Design Development and Analysis of Portable Roll-Forming for Polyhouse Gutters

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Abstract: Poly-house construction is a blooming business where in metal structures combined with polyester / polyethylene sheets and covers are used to fabricate enclosures for growing fruits/ flowers/ vegetables etc. under controlled atmosphere conditions, especially protection against rain and sun. Many sections used in the fabrication of poly-house are produced cold roll forming process. But as the Poly-house construction takes place as an onsite job, often these sections especially the gutters are found to fall short, and often lead to creation of bottle neck in fabrication of poly house thereby wasting time and money on labor and transport.

Keywords: Roll forming machine, Gear system Mechanism

1. INTRODUCTION

Poly-house construction is a blooming business where in metal structures combined with polyester / polyethylene sheets and covers are used to fabricate enclosures for growing fruits/ flowers/ vegetables etc. under controlled atmosphere conditions, especially protection against rain and sun. Many sections used in the fabrication of poly-house are produced cold roll forming process. But as the Poly-house construction takes place as an onsite job, often these sections especially the gutters are found to fall short, and often lead to creation of bottle neck in fabrication of poly house thereby wasting time and money on labor and transport.

Nowadays, sheet metal forming processes are widely used to produce three-dimensional surface. The most common forming methods employed are stamping, stretch-bending, hydro forming etc. The main advantages of these traditional processes are a short production time and high productivity. Nevertheless, large initial investments and long setup time make these processes inflexible and only profitable for mass production and economically unsuitable for single or small batch products.

A. PROBLEM STATEMENT

M/s Prathamesh Agrotech is one such company that fabricate and erect ploy house in Maharashtra state, Madhya Pradesh and other sites all over India. In Such onsite constructions to avoid the bottle necks in production they proposes To M/s Paramount Industries to Design and fabricate a portable roll forming machine for forming short length (2 feet) gutter lengths of formed-U- shape section from galvanized sheets of 0.6 mm to 1.2 mm thickness to be installed in rain water drain system in ploy house construction. Machine is to be kept below 1.5 feet in length, 1ft in width and 2 ft. in height, not to weigh more than 18 kg weight, to run on 230 volt ac power.

B. OBJECTIVES

1. Design of Roll forming section for three stage roll forming of U-section by theoretical method,rollers profile geometry by graphical method, Determination of pressure roller force and power requirement of machine.
2. Design of Roll forming section for three stage roll forming of U-section by Software method ,rollers profile geometry by application of the Profile- Roll software.
3. Design , modelling , drafting and analysis of roller system and critical machine components of roll forming machine by use of CATIA V5 and Ansys Workbench 16.0
4. Fabrication assembly and testing of machine to experimentally validate the stage wise section profile dimensions by all three methods i.e. theoretical, software and experiment.

C. SCOPE

1. Design development of three roller profiles using Profile-Roll software for 30 % section development in each first and second stage of roll forming and 40 % in last section of roll forming.
2. Design Development modelling and analysis of the male and female rollers for three stage roll forming using Unigraphix NX8, Ansys Work bench16.0
3. Fabrication of machine three stage cold roll forming machine with adjustable pressure roller system.

2. DESIGN AND DEVELOPMENT

System design as to and theoretical derivation of dimensions of the Rollers section for three stage roll forming of U-section by theoretical method , rollers profile geometry by graphical method :

a) System Design and theoretical derivation of power required to perform the roll forming operation, determination of gear train dimensions to get desired surface speed during roll forming operation.
b) System Design and theoretical derivations of critical components of the system as to shaft, bearings, pressure adjustment screw etc.
c) Design, modeling, drafting and analysis of roller system and critical machine components of roll forming machine by use of CATIA V5 and Ansys Workbench 16.0.

3. DESIGN OF ROLL FORMING MACHINE

In our attempt to design a special purpose machine we have adopted a very a very careful approach, the total design work has been divided into two parts mainly;

System design

Mechanical design

System design mainly concerns with the various physical constraints and ergonomics, space requirements, arrangement of various components on the main frame of machine no of controls position of these controls ease of maintenance scope of further improvement; height of m/c from ground etc. In Mechanical design the components are categories in two parts. Design parts Parts to be purchased. For design parts detail design is done and dimensions thus obtained are compared to next highest dimension.

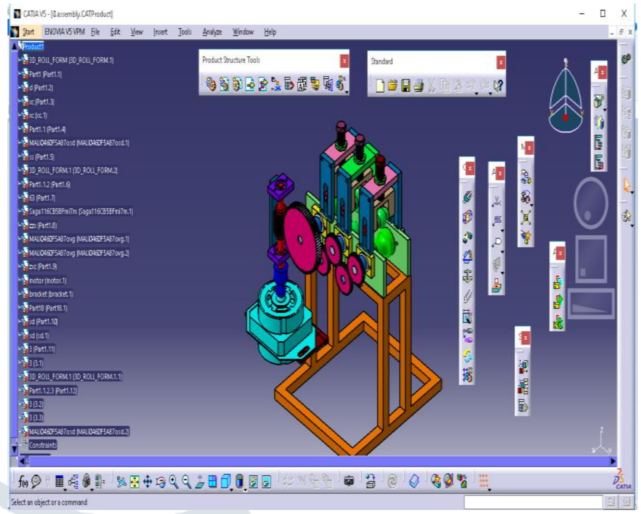

Figure3.1- Complete Assembly

The various tolerances on work pieces are specified in the manufacturing drawings. The process charts are prepared & passed on to the manufacturing stage .The parts are to be purchased directly are specified &selected from standard catalogues.

4. DESIGN CALCULATION

Assumption

Material to Be Rolled = Carbon Steel Sheet Cold Rolled and Annealed (C20)

Ultimate Tensile Strength (σ) = 390 N/mm2

Yield strength =220 N/mm2

Maximum sheet thickness (t) = 18 gage = 1.22 mm

Maximum width of sheet (L) = 40 cm = 400 mm

Diameter of machine rolls = 70 mm

Coefficient of friction (steel to steel) = 0.10

The method of sheet metal rolling is analogous to the sheet metal bending process hence it is necessary to calculate the bending force required to give the sheet ‘U’ shape using the movable roll, and then using coefficient of friction between rolls and sheet metal one can determine the torque requirements of machine for sheet metal rolling operation.

Bending force is given by,

$F = K\ L\ \sigma\ t^2/w$

Where;

F = Bending force, N

L = Width of sheet = 400 mm

σ = Ultimate Tensile Strength = 390 N/mm2

t = Thickness of sheet =1.22 mm

W = die opening = Π d /2 = 109.96

K = die opening factor = 1.20

F = 1.20 x 400 x 390 x 1.222 /109.96

F = 2533.90 N

This is the bending force required to form a U shaped bend of diameter 70 mm, to calculate the torque required to roll sheet,

T = μ F r

T = 0.10 x 2533.33 x 35 = 8866.65 N-mm

Assuming 100 % overload

Material Combination	Coefficient of friction (starting)	Coefficient of friction (running)
Soft steel- Steel	0.10	0.08

i.e., factor of safety =2

T design = 17.73×10^3 N-mm

A. MOTOR SELECTION

Motor Specifications

Power = 185 watt

Speed = 1440 rpm

P= 2 Π N T/60

T = 60 x P/2 Π N

T = 1.2268 N-m

Assuming an transmission ratio of 40:1 between motor and the machine using worm gear box

Tavailable = 40 X 1.2268 = 49 N-m

As Tavailable > T design

The motor we have selected is appropriate for the given application.

B. DESIGN OF ROLL PRESSURE SCREW

The roll pressure screw is used on either ends of the adjustable roller to give the desired rolling pressure, in our earlier calculations it is the equivalent to the bending force , hence the screw should be able to apply a force ,

F = 2533.90 N

The screw is rotated by means of a handle of 130 mm length, and assuming that one can apply a force of 100 N by hand,

The total external torque applied to handle is

13 N-m

Therefore,

(Mt) = 13 N-m--------- (A)

⇒ W X C = 13 N-m

Where; C = (dm/2) tan (Ø +∝)

W = load applied

Initially assuming dimensions of screw, which we shall check under the given system of forces.

Table-1 Selecting material combination for screw and nut.

Design Check**:-**

d = Nominal /outer diameter (mm) = 18mm

dc = core / inner diameter (mm) = 14mm

dm = mean diameter (mm) = 16mm

$M_t = W \times (dm/2) \tan (Ø + \propto)$

Where, W = Axial load

Ø = friction angle

∝ = Helix angle

Helix angle:-

$$\tan \propto = \frac{L}{\pi \, dm}$$

For the single start sq. thread lead is same as pitch=5

$$\tan \propto = \frac{4}{\pi \ X \ 16}$$

$\Rightarrow \propto = 4.54^0$

Coefficient of friction under different conditions

$\Rightarrow \mu = \tan \text{Ø}$

0.18 = tan Ø

⇒ Ø = 10.2

Mt = W X16/2 x tan (10.2 + 4.54)

Mt = 2.10 X W N-mm -------- (B)

Equating (A) & (B)

Wavailable = 6176 N

As W required is less than Wavailable the screw dimensions we have selected for the above application are appropriate

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