# Design and Fabrication of Portable Sheet Metal Bending Machine

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***Abstract***- *Now a days in industries sheets are bended by applying manual force by hammer or other device. We are designing the 3-Roll bending machine for sheet metal and for reducing the men effort we are adding the hydraulic jack. Because in hydraulics small effort can generate larger force by incompressible fluid while getting accuracy as well as reduction in men power. We are developing semi-automatic operated metal bending machine with use of metal shaft, hydraulic bottle jack, pedestal bearing, geared motor and support (frame). This machine works on simple kinematic system instead of complicated design. This machine can bend up-to 5 mm thick sheet. Due to its light weight and portability it can be used by small workshop, fabrication shop, small scale industry etc.*

***Keywords***- 3 roll bending, sheet metal bending, geared motor, bending with hydraulic jack, pedestal bearing, semi- automatic bending machine

## I. INTRODUCTION

Now a day in industries especially in automobile and other industries the automatic plate bending machines are widely used. Earlier the bending machines where operated manually. So the output of machine was very less. Because of the movement of ram was done manually by rotating the screw. Now the technique of bending operation of the component is changed. Once the plate is loaded the operator should not only use once push button to start the machine. But he has operated two push buttons so that both the hands of the operator are engaged. This arrangement is made in order to avoid injuries to operators.

The main aim of this project is to have the complete know how of hydraulics by which the manually operated press or any machine can be converted into a semi or fully automatic unit. In this project the bending machine is a semi-automatic bending machine, in which the loading and unloading of the component is done manually and the bending of the plate is done automatically.

A number of factors including type of metal, type of the roller bender, power driven or manual and the size of the bending machine are taken into consideration while designing the bending machine. Usually, the difference of these types of bending machine is only on the capacity of the bending machine that can bend a sheet metal or tube. Today, the bending machine that available in the market is for the sheet metal and tube bending machine. [1]

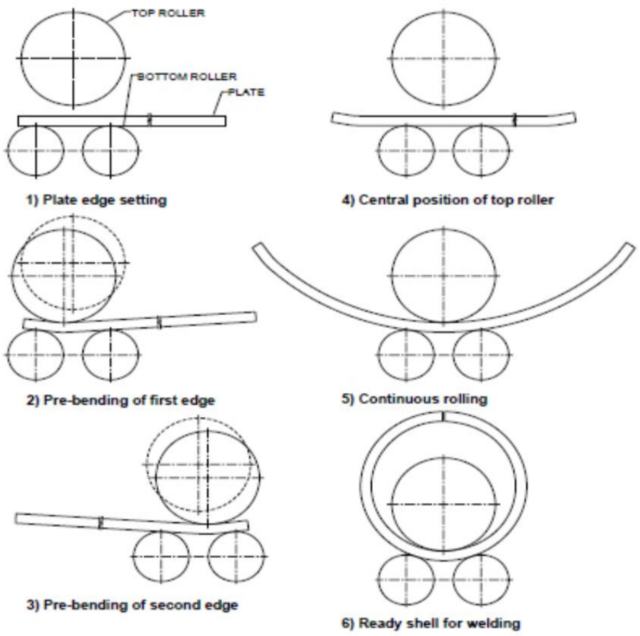
Many machine makers vary their products based on the capacity of the bending machine and power driven or manual. Moreover, most of the machine uses roll bending type.

This type of machine has three rolls which have one pressing top roll and two pressing side roll. The sheet metal needs to put in the roller and then rolls around it until the desire shape is acquired.

The products that can be produced with this machine are various curves, structural elements, automobile parts etc. [2]

**Working of Bending Machine:** The three roll push bending is the most commonly used free form bending process to manufacture bending geometries consisting of several plane bending curves. The profile is guided between bending roll and supporting rolls, while being pushed through the rolls. The position of the forming roll defines the bending radius. The bending point is the tangent point between shafts and metal to change the bending plane. The process is very flexible. The machine is power operated to increase accuracy at low prize without affecting the bending productivity.

We are going to design and develop sheet metal bending machine with the help of a hydraulic bottle jack and rollers. It consist three rollers. One roller is at the upper frame and another two rollers are at the lower frame, and with the help of bottle jack force we will bend the metals. It has two MS square pipe frames; one is fixed horizontally and one is vertically. At horizontal frame consist pedestal bearing through which shaft or roller is rotates easily. At horizontal frame have two rollers at parallel and at vertical frame carries also two pedestal bearing and one roller through it. Hydraulic bottle jack is used to give motion to vertical frame by which we can apply gradual load while bending. Sheet is fed from these rollers, because of the movement of roller driven by gear mechanism which is attached at roller of vertical frame. The pre-bending is accomplished by clamping the plate between the top roll and one of the lower rolls. The plate bend towards the top roller by the other roller; and the plate edge is pre-bent to minimum flat end possible. The length of the plate is rolled and radius is checked. Now lower the clamping roll until the plate is clamped again roll the plate into closed cylinder and pre-bend the second plate edge. Figure shows the working of 3 roll bending machine. [1]



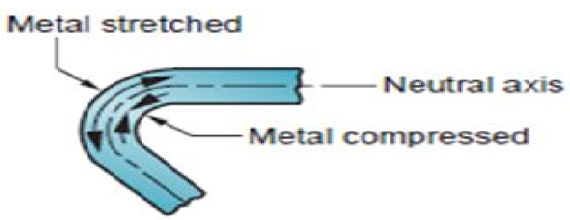




**Figure (a) both compression and tensile elongation of the metal occur in bending**

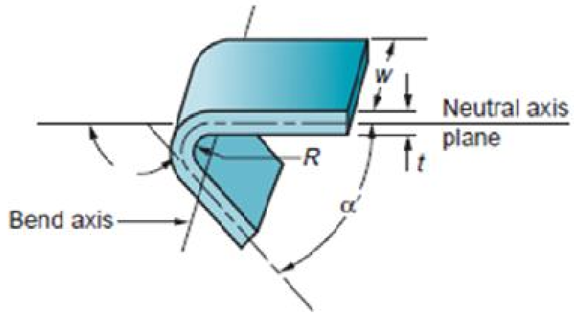



**Figure (b) Bending of sheet metal**

## II. LITERATURE REVIEW

**1. "Pooja K. Borkar, Prof. Pankaj H. Meshram" Review on Design and Analysis of Portable Rolling and Bending Machine" ISSN: 2321-0613 Year: 2015**

**Conclusion:** In this research paper they have used PRO/Engineer 3-D modelling software to create high quality graphics on which they have done analysis. Pro/ENGINEER models are the complete solid. This not only facilitates the creation of realistic geometry, but also allows for accurate model calculations. They have assumed the pressure linear on the beam with thickness 1/10 or less is used. The work has been held in two squares or diamond shaped formers. There is one problem in their portable machine that the machine is fitted on table and vice is used to hold work & the harming tool used to bend gives uniformed stress distribution which causes low accuracy.

**2. "Prof. Nilesh Nirwan and Prof. A.K.Mahalle" Design and Analysis of Portable Rolling and Bending Machine Using CAD and FEA Tool ISSN: 2278-0181 Year: April-2013**

**Conclusion:** Here in this paper they have designed a portable bending machine which can be used to bend beams and sections using QUASISTATIC BENDING and EULER-BERNOULLI BENDING THEORY. In which the stress induced in beam does not change over time and any deformation due to shear across the section is not accounted for no shear deformation. Also, this linear distribution is only applicable if the maximum stress is less than the yield stress of the material respectively.

**3. "A. D.Zope, R.R.Deshmukh, D.R.Mete, V.S.Mane" "Review Paper on Design and Development of Metal Bending Machine"ISSN: 2320-334X Year: 2015**

**Conclusion:** In this research paper they have used hydraulic jack instead of lead screw for loading and unloading and there is a hand wheel which is used for bending operation. This machine has 2 fixed roller and 1 free roller. Bending takes place by rotating hand wheel manually and roller movement of the free roller takes place by hydraulic jack. It's made for small scale fabrication shops whose owner cannot afford automatic bending machine. This machine can bend both pipe as well as sheet metal which increase its productivity.

**4. "M.Santhosh, S. Sathishkumar, A.Selvamani" "Experimental Design and Fabrication of Hydraulic Rod Bending Machine" ISSN: 2319 – 8753 Year: May 2015**

**Conclusion:** Here the machine is designed to produce stirrups**.** In this paper a successful solution for the manual stirrup making is obtained. By changing the fixture in the table we can obtain various sizes of the stirrups. Instead of complicated designs the simple kinematic system is used. In this system bending of stirrup wire can extended to its length against workstation is possible. The system can be handled by any operator very easily.

Due to low cost and simple design this can be marketed to any of the nation. Here hydraulic cylinder having 40literes of capacity has been used with Direct Control Valve (DVC) with vane pump and motor (2Hp). The rate of production is around 1000 to 1250 stirrups in 8 hours of effective working per day.

**5. "Dhaval T. Suthar, Kiran R. Malvi, Deneesh K Patel" "Final Working of Rolling Pipe Bending Machine" ISSN: 2249-5770 Year: April-2015**

**Conclusion:** In This paper pipe bending machine design provides the precise location of the work piece, thereby increasing the accuracy of the operations Provisions are also made so as to reduce the Vibrations and eliminate damage to the work piece. Via the analysis of bending characteristics and multiple defects, advances on exploring the common issues in tube bending are summarized regarding wrinkling instability at the intrados, wall thinning (cracking) at the extrados, spring Back phenomenon, cross-section deformation, forming limit and process/tooling design/optimization. In this design, material used for the components of the machine is mild steel, which is of considerable strength as well as of low cost.

**6. "Mr. Nitin P Padghan, Mr. Prafulla D. Deshpande, Dr.C. N. Sakhale" "Force Analysis of Metal Sheet in Bending Operation on Sheet Bending Machine" ISSN: 2278-0181 Year: January-2015**

**Conclusion:** Here in this research paper after performing actual experiment force calculation and fem analysis on metal sheet at different materials, we conclude that the force which required for bending the sheet is found by virtually it is tested in terms of factor of safety as well as material safety while bending operation. On the basis of the results and its analysis, following conclusion can be drawn. From the result's analysis for constant radius of curvature (R), constant dimensions by changing the material, load (W) increases as the value of modulus of elasticity (E) increase. From the result's analysis and calculations we can conclude that for same material keeping dimensions constant change in radius of curvature(R) changes the value of load (W). As radius of Curvature(R) increases the load (W) value also increases. From the result's analysis and calculations, for same radius of curvature (R) and material if thickness varies from 5 mm to 25 mm, it directly affects the value of load (W). Required surface finish of cylinder or any circular product is directly affected by skilled labour as they lowered the top roller with the help of power screw in some extent.

**7. "P.S. Thakare, P.G. Mehar, Dr. A.V.Vanalkar, Dr.C.C.Handa" "Productivity Analysis of Manually Operated and Power Operated Sheet Bending Machine: A Comparative Study ISSN: 2248-9622 Year: April 2012**

**Conclusion:** This paper deals with the difference of productivity between manually operated sheet metal bending machine and power operated sheet metal bending machine. After predefining parameters like working hours, manufacturing cost per kg, Weight of the sheet, it has been seen that the productivity we get in power operated sheet metal bending machine is much higher with lesser amount of time as well as labour compared to that manually operated sheet metal bending machine. Here productivity improved 89.61% with the help of formula as below.

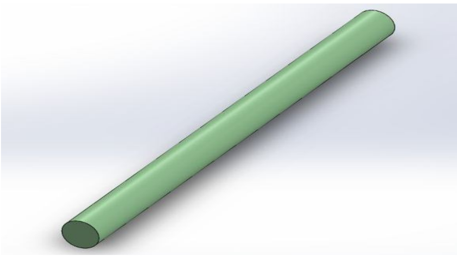
**Conclusion of literature review:** It can be conclude that from all research paper we study, in earlier days manual machine are made and some automatic machine were design and analysed on PRO-E. We find that the productivity of the manual machine is very less and time consuming compare to the automatic or semi automatic machine. So here we are design and fabricate semiautomatic 3 roller sheet metal bending machine in which rollers are rotate using 3 phase geared motor and sheets are feded by manually.

## III. DESIGN METHODOLOGY

HAYDRAULIC JACK

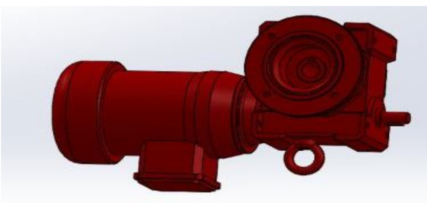
- To lift heavy loads, hydraulic jack is used. We use the hydraulic bottle jack capacity of 5 ton to lift the inner frame

SHAFT



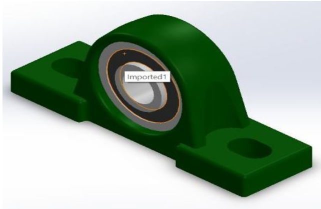
- Stationary shaft: They are used to give support to sheet.
- Moving shaft: It is used to move the sheet in continuous motion which is further used to bend the sheet. The moving shaft is directly connected with geared motor.

GEARED MOTOR



- Geared motor is the main power source. It is used to drive the moving shaft. We use 0.25 hp geared motor.

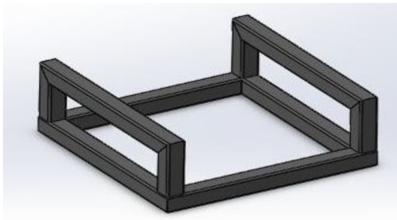
PEDESTAL BEARING



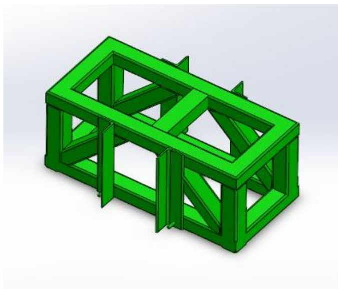
- It is used to support the shaft.

HIGH TENSION SPRING

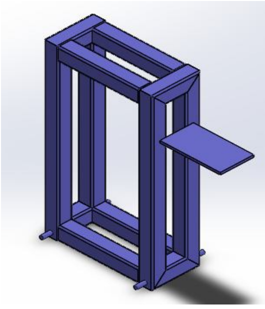
MS STRUCTURE



- Base is used to ground vibration and the material is Mild Steel

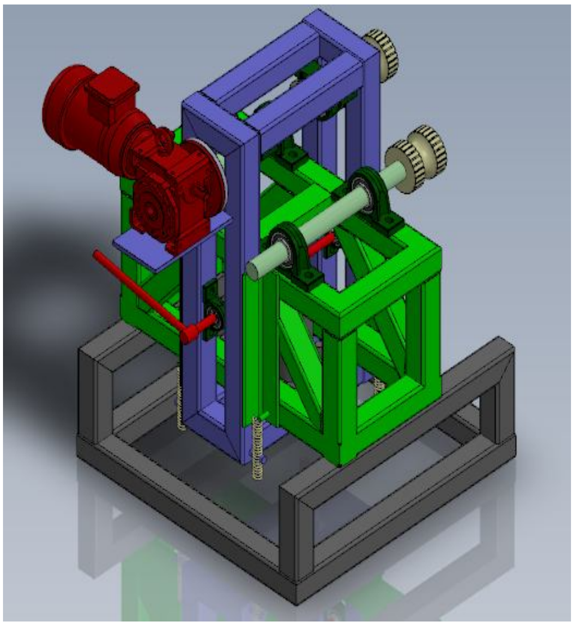


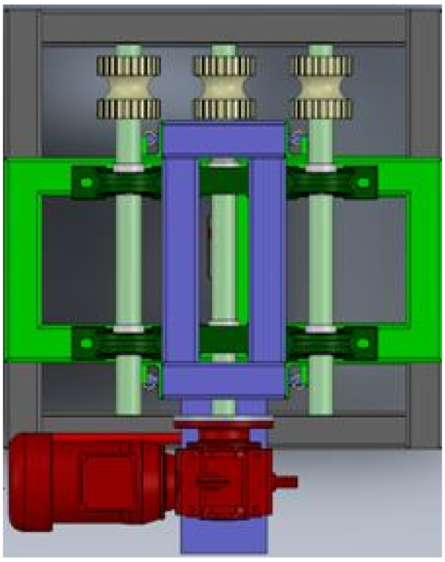
- Horizontal structure is used to support the stationary shafts.



- Vertical structure is used to support the moving shaft and geared motor.

3D MODEL





## IV. CALCULATION OF BENDING MACHINE

**Selected Material : Mild Steel E250**

**Calculation of required power**

Dead weight of the machine = 70kg {Approx.}
$Power$ = Work/Time
$P = Force \times$ (Distance/Time)
P = mg × Vs; Vs = Lifting rate of the machine
P = 70 × 10 × 0.2
P = 140 watt {for 100% efficiency}

P = 140/0.8 {for 80% efficiency}
P = 175 watt
P = 175/746
P = 0.23hp ≈ 0.25hp

**Calculation of Bending Moment**

Sheet metal Thickness $t_1$ = 3 mm
Sheet metal Width b = 250 mm
Sheet metal Length l = 600 mm
Yield stress for mild steel S = 250 N/mm2
Shear stress for mild steel $\tau$ = 0.57 × S = 142.5 N/mm2
Bending Moment M = $St^2 / 4$
= (250 × 3 × 3)/4
= 562.5 N × mm2 per mm
Bending moment for entire length M = 562.5 × 600
= $337.5 \times 10^3$ N × mm

**Calculation of Radius of Curvature R**

Moment of inertia I = bt3/12
= (250 × 3 × 3 × 3)/12
= 562.5 mm4
Now, M/I = $E/R$ ;E = Modulus of elasticity of compression
= $(337.5 \times 10^3)/562.5$
= $(196 \times 10^3)/R$
R = 326.67 mm ≈ 330 mm

**Calculation of Load W**

W = (4 × E × I)/(R × L)
W = $(4 \times 196 \times 10^3 \times 562.5)/(330 \times 600)$
Load W = 2227.27 N

**Calculation of Equivalent Twisting Moment**

Power $P = 2\pi NT/60$ ; N = RPM of Motor

$186.5 = (2 \times \pi \times 48 \times T)/60$

Twisting Moment $T = 37.1 \times 10^3$ N × mm

$Te = \{(Kb \times M)^2+(Kt \times T)^2\}^{1/2}$

Here $kb$=1.5 and $kt$=1

$Te =\{(1.5 \times 337.5 \times 10^3)^2 +(1 \times 37.1 \times 10^3)^2\}^{1/2}$

$Te = 507.607 \times 10^3$ N-mm

**Calculation of Shaft Diameter from Twisting moment**

$\tau = 16Te/\pi d^3$

$142.5 = (16 \times 507.607 \times 10^3) / (\pi \times d^3)$

$d^3 = 18141.90$ mm3

d = 26.19 mm ………………………………… (1)

**Calculation of Equivalent Bending Moment**

$Me = (Te + M)/2$

$= (507.607 \times 10^3 + 337.5 \times 10^3)/2$

$Me = 422.55 \times 10^3$ N × mm

**Calculation of Shaft Diameter from Bending moment**

$\sigma b = \frac{MY}{I}$

$= (337.5 \times 10^3 \times 1.5)/562.5$

σ b = 900 N/mm2

Now, $\sigma b = 32Me/\pi d^3$

$900 = 32 \times 422.55 \times 10^3 \pi d^3$

d3 = 4782.28 mm3

d = 16.37 mm

As per the safe design procedure shaft diameter should be consider the maximum value from the answers therefore the shaft diameter

ANS: **d = 26.19 mm ≈ 30 mm**

**Minimum diameter of shaft for different thickness of sheet metal**

| Sheet metal Thickness in mm | Shaft Diameter in mm |
|---|---|
| *1* | *15* |
| *3* | *30* |
| *5* | *35* |

**Calculation for spring**

**High tension spring**

Load acting on spring 4 spring = 500N (approx.)
Load acting on each spring = 125N
Spring index C = 10 (Assumed)
Shear stress for spring wire = 140 N/mm2
Modulus of rigidity G = $84 \times 10^3$ N/mm2
Factor of safety = 3

**Calculation for mean diameter of spring coil**

D = mean diameter of spring coil
d = Diameter of spring wire

whal's stress factor $K = (4C-1)/(4C-4) + 0.615/C$

$= (4\times10-1)/(4\times10-4) +0.615/10$

K = 1.144

**Shear stress** $\tau = K\times 8WC/(\pi d \times d)$

$140\times3 = (1.144\times8\times125\times10)/(\pi d\times d)$**;** factor of safety is **3**

d2 = 8.67 mm

d = 2.944 mm

d ≈ 3 mm

D = C×d

D = 10×3

**D = 30 mm**

**Calculation for number of coil n**

$\delta = 8WC^3 n/G\times d$

$\delta = 8\times125\times1000\times30/84000\times3$

δ = 119.04mm ≈ 120mm

**Calculation for free length of spring Lf**

Lf = n×d + (n-1)

= 30×3 + 29

= 119 mm say 150 mm

pitch $p = Lf/(n-1)$

= 150/29

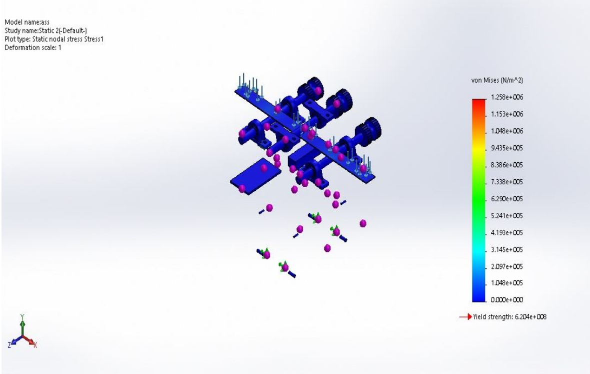
= 5.17mm

≈6 mm

## V. ANALYSIS

**Stress analysis**

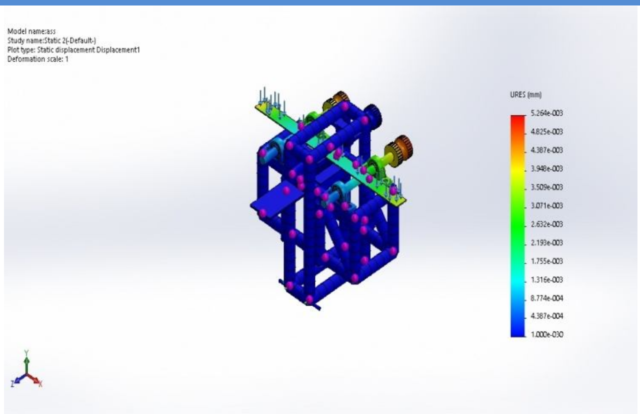
| Name | Type | Min | Max |
| --- | --- | --- | --- |
| Stress1 | VON: von Mises Stress | 0 N/m^2 Node: 1 | 1.25794e+006 N/m^2 Node: 4782 |



ass-Static 2-Stress-Stress1

**Displacement analysis**

| Name | Type | Min | Max |
| --- | --- | --- | --- |
| Displacement1 | URES: Resultant Displacement | 0 mm Node: 1 | 0.00526418 mm Node: 30068 |

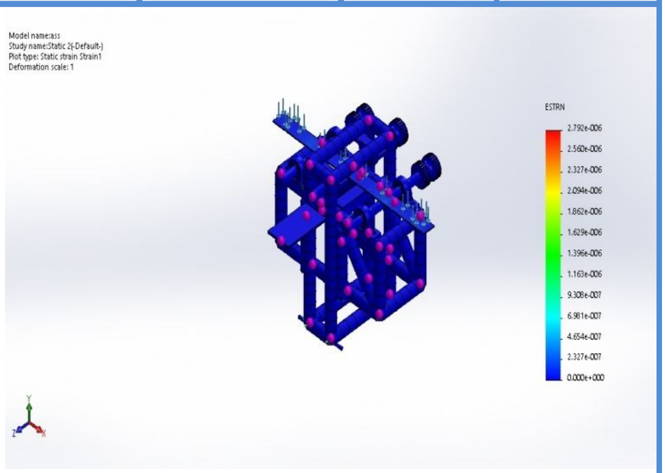


ass-Static 2-Displacement-Displacement1

**Strain analysis**

| Name | Type | Min | Max |
| --- | --- | --- | --- |
| Strain1 | ESTRN: Equivalent Strain | 0 Element: 1 | 2.79226e-006 Element: 4869 |

| Name | Type | Min | Max |
| --- | --- | --- | --- |



ass-Static 2-Strain-Strain1

## VI. CONCLUSION

The design model of sheet metal bending machine was successfully fabricated. we also successfully carried out the experimental and software analysis of the model.The design is made and analysed in the solid work software.In manual machine different force applied at every time but in semi automatic machine same force applied at every time so we get same finish product at every time.From the experimenatl analysis, in this machine we can bend a sheet metal upto 5mm thickness.

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