Design And FEA Analysis Of Flexible Roll Forming Profile For Engineering Applications

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Abstract— There are various applications where sheet metal profiles are widely used due to characteristic of useful weight to strength ratio. These profiles are conventionally manufactured by using roll forming machines and mostly manufactured with uniform cross section along the length. However, now a days there are many applications where it is desired to have sheet metal profiles with variable cross sections along the length. This Paper focuses on the basic steps to design such a sheet metal profile with variable cross section to overcome the problem of manufacturing such profiles with tin smithy means to manufacture by hand tools which is not that much accurate process and also takes more time and consume more other resources.

This Paper throws the light on all the basic steps of design like, Selection of Profile and study of profile terminology, Selection of Material, Determination of Geometrical dimensions, Preparation of Drawings by using CAD Software and Finally Finite Element Analysis for getting Safety against predetermined loading.

Keywords—Finite Element Analysis plants, Geometrical dimensions, sheet metal profiles, loading

I. Profile Selection

Roll forming profile sections are classified as Simple (open), closed medium complex, very complex, and panel type cross-section. Also, through literature survey it is found that, for simple (open) cross-section research papers with analytical equations and analysis methods are available .Hence, for this research work simple (open) cross-section is finalized. A simple-open profile section is widely used due to its simplex shape. Hence in this paper we have done design and analysis of simple-open profile sections.

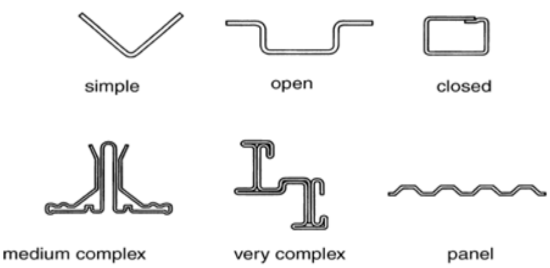

Figure 1- Types of profile

Here the word simple-open indicates the combination of two profile sections which is mostly used in practical applications. The use of simple-open profiles helps to reduce the maintenance cost of the overall component.

II. Terminology

To design the Simple (open) cross-section profile, we should first know the terminology of that profile. From Roll Forming Handbook Terminology is as follow. Here the basic dimension is profile thickness depending on which other dimensions are varying in proportion.

A. Thickness(t)- It is the thickness of the sheet metal which is to be used for profile section. Thickness of the sheet metal should be as small as possible to reduce the overall weight of the profile.

B. Bend radius(r)-The radius at the bend of the sheet metal during its depth variation is called as bend radius. The minimum value of bend radius is 2t and it maximum value is the choice of design engineer as per the requirement of the application.

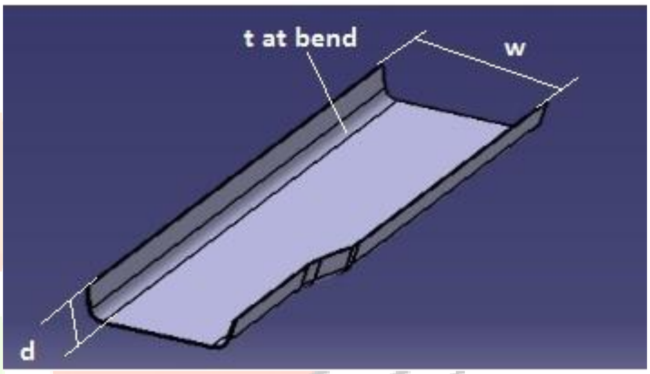

Figure 2- Terminology of profile

C. Section Depth/Pressure Roller depth(d)-It is the vertical distance from top of the flange up to flat surface of the sheet metal. For flexible roll forming profile sections, section depth is equal to the value of the pressure roller depth and its value is selected as per the requirement.

D. Section Width(W)-It is the horizontal distance from one end to another end of the flat surface. Usually section width is of two types for simple (open) cross section profiles. First is called as initial section width and other is called as final section width.

III. Material Selection

Currently using materials in sheet metal industries are Steel, Al, Cu, and Brass. Thorough literature survey it is observed that steel and aluminium are the most widely used materials in automotive industries as well as in other applications. However based on the following material selection criteria, Aluminium 3105 material sheet is selected for this project work.

Aluminium and steel materials are most widely used materials in automotive and other day to day life applications. Aluminium is widely used material due to its more formability and low weight. Aluminium cost is more than steel sheet however it is affordable in comparison with its best forming characteristics. Hence through this paper our focus is to use very thin sheet metal of aluminium.

IV. Determination of Geometrical dimensions

Kurtz lange in hand book of metal forming described a universally accepted simplified model for forming of aluminium sheet metals. As these values are given in the range, design engineer has to select required values as per requirements. Through this work kurtz proved that, shape error and profile defects for forming of aluminium sheet metals are considerably reduced at minimum level and in industries without the work of defect analysis forming of aluminium sheet metals can be done. Therefore, final theoretical dimensions are taken as follow:-

1. t=0.8mm
2. r=2t to 7t, That is for 0.8mm it should not be less than 1.6mm
3. %E=Theoretical reduction in thickness 5% to 7%,therefore Theoretical Reduction in thickness will be 0.8mm to 0.76mm at bend radius.
4. d=2t to 7t, d=2.5 to 5 mm and
5. Flange length should be 50t to 70t;
6. W1 (Initial) =56mm,W2 (Final) =52mm
7. Number of Pass- Practically, there is no universal formula or equation to calculate the roller stages. These are selected on the basis of theoretical or practical required results.

V. Modelling

The model of flexible roll forming profile is as follow- Using geometrical dimensions we have modelled the extreme condition profile as follow. The stp. File of this is then created to import it in ANSYS for analysis.

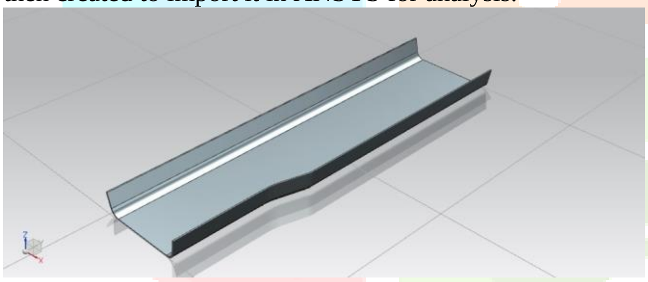

Figure 3- Modelling of the profile

Drafting of the above profile is as follow, it shows the top and front view of the profile.

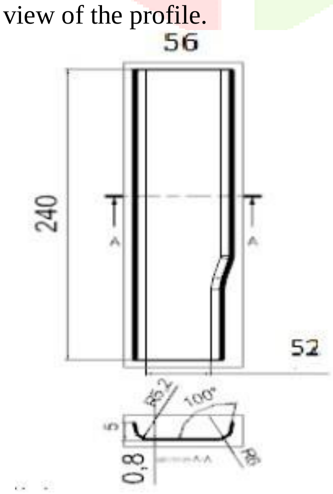

Figure 4- Dimensions of the profile

VI. Profile Analysis

The stp. File of the profile created is initially imported in ANSYS for analysis. Figure shows the profile in ANSYS Workbench 16.0

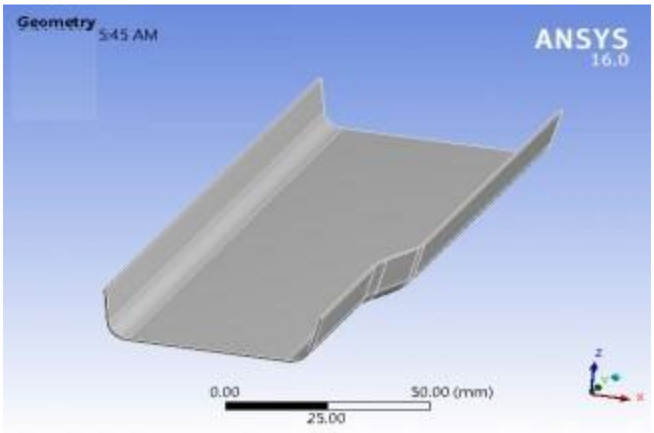

Figure 5- Geometry of the profile

For the profile hexahedron element is used for meshing because for the same cell amount this element gives the highest accuracy. A hexahedron, a topological cube, has 8 vertices, 12 edges, bounded by 6 quadrilateral faces. It is also called a hex or a brick. Here nodes are 3203 and elements are 420 in numbers.

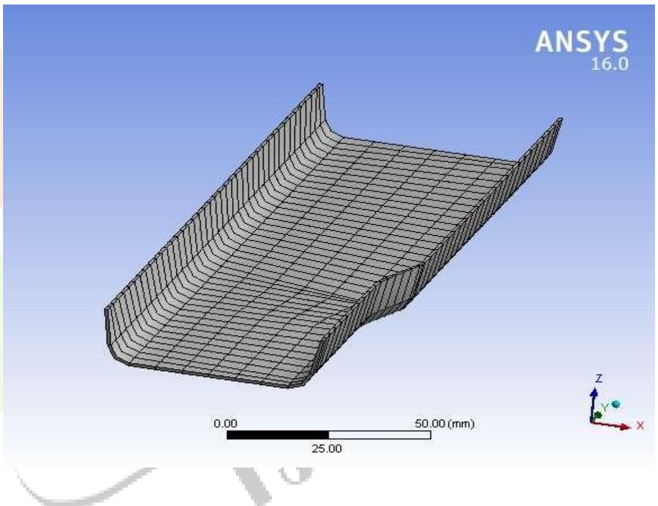

Figure 6- Meshing of the Profile

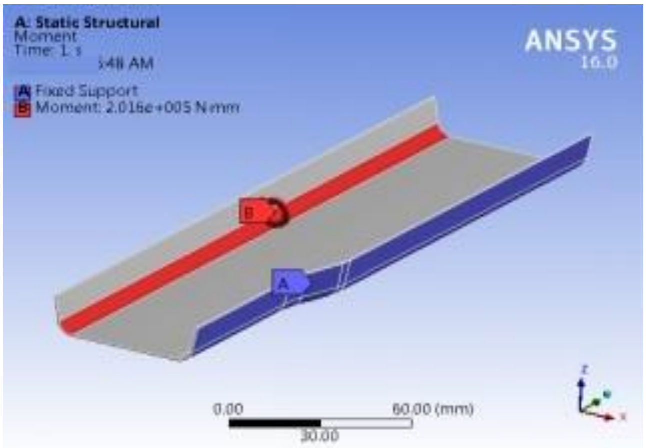

Figure 7- Boundary Conditions

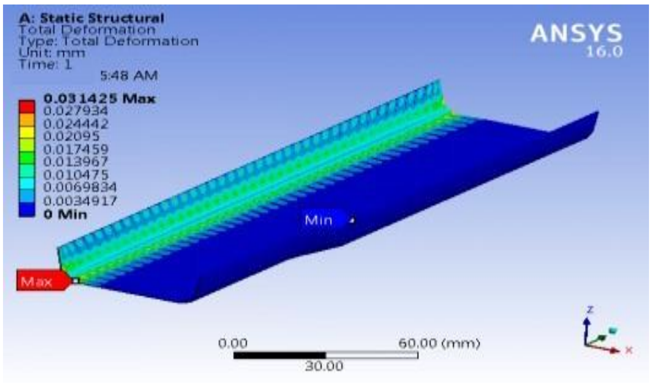

Figure 8- Total deformation

$M_t = (Force \times PerpendicularDistance)$

$M_t = (1 \times 9.80665 \times 0.74) \times 28$

$M_t = 201.6 Nm$

$M_t = 2.016 \times 10^5 Nmm$

$Maximum\_Deformation\_is$

$= 0.031425 mm$

Reduction in thickness at the bend radius is a critical parameter which needs to find by the design engineer. If this reduction is beyond the limit of kurtz model, profile section may damage early at this section. The reduction in thickness is calculated as follow

Reduction in thickness= Original thickness- Maximum deformation

Reduction in thickness=0.8-0.031 = 0.769mm

The above value is within the range and similar to the value of the theoretical model. Hence, the profile is safe at the bend radius. As the values of compressive longitudinal strains very less. Hence, by finite element analysis, the profile design will be safe against the necking, fracture, and shear and wrinkling.

VII. CONCLUSION

From the theoretical and finite element analysis results it is clear that percentage error in dimension is well below permissible value and validating the dimensions of profile and percentage reduction in thickness is also below the permissible value which ensures the safety of profile as minimal deformation at the radius of bent of sheet metal, thereby maintaining the strength of part produced and validating the design of rollers profiles also.

From this we can conclude that the percentage error in theoretical and practical dimensions is less than 10% hence our profile design parameters are correct.

Also from this we can conclude that flexible roll forming is a very important manufacturing process which helps us to produce different profiles with same set of tool and advantages in comparison with the conventional methods.

VIII. FUTURE SCOPE

In future, this method with wide range of flexibility in profile dimensions will be helpful in automotive and other day to day life applications. Also, along with steel and aluminium this method can be investigated for other metallic materials.

As mentioned earlier that, with the same set of tools many profiles can be manufactured, which will helpful to reduce manufacturing cost of automotive components and due to use of sheet metals overall reduction in weight of the parts can also be achieved, which simultaneously increases the fuel economy for auto-mobile sector.

In future, application of this method to specific sector will helpful to spread its area of working and helps to develop other standard mathematical models for design of profiles.

ACKNOWLEDGMENT

With all due respect and gratitude, I would like to thank all the people who have helped me directly or indirectly with the completion of this dissertation work. I express my hearty gratitude towards, the Head of the Department of First Engineering for guiding me to understand the work conceptually and also for providing the necessary information and required resources with his constant encouragement to complete this dissertation work. With a deep sense of gratitude, I thank our Principal and Management of the NMIET for providing all necessary facilities and for their constant encouragement and support. Last but not least, I thank all the Teaching & Non-teaching staff members of the first Engineering Department for providing the necessary information and required resources. I am ending this acknowledgment with deep indebtedness to my friends who have helped me.

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