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Design & Development of Cooling Systems for Roll Forming Machine

Aejaz Sayed¹, Asst. Prof. Rajesh S. Kalase², Kunal Patil³, Onkar Hooda⁴, Atul Shirke⁵ Shubham Tambe⁶

¹(Maintenance Head, Klassic Wheels Ltd)

^{2, 3, 4, 5, 6}Mechanical Engineering Department, G. H. Raison College of Engineering and Management, Ahmednagar,
Savitribai Phule Pune University

Abstract: *Cooling of the job (work piece) is essential as if cooling is not done to the Roll forming machine there is increase in the temperature of the roller being used due to the friction between roller and the rim & also the rim which is being sent for the forming is being thermally expanded in its previous operation so its temperature is more which is transferred to the roller. So there is deformation and undercut of the roller. As coolant splashes on the floor so there was no provision for the cooling system. So the casing is designed for the roll forming machine to avoid splashing of coolant, friction between roller and rim. Automation concept is used by introducing PLC. Hydraulic system with pumps & motors, so that heat generation during forming operation will be minimized which will result in improvement of roller life & overall productivity will increase. Also the cleaning operation of the rim would be eliminated. The rim which is hot would be cooled down so increasing the safety of the worker working on that machine.*

Keywords: *Roll Forming, PLC, Pneumatic cylinder, coolant, casing*

I. INTRODUCTION

Roll Forming is type of rolling which involves continuous bending of long strip of sheet metal into desired cross-section. Strip is then passed through set of rollers until desired profile is obtained. Roll Forming Machines are available that produce shape of different size and material thickness using the same roll. Variation in size is achieved by making the distance between the rolls, variable by manual adjustment or computerized control allowing for rapid changeover. The specialized mill are present in the light gauge framing industry where metal studs and tracks of standardized profile & thickness. The roll forming machine is being manufactured by 'Jaya Hind Sciaky Ltd', Pune. Cold forming is the operation used for manufacturing of rim. In roll forming two or more rollers are used without addition of any heat.

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The Roll Forming Machine is being manufactured by the "JAYA HIND SCI AKY LTD, a company from Pune, which is a joint venture of Kinetic Engineering & Sciaky Ltd, France. Before Forming is being done the various operations done on the metal sheet is as follows.

- 1) Sheet is being bent in a circular shape
- 2) Then the circular metal sheet is being welded by using two welding operations viz butt welding & Spot welding
- 3) Then knipping of the unwanted welded portion is being done
- 4) Then the circular metal sheet is being thermally expanded & given a specific curvature shape to it
- 5) Then the forming operations are being done on the circular metal sheet, it is being done in 3 stages viz 1st forming, 2nd forming & 3rd forming.
- 6) Then they formed round metal sheet (Rim) has a tapered hole made from where tube valve can be inserted.
- 7) Then the round metal sheet is being visually inspected
- 8) Then again CO₂ welding is being done, where the metal plate manufactured in the press shop is assembled here with the round metal sheet.

So in this way a rim is being manufactured in the company for two wheelers, 3 wheelers & 4 wheelers vehicles of brands like Vespa, Honda, Piaggio, kinetic motors, LML, Suzuki & Mahindra 2 wheelers. So while performing these operations as mentioned above it was observed that the Roll forming had some issues in it.

II. LITERATURE SURVEY

Youngyun Woo, et.al^[1]: They stated that the metal sheet of various cross section profiles like profile for automotive railway, sheet construction, building industries, etc are being studied. Two sheets are being joined together by adhesive material. Here the two layers are used of SPCC and AL5052 material. The bend angle of roll form blank decreased. When the combination is changed from SPCC+ AL5052 to AL5052+SPCC. The longitudinal bow height increases in order of concave, trapezoidal and convex shape.

William Ion, et.al^[2]: In this paper the author says that cold roll forming is an incremental sheet forming process, which offers a wide range of advantages. The material used for sheet metal is UHSS (Ultra High Speed Steel). Here two profiles are being studied. i) v-section ii) flat strip with the rim. Here as number of passes increases, the length of sheet also increases.

Aromal kannan, et.al^[3]: In it different natural oils like castor oil, palm oil, rice ban oil, sesame oil, sunflower oil, etc are being studied for their coolant action on cutting. They have stated the property of vegetable oil that they have higher boiling point and greater molecular weight and this result in less loss due to vaporization and misting. Also the temperature is not much as compared to conventional cutting fluids. Also the roughness is reduced by using natural oils. Natural oils for using as coolant are being checked for output parameters like cutting force, tool wear and tool life.

Zinat Ara Nisha, et.al^[4]: In it they have explained that minimum quantity of lubrication, they have carried out analysis regarding machining cost and they have stated that 15% of total machining cost is spent on cutting fluid. In this they have used temperature sensors for their experiment. When temperature is less than 40°C for the turning operation on lathe then according to the setup the solenoid valve which makes the coolant flow on the workpiece is in closed state and when it becomes equal to 40°C then the solenoid valve opens for 2 seconds and when temperature exceeds 40°C, then solenoid valve is continuously open and cutting fluid flows continuously. Also due to intelligent cooling, surface roughness is more, also tool life reduces a bit as compared to flood cooling but wastage of coolant is comparatively very less as compared to flood cooling. If intelligent cooling system is brought in operation then machining cost reduces as coolant cost reduces.

Junsong Jin, et.al^[5]: In this paper finite element analysis is done on the rotary forming process of rim. In this paper they have compared experimental study and observations with the FEA calculations. They have made FEA calculations on rolling of upper roller surface, lower roller surface as well as arc bottom surface. The rotary forming process for thickening of rim is divided into three parts: i) Elastic Bending ii) Roller Groove Filling iii) Flash Forming.

WANG Hai-tao, et.al^[6]: Explains that Speed and working condition of the Piston has effect on friction force. By the setup as the speed increases friction force also increases to some extent and then reduces gradually. Stroke length doesn't have any effect on friction force. It is independent of stroke length. As pressure of compressor air increases, friction force also increases for same stroke length of piston cylinder arrangement. Friction Force varies with working condition of piston. When piston is stationary friction force is high.

III. METHODOLOGY

The manufacturing of the casing includes the different operations performed on the raw material. The sheet metal is cut into required size by the process of shearing and shearing machine is used for this purpose. This is used because it is the most economical method for sheet metal cutting and the accuracy requirement is not that high. After the cutting of sheet metal for different parts of the casing the joining of the various parts is to be done.

For the lower casing, the requirement is that there should be no leakage. The lower casing used for storing the coolant. The lower casing is made up of 3 mm sheet because it has to bear the weight of the casing. The joining process used for this is CO2 welding. Other welding processes like oxyacetylene welding, arc welding, etc. cannot be used because the heat generated is very high which heat will melt the sheet. CO2 welding is used for this because this has less temperature than the others. And also, the different welding materials can be used for the welding and temperature can also be controlled. The lower casing is reinforced by bending the top portion of the casing. This also serves as the platform for the seating for the upper casing. This bend, which is the flange has holes drilled for the alignment of the upper and lower casing. The upper casing is made up of 2 mm thick sheet. As upper casing should have less weight for easy removal and insertion, the 2mm thick sheet is used. Same CO2 welding is used for this process. Space for side window front door and the groove for the hydraulic pipes and electrical connections are cut on the sheet. At the edges, rubber covering is applied so for the safety purpose. It is also reinforced by bending the edges in 90 degree and the corresponding holes are drilled in which the bolts are inserted for assembling the upper casing with the lower casing. Between these flanges a silicon rubber gasket is placed so that splashed coolant will not leak out of the flanges. Automatic door opening mechanism consists of pneumatic cylinders, transparent glass that is acrylic sheet. The acrylic sheet is attached to the top plate and this plate is attached to the end of the pneumatic cylinder. This is done by using bolting. This assembly is then attached to the lower casing on the inside by proper cylinder mountings. The cylinder mounting used is lugs both end.

The upper casing is also divided into two parts, the upper front and the upper back. Hinges are provided at the top of the two casings. The front top rotates about the hinge in 180 degree so that the machine inside the casing will be accessible for the maintenance. Then all the sub-assemblies are combined and casing is complete.

IV. COMPONENTS OF COOLING ARRANGEMENT

A. Casing

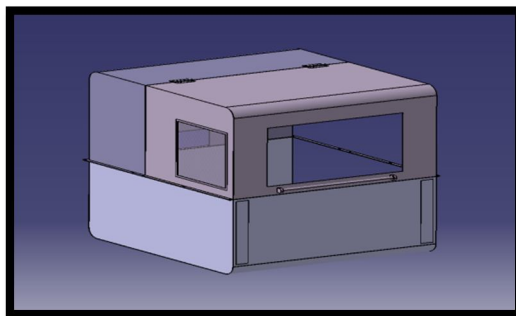


FIG: CASING

- 1) Casing is basically an enclosure. It separates the machine from the surroundings.
- 2) It avoids the danger to the operator and chances of accidents. It avoids the dust and the dirt to get into the machining process.
- 3) This also serves for a place to mount other things like control panels and different gauges and other things.
- 4) This casing has divided into 3 parts. The lower half which stores the coolant. The upper back half which has space for accommodation for hydraulic pipes.
- 5) The front upper half which has the front door cut-out for easy inserting and removal of the rim. The upper and lower half's are joined by bolts. The upper half has studs for easy alignment of the two halves.

B. Pneumatic Cylinder Arrangement

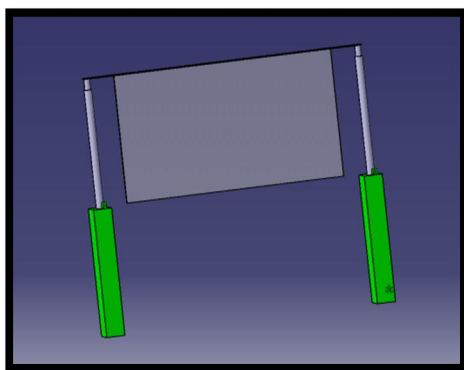


Fig: Pneumatic Cylinder Arrangement

- 1) Pneumatic cylinders are used for a faster opening and closing of the door. Two cylinders with cushioning are used for avoids the sudden impact on extension and retraction.
- 2) The cylinders have approximately 650 mm stroke lengths.
- 3) The upper portion of the piston rod has an extension provided which can be adjusted as per the opening area of the door required.
- 4) The extension has a rectangular plate provided for the mounting of the glass door. The plate along with the glass moves with the piston.
- 5) The door is of acrylic sheet and is transparent to see the operation. The acrylic sheets are not fragile so that they will not crack if anything hits it.

C. Stand

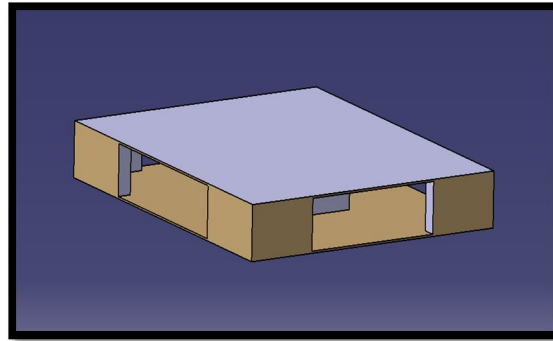


Fig: Stand

- 1) It's used to avoid the contact between the coolant and the lower surface of the machine.
- 2) Serves the purpose of dampening and absorbing the vibrations of the machine and also transmits the weight of the machine evenly to the ground

D. Coolant Tank

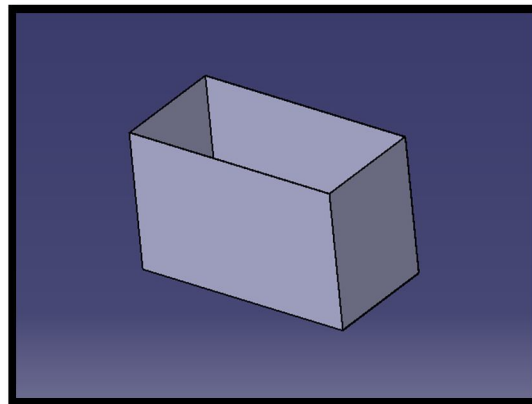


FIG: COOLANT TANK

- 1) The coolant reservoir is a tank that contains the excess coolant. It receives the coolant from the main tank via a pump.
- 2) This tank is provided with the filtering mechanism which filters the coolant and separates the unwanted particles, dust and dirt.

E. Pumps



FIG: MOTOR

- 1) Coolant pumps are used for the pumping the cooling lubricants from the coolant reservoir.
- 2) It pressurizes the coolant so that the dirt and the debris can be easily removed from the rim and the roller.
- 3) They are multistage, centrifugal pumps that are designed to be placed in the liquid that is to be pumped, and as such they are fully submersible. They are safe for use with both water and water-soluble coolants.
- 4) Two pumps are used. A low pressure for pumping the coolant from the primary tank to secondary tank.
- 5) High pressure pumps for pumping the coolant at high pressure to the rolling area so that the unwanted particles can be removed easily. Nozzles are used for directing the stream of coolant onto the rolling area.

F. PLC (Programmable Logic Controller)



FIG: PLC

- 1) A programmable logic controller (PLC) or programmable controller is an industrial digital computer which has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, or robotic devices, or any activity that requires high reliability control and ease of programming and process fault diagnosis.
- 2) They were first developed in the automobile manufacturing industry to provide flexible, ruggedized and easily programmable controllers to replace hard-wired relays, timers and sequencers. Since then they have been widely adopted as high-reliability automation controllers suitable for harsh environments.
- 3) A PLC is an example of a "hard" real-time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.

V. PROPOSED DESIGN

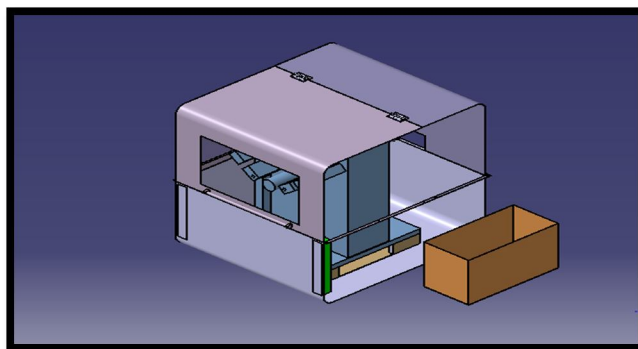


FIG: PROPOSED DESIGN

VI. DESIGN CALCULATIONS

A. Volume of Coolant in Casing

$$V_c = \text{Length} \times \text{Breadth} \times \text{Height} \text{ (m}^3\text{)}$$

$$= 1.2 \times 1 \times 0.162$$

$$= 194.4 \text{ litres}$$

B. Volume of Coolant in Collecting Tank

$$V_T = \text{Length} * \text{Breadth} * \text{Height} \text{ (m}^3\text{)}$$

$$= 0.5 * 0.6 * 1$$

$$= 300 \text{ litres}$$

C. Pneumatic Cylinder

Standards Available (SMC Pneumatics)

(Cylinder) bore size (D) = 32 mm

Piston rod= 12 mm

Piston area=804 mm

Assume operating pressure 0.5-0.65 N/mm²

$$\text{Force (extension)} = p * (\pi/4) * d^2$$

$$= 0.5 * (\pi/4) * 12$$

$$= 60 \text{ N}$$

$$\text{Force (retraction)} = (\pi/4) * (D^2) - (d^2)$$

$$= (\pi/4) * (16^2) - (12^2)$$

$$= 345 \text{ N}$$

D. Coolant Flow Rate

$$Q = \text{Area} * \text{Height/Time}$$

$$= (\pi/4) * 1.9^2 * (200/8)$$

$$= 70.88 \text{ cm}^3/\text{s}$$

$$= 4.25 \text{ litres/ min}$$

$$= 1.1227 \text{ gallons/minute}$$

E. Pump Horse Power

$$\text{HP} = (Q * H) / 39.60$$

$$= (1.1227 * 6.5616)$$

$$= 0.18$$

Where Q= Discharge in gallons/minute

H= Head in foot

VII. OBSERVATIONS

TABLE I PRODUCTION BEFORE EXPERIMENT

	Shift 1	Shift 2	Shift 3	Total	Rejection
Day 1	1300	1200	930	3430	177
Day2	1280	1240	940	3460	155
Day3	1320	1240	960	3480	158
Day4	1310	1240	980	3540	172
Day5	1290	1250	990	3530	165
Day6	1270	1200	940	3410	159
Day7	1290	1190	950	3430	180
Day8	1320	1250	930	3500	169
Day9	1300	1180	930	3410	168
Day10	1300	1190	940	3430	175
Day11	1280	1220	930	3430	176
Day12	1260	1230	920	3410	164
Day13	1290	1250	960	3500	150
Day14	1310	1200	930	3440	152
Day15	1320	1210	940	3470	172
TOTAL					2492

TABLE II
PRODUCTION AFTER EXPERIMENT

	Shift 1	Shift 2	Shift 3	Total	Rejection
Day 1	1320	1200	960	3480	125
Day2	1280	1240	950	3470	130
Day3	1320	1240	940	3500	145
Day4	1310	1240	980	3530	129
Day5	1290	1250	930	3470	135
Day6	1270	1200	930	3400	140
Day7	1290	1190	950	3430	138
Day8	1320	1250	960	3530	142
Day9	1300	1180	930	3410	130
Day10	1300	1190	920	3410	136
Day11	1280	1220	940	3440	126
Day12	1260	1230	950	3440	129
Day13	1290	1250	960	3500	138
Day14	1310	1200	930	3440	132
Day15	1320	1210	940	3470	125
TOTAL					2000

VIII. RESULTS AND DISCUSSION

- A. Casing being done so splashing of the coolant is being avoided
- B. Roller life increased due to application of coolant
- C. Machine is brought under automation.
- D. Safety of the operator improved
- E. Rejection of the Rims Reduced

IX. CONCLUSION

At last of this paper we conclude that the project on Design and Development of Cooling system for Roll Forming Machine was carried out successfully. This project helped the company to increase their productivity in enormous forms like safety of the operator, implementation of 5s Culture, Poka Yoke, kaizen, rejection control and optimum utilization of available resources. Also Cleanliness of the floor space increased to a greater extent

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