Design & Development of Horizontal Hydraulic Embossing Machine

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Abstract— Sheet metal is simply metal formed into thin and flat pieces. It is one of the fundamental forms used in metalworking and can be cut and bent into a variety of different shapes. Countless everyday objects are constructed with sheet metal. Thicknesses can vary significantly; extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate. Embossing and debossing are similar processes that create a different result. Both processes involve making a metal plate and counter. The plate is mounted on a press and the paper is stamped between the plate and counter. This force of pressure pushes the stock into the plate creating the impression. Embossing creates a raised impression on stock – pushes the image above the level of the paper. Debossing is the reverse of embossing. Debossing creates a depressed impression on stock – pushes the image below the level of the paper.

Key words: Press Tool Housing, Horizontal Hydraulic Embossing Machine

I. Introduction

- Only one part of component can be debossed at a time.
- Frequent Breakdown of machine.
- Frequent changes of press tools.
- Low Productivity.
- Three Press Tools are required for completed embossing of Strip.

II. Problem Overview

On the given Hot rolled strip (612*110 *4mm) there was a need to emboss letters in three section of the strip. These emboss letters include Company Name, license number and weight of the cylinder.

The industry was using press tool to emboss letters on the Hot rolled strip. For completing the embossing operation on the strip it need three press tools each with its own design.

- Need of three types of embossing dies with different press housings.
- Requires three different set ups for completing the embossing operation in strip.
- More Handling and operation time
- High capital cost involved in making press tool.

III. Objective

Main scope of the research is to design and fabrication of Horizontal Hydraulic Embossing machine which are used for embossing foot ring of LPG cylinders for BTP Structural Private India Ltd.

IV. Methodology

The paper involves identifying, defining, listing, and providing appropriate solutions to various problems during the machining of various components in order to improve the productivity. The methodology is as follows:

A. *Problem Identification and Definition:*

As an initial step, a considerable amount of time was spent on the shop floor to understand the process and operating procedure. The detailed study of the connecting rods was done. The various types of the connecting rods were studied. K110 and WABCO a type of the connecting rods were considered for analysis and study.

B. *Study of Existing Process:*

The operations were briefly studied with a view to get a better understanding of the processes and the material movement. This has given a better chance to get acquainted with labor, which helped in learning many intrinsic details about the process as also understanding the shop floor difficulties.

C. *Detailed Data Collection*

A detailed method study for the selected process has been carried out. In the phase process sheets and flow diagram have been prepared. The entire process was placed under observation and any anomalies were noted down. Data Collected

- Time study
- Flow process chart

D. *Proposed Solutions and Action Plans:*

Appropriate actions plans have been taken so that the objective of the research is achieved. The process is reviewed such that the critical points are considered and important factors are not left out. Appropriate solutions were proposed so as to achieve the objectivity and also reach the results

E. *Results:*

This step includes the tabulation of savings and results of the work carried out. This provides the solution to the above problem or any anomalies.

V. Experimentation

A. *Tensile Test:*

- Acceptance Test is performed on Universal Testing Machine (UTM)
- Specimen used for acceptance test

Fig. 1: Tensile Test Specimen

Dimensions of specimen	
Width(mm)	26.6
Thickness(mm)	2.90

Area (mm^2)	77.14

Table 1: Specimen Dimenstion

Acceptance Test	
Width(mm)	26.6
Thickness(mm)	2.90
Area (mm^2)	77.14
Yield Load(kgf)	2800
Yield Strength (Mpa)	355
Tensile Load (kgf)	3250
Tensile Strength (Mpa)	413

Table 2: Test Results

B. Formulae:

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} \text{ in } {}^{N}/_{m^2}$$

Discharge = Area*velocity in ${}^{m^3}/_{sec}$
Power = Pressure*Discharge in watts

C. Data Available:

Force = 29430 N
Velocity = 0.12 m\s

Bore Diameter	Area	Pressure	Discharge	Power in watts	Power in HP
0.08	$5.03*10^{-3}$	$5.85*10^6$	$6.04*10^{-4}$	3531.06	4.73
0.1	$7.85*10^{-3}$	$3.74*10^6$	$9.42*10^{-4}$	3523.08	4.72
0.125	$12.3*10^{-3}$	$2.39*10^6$	$1.48*10^{-3}$	3527.64	4.73
0.140	$15.4*10^{-3}$	$1.91*10^6$	$1.85*10^{-3}$	3514.4	4.71
0.160	$20.1*10^{-3}$	$1.46*10^6$	$2.41*10^{-3}$	3521.52	4.72

Table 3: Measured Parameters

– Since Power generated considering the above 5 bore diameters is approximately equal. Therefore considering the cost factor we have selected 80mm bore Diameter cylinder.
– Since Maximum pressure acting on cylinder is 5.85 Mpa therefore Vane Pump is recommended.
– Since Maximum Power required is 4.73 HP therefore electric Motor of 5HP is recommended.

D. Analytical Analysis of Column and Roller Holder

Critical Load for Column according to Euler's Column Theory for one side fixed and other end is free: $\frac{\pi^2 EI}{4L^2}$

Where E=Young's Modulus of steel ($210*10^3 \frac{N}{mm}^2$)
I=Moment of Inertia in mm^4
L=Length of Column in mm
Inertia of Column (I) =Inertia of whole column(X)-(Inertia of Pocket 1(Y) +Inertia of Pocket 2(Z))

$\text{Inertia(X)} = \frac{bh^3}{12} = \frac{305*580^3}{12} = 4.96*10^9 mm^4$

$\text{Inertia(Y)} = \frac{bh^3}{12} = \frac{165*250^3}{12} = 0.215*10^9 mm^4$

$\text{Inertia (Z)} = \frac{bh^3}{12} = \frac{165*275^3}{12} = 0.285*10^9 mm^4$

Inertia I=Inertia X-(Inertia Y+ Inertia Z)
$I=4.96*10^9 - (0.215*10^9 + 0.285*10^9)$
$I=4.45*10^9 mm^4$

Critical load for column $F_{cr} = \frac{\pi^2 * 210*10^3 * 4.45*10^9}{4*580^2}$
$=6.85*10^5$ N
Actual Load acting on Column $F_{actual}=3.96*10^3$ N
$F_{actual} < F_{cr}$
Hence Column Design is safe

Pressure acting on Roller Holder = $\frac{\text{Load}}{\text{length*Diameter}}$
$= \frac{1350*9.81}{100*104}$
$=1.27 \text{ N/mm}^2$
Compressive Strength of Mild Steel=841 N/mm^2
Pressure acting on roller Holder < Compressive strength of Mild Steel
Hence Design of Roller Holder is safe

No.	Body Name	Material	Mass	Volume
1	Strip	AISI 1020 Hot Rolled steel	2.88565 kg	0.000365272 m^3
Material name:		AISI 1045 Steel, cold drawn		
Description:		AISI 1020 Hot Rolled Steel		
Material Model Type:		Linear Elastic Isotropic		
Default Failure Criterion:		Max von Mises Stress		

Table 4: Analysis of Rolled Steel Strip

Property Name	Value	Units	Value Type
Elastic modulus	2e+011	N/m^2	Constant
Poisson's ratio	0.29	NA	Constant
Shear modulus	7.7e+010	N/m^2	Constant
Mass density	7900	kg/m^3	Constant
Tensile strength	4.2051e+008	N/m^2	Constant
Yield strength	3.5157e+008	N/m^2	Constant
Thermal expansion coefficient	1.5e-005	/Kelvin	Constant
Thermal conductivity	47	W/(m.K)	Constant
Specific heat	420	J/(kg.K)	Constant

Table 5: Material Properties

Mesh Type:	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Smooth Surface:	On
Jacobian Check:	16 Points
Element Size:	0.0087243 m
Tolerance:	0.00043621 m
Quality:	High
Number of elements:	8212
Number of nodes:	17016

Table 6: Mesh Information

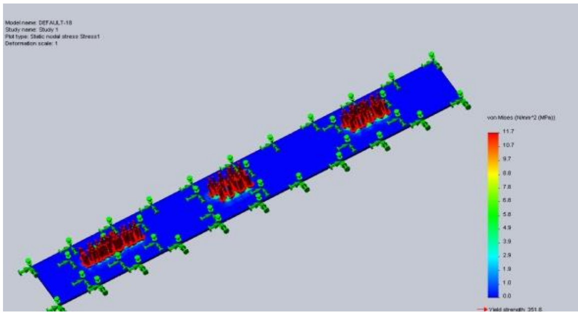

Fig. 2: Stress analysis:

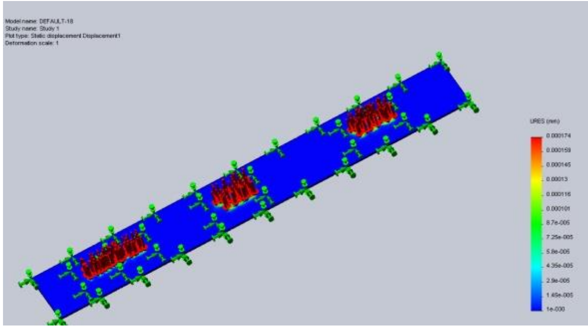

Fig. 3: Displacement analysis:

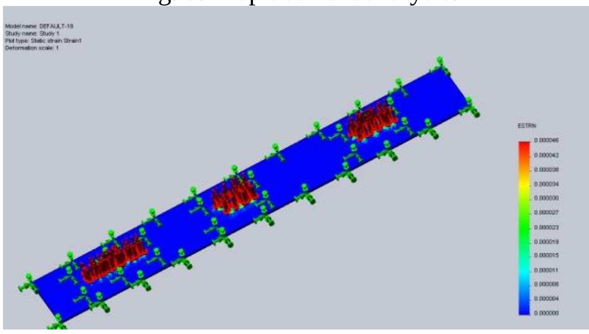

Fig. 4: Strain Analysis

Name	Type	Min	Max
Stress1	Von Mises Stress	0.00139945 N/mm^2 (MPa) Node: 632	1.78359 N/mm^2 (MPa) Node: 12694
Displacement 1	URES: Resultant Displacement	0 mm Node: 74	0.00101102 mm Node: 437
Strain1	ESTRN: Equivalent Strain	1.06641e-008 Element: 2032	5.4053e-006 Element: 2812

Table 6: Results

E. Analysis of Roller:

No.	Body Name	Material	Mass	Volume
1	Roller	EN5 Mild Steel	225.489 kg	0.0287247 m^3
Material name:		AISI 1045 Steel, cold drawn		
Description:				
Material Source:				
Material Model Type:		Linear Elastic Isotropic		
Default Failure Criterion:		Max von Mises Stress		
Application Data:				

Table 7: Material Properties

Property Name	Value	Units	Value Type
Elastic modulus	2.05e+011	N/m^2	Constant
Poisson's ratio	0.29	NA	Constant
Shear modulus	8e+010	N/m^2	Constant
Mass density	7850	kg/m^3	Constant
Tensile strength	6.25e+008	N/m^2	Constant
Yield strength	5.3e+008	N/m^2	Constant
Thermal expansion coefficient	1.15e-005	/Kelvin	Constant
Thermal conductivity	49.8	W/(m.K)	Constant
Specific heat	486	J/(kg.K)	Constant

Table 8: Material Properties

Mesh Type:	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Smooth Surface:	On
Jacobian Check:	4 Points
Element Size:	30.63 mm
Tolerance:	1.5315 mm
Quality:	High
Number of elements:	8677
Number of nodes:	13451
Time to complete mesh(hh;mm;ss):	00:00:03
Computer name:	SYSTEM

Table 9: Mesh Information

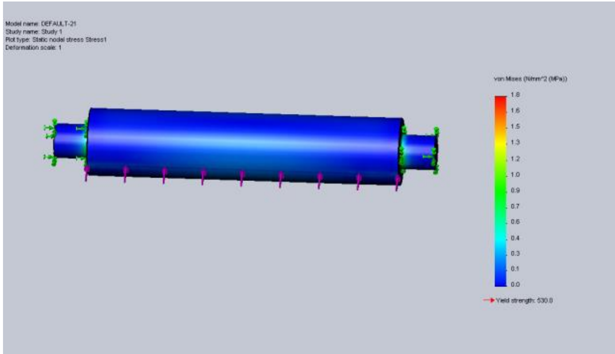

Fig. 5: Stress Analysis

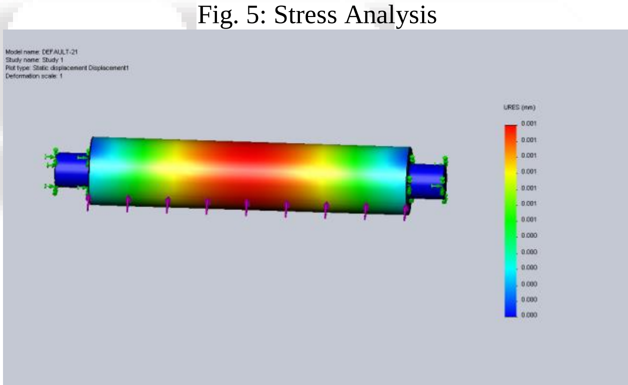

Fig. 6: Displacement Analysis

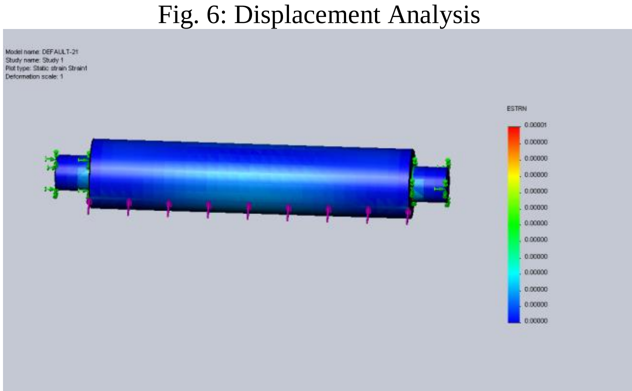

Fig. 7: Strain Analysis

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.00139945 N/mm^2 (MPa) Node: 632	1.78359 N/mm^2 (MPa) Node: 12694

Displacement1	URES: Resultant Displacement	0 mm Node: 74	0.00101102 mm Node: 437
Strain1	ESTRN: Equivalent Strain	1.06641e-008 Element: 2032	5.4053e-006 Element: 2812

Table 10: Results

Yield strength of Strip: 351.6 Mpa.
Yield Strength of Roller: 530 Mpa.

Since yield strength of roller (EN8 Material) is greater than yield strength of strip (Hot rolled steel) therefore roller can deform the strip.

VI. Conclusion

- The proposed horizontal hydraulic embossing machine for foot ring strips helps to emboss three sections of strips simultaneously.
- Press tools are used presently which consumes lot of time & effort in replacement of press tool housing. The proposed machine offers flexibility towards replacement of dies based on the letter configuration.
- Total cycle time will be considerably reduced from forty five minutes to fifteen minutes, resulting in increased productivity.
- Proposed machine offers only replacement of dies; four components can be embossed at a time.

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