/{}_{S_y}]$ should be minimum.

Selection of material

$[{}^{C\rho}/{}_{S_y}]$ Calculated for all available or feasible material and lower value $[{}^{C\rho}/{}_{S_y}]$ selected.

Determination of elimination parameter

The eliminated parameter A can be determined by using S.D.E.

Therefore,

$$\sigma_t = {}^{Sy}/{}_{N_f} = \frac{F}{A}$$

$$A = \frac{F\,N_f}{Sy}$$

Determination of optimum quality

Finally, the most significant undesirable effect can be the minimum that is the Cm is determined by the P.D.E.

V. ACKNOWLEDGMENT

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