"SHEET METAL BENDING MACHINE"

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ABSTRACT

The paper deals with manufacturing or bending of sheet metal by using power operated sheet bending machine. Especially discussion made the productivity analysis of manually or power operated sheet bending machine. Considering manual operation is replaced by power operated devices .It also gives information about limitation of manually operated sheet bending machine and power operated sheet bending machine.

Key Words: Shape, Bending, Cylindrical, Automatic, Hoppers, Frame, Fabrication, Production

INTRODUCTION

Sheet metal fabrication plays an important role in the metal manufacturing world. Sheet metal is used in the production of materials ranging from tools, to hinges, automobiles etc. Sheet metal fabrication ranges from deep drawing, stamping, forming, and hydro forming, to high-energy-rate forming (HERF) to create desired shapes. Fascinating and elegant shapes may be folded from a single plane sheet of material without stretching, tearing or cutting, if shape rolling of sheet metal is the bending continually of the piece along a linear axis. This causes alteration of the original form of the sheet as it passes through a pathway of series of rollers. The present invention relates to plate bending machines of the type which operates with rolls. Such machines involve certain well-known difficulties in respect of bending plates into conical shape. The invention has for its object to remedy this drawback and to enable, by including auxiliary means, the bending of conical mantles and the like.

The main characterizing feature of the plate bending machine according to the invention resides in that it comprises a pin which is adapted, during the bending operation, to be moved into engagement with

one of the rolls in a substantially radial direction so as to serve as an abutment for one edge of the blank to be bent.

In a plate bending machine, a frame, two parallel cylindrical rolls rotatable mounted in side frame and adapted to be driven in the same direction, a third cylindrical roll situated substantially in the median plane between the two first-mentioned rolls and freely rotates, mounted in side frame in adjustable bearings permitting side third roll to be inclined relatively to the two first-mentioned rolls for producing conical bends, a tubular support mounted in fixed relation to said frame adjacent one end of said third roll and substantially perpendicularly to its axis, and a pin slid-ably mounted in said tubular support and movable into engagement with the periphery of said third roll to serve as an abutment for the edge of a plate when producing a conical bend.

1.1.a. Features:

- Low initial cost
- Low tooling cost
- Easy & Quick setting
- Enormous versatility
- Accurate repetition & bending
- User friendly
- Easy maintenance
- Standard spares, hence easy availability

1.1.b. Standard Features/Accessories:

- Main Drive Motor
- Frame built of laser cut high strength steel, welded, stress relieved and sand blasted.
- Hydraulic pressing system on top roll.
- Hydraulic unit by Rexroth and valves by Aron.
- Screw jack drop-end.
- Mechanical rolls parallelism.
- Bending rolls assembled on heavy duty SKF bear.

1.2 History

Gum/AR d E. EABERG' Patented Apr. 6, 1954 UNITED STATES PATENT OFFICE PLATE BENDING MACHINE Application February 19, 1953, Serial No. 337,808

Such machines involve certain well-known difficulties in respect of bending plates into conical shape. The invention has for its object to remedy this drawback and to enable, by including auxiliary means, the bending of conical mantles and the like. The main characterizing feature of the plate bending machine according to the invention resides in that it comprises a pin which is adapted, during the bending operation,

to be moved into engagement with one of the rolls in a substantially radial direction so as to serve as an abutment for one edge of the blank to be bent.

These gear wheels are engaged by a common pinion (Not shown) which rotates the lower rolls in the same sense. The source of power may be an electrical motor. The upper roll of the machine is mounted with one journal in a bearing which is vertically adjustable in the end member I by means of a screw. Its other journal is, in a similar manner, mounted in a bearing which is vertically adjustable by means of a screw II and is mounted in a bracket on the right hand frame end member. The bracket has a pin which engages a bore or bearing I in the frame end member 2, and is provided with a suitable locking device whereby it can be secured to the frame end member in a vertical position. After the bending operation the bracket I3 may be pulled slightly outward and be turned laterally whereby the bent plate can be removed from the machine.

1.3 Objectives of the work:

The following are the objectives of the work:

a. To make a bending machine to bend metal sheets up to 8 mm.
b. To make on simple working principle.
c. To reduce the time for operation.
d. To make in minimum cost.

1.4 Applications

- Fabricating/Rolling
- Boilers, Pressure Vessels
- Storage Tanks, Silos
- Tubes and Pipelines
- Pumps, Burners and Filters
- Heating and Ventilation
- Wind Towers, Power Generation

Fig: 1. Hopper & Mixture

2. DESIGN CONSIDERATION

2.1. General design principles

Following basic shearing operation on a sheet metal, components can be rolled to give it a definite shape. Bending of parts depends upon material properties at the location of the bend. To achieve bending, the work material must be subjected to two major forces; frictional force which causes a no-slip action when metal and roller came in contact and a bending force acting against the forward speed and the torque applied to move the material.
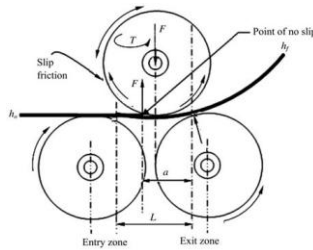
Fig 2. Shape rolling mechanism

Where, a = distance from exit zone to the no-slip point (assume a = L/2);

F = force applied to rollers;

T = torque applied to rollers;

L = roll gap;

r = radius of rollers;

μ = frictional force 0.4 Nm-1;

ho, hf = thickness of the sheet before and after time t.

At least two rollers are involved in flat rolling depending on the thickness and properties of material while three or multiple roller system is required in shape rolling. A work material under bending load is subjected to some form of residual stress and deformation as it bends. Materials at the outer bend radius undergo tensile plastic deformation while the material at the inner bend radius undergoes compressive plastic deformation.

2.2 Types of Bending Machines

Bending is a manufacturing process that produces a V-shape, U-shape, or channel shape along a straight axis in ductile materials, most commonly sheet metal. Commonly used equipment includes box and pan

brakes, brake presses, and other specialized machine presses. Typical products that are made like this are boxes such as electrical enclosures and rectangular ductwork.

- Air bending
- Bottoming
- Coining
- Three-point bending
- Folding
- Wiping
- Rotary bending
- Roll bending
- Elastomer bending
- Joggling

1. Air bending

This bending method forms material by pressing a punch (also called the upper or top die) into the material, forcing it into a bottom V-die, which is mounted on the press. The punch forms the bend so that the distance between the punch and the side wall of the V is greater than the material thickness (T).

Either a V-shaped or square opening may be used in the bottom die (dies are frequently referred to as tools or tooling). A set of top and bottom dies are made for each product or part produced on the press. Because it requires less bend force, air bending tends to use smaller tools than other methods.

2. Bottoming

In bottoming, the sheet is forced against the V opening in the bottom tool. U-shaped openings cannot be used. Space is left between the sheet and the bottom of the V opening. The optimum width of the V opening is 6 T (T stands for material thickness) for sheets about 3 mm thick, up to about 12 T for 12 mm thick sheets. The bending radius must be at least 0.8 T to 2 T for sheet steel. Larger bend radius require about the same force as larger radii in air bending, however, smaller radii require greater force—up to five times as much—than air bending. Advantages of bottoming include greater accuracy and less spring-back. A disadvantage is that a different tool set is needed for each bend angle, sheet thickness, and material. In general, air bending is the preferred technique.

3. Coining

In coining, the top tool forces the material into the bottom die with 5 to 30 times the force of air bending, causing permanent deformation through the sheet. There is little, if any, spring back. Coining can produce an inside radius is as low as 0.4 T, with a 5 T width of the V opening. While coining can attain high precision, higher costs mean that it is not often used.

4. Three point bending

Three-point bending is a newer process that uses a die with an adjustable-height bottom tool, moved by a servo motor. The height can be set within 0.01 mm. Adjustments between the ram and the upper tool is made using a hydraulic cushion, which accommodates deviations in sheet thickness. Three-point bending can achieve bend angles with 0.25 deg. precision. While three-point bending permits high flexibility and precision, it also entails high costs and there are fewer tools readily available. It is being used mostly in high-value niche markets.

5. Folding

In folding, clamping beams hold the longer side of the sheet. The beam rises and folds the sheet around a bend profile. The bend beam can move the sheet up or down, permitting the fabricating of parts with positive and negative bend angles. The resulting bend angle is influenced by the folding angle of the beam, tool geometry, and material properties. Large sheets can be handled in this process, making the operation easily automated. There is little risk of surface damage to the sheet.

6. Wiping

In wiping, the longest end of the sheet is clamped, and then the tool moves up and down, bending the sheet around the bend profile. Though faster than folding, wiping has a higher risk of producing scratches or otherwise damaging the sheet, because the tool is moving over the sheet surface. The risk increases if sharp angles are being produced. Wiping on press brakes involves special tools.

7. Rotary bending

Rotary bending is similar to wiping but the top die is made of a freely rotating cylinder with the final formed shape cut into it and a matching bottom die. On contact with the sheet, the roll contacts on two points and it rotates as the forming process bends the sheet. This bending method is typically considered a "non-marking" forming process suitable to pre-painted or easily marred surfaces. This bending process can produce angles greater than 90° in a single hit on standard press brakes or flat presses.

8. Roll bending

The roll bending process induces a curve into bar or plate work pieces.

9. Elastomer bending

In this method, the bottom V-die is replaced by a flat pad of urethane or rubber. As the punch forms the part, the urethane deflects and allows the material to form around the punch. This bending method has a number of advantages. The urethane will wrap the material around the punch and the end bend radius will

be very close to the actual radius on the punch. It provides a non-marring bend and is suitable for pre-painted or sensitive materials.
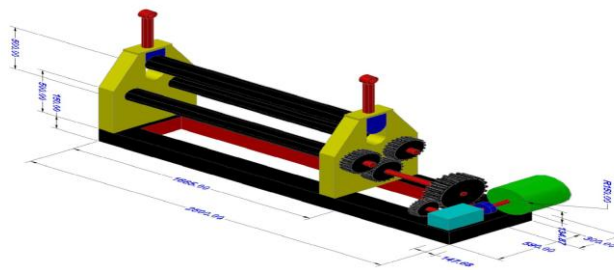
3. DESIGN OF BENDING MACHINE

Fig.No.3-Design of Bending Machine.

4. Calculations

Many variations of these formulas exist, these variations may often seem to be at odds with one another, but they are invariably the same formulas simplified or combined. What are presented here are the un-simplified formulas. All formulas use the following keys:

BA = bend allowance

BD = bend deduction

R = inside bend radius

K = K-Factor, which is t / T

T = material thickness

t = distance from inside face to the neutral line

A = bend angle in degrees (the angle through which the material is bent)

The neutral line (also called the neutral axis) is an imaginary line that can be drawn through the cross-section of the work-piece that represents the lack of any internal forces. Its location in the material is a function of the forces used to form the part and the material yield and tensile strengths. In the bend region, the material between the neutral line and the inside radius will be under compression during the bend. The material between the neutral line and the outside radius will be under tension during the bend. Both bend deduction and bend allowance represent the difference between the neutral line or unbent flat pattern (the required length of the material prior to bending) and the formed bend.

4.1 Bend allowance

The bend allowance (BA) is the length of the arc of the neutral line between the tangent points of a bend in any material. Adding the length of each flange taken between the center of the radius to the BA gives the Flat Pattern length. This bend allowance formula is used to determine the flat pattern length when a bend is dimensioned from 1) the center of the radius, 2) a tangent point of the radius or 3) the outside tangent point of the radius on an acute angle bend.

The BA can be calculated using the following formula

$$BA = A \left (\frac{\pi}{180} \right) \left(R + K \times T \right)$$

Diagram of Bend Deduction for sheet metal calculations

Diagram shows a standard dimensioning scheme when using Bend Allowance formulas. Note that when dimensions "C" are specified, dimension B = C - R – T

Example:

Angle	90
Pl	3.142
Radius	10.0
K-Factor	0.33
Thickness	10
Bend allowance	5.46708

4.2 Bend deduction

Diagram of Bend Deduction for sheet metal calculations

Diagram showing standard dimensioning scheme when using Bend Deduction formulas unknown (error) factors for a given setup. The K-factor depends on many factors including the material, the type of bending operation (coining, bottoming, air-bending, etc.) the tools, etc. and is typically between 0.3 to 0.5. The following table is a "Rule of Thumb". Actual results may vary remarkably.

Generic K-Factors	Aluminium		Steel
Radius	Soft Materials	Medium Materials	Hard Materials
Air Bending			
0 to Thickness	0.33	0.38	0.40
Thickness to 3 x Thickness	0.40	0.43	0.45

Greater than 3 x Thickness	0.50	0.50	0.50
Bottoming			
0 to Thickness	0.42	0.44	0.46

LIMITATIONS SAFETY & MAINTENANCE

4.2.1. Problems associated with sheet metal/plate rolling machines

Sheet metal/plate rolling machines are extremely dangerous, especially because it is not generally practicable to have the rollers guarded with a solid structure (e.g. fixed guard). Often the operator's hands are caught and drawn into the counter-rotating rollers, usually during the initial feeding of the work piece. A large number of incidents involving sheet metal/plate rolling machines have resulted in amputations and other serious injuries, with a large proportion of them being associated with the operator wearing gloves. Additionally, it is not uncommon for a person walking past the machine to slip, trip or fall and find that their hands have been caught in the machine.

4.2.2. Addressing the problem

A combination of safety devices (trip devices, emergency stops, hold-to-run controls, etc.) and administrative measures should be used to protect the operator and anyone near the machine.

Note: Safety devices that should be used will not directly prevent a person from having their fingers, hands or other body parts entangled or entrapped in the machine, but are intended to minimize the likelihood and severity of injury by stopping the machine in the quickest way possible. Machines should have hold-to-run controls, which only allow movement of the rollers when the control is held in the run position. On releasing the control, it should automatically return to the stop position.

An emergency stop button should be provided at the machine control console and any other workstation. These should be the lock-in type, so the machine cannot be restarted until it has been reset manually. On resetting the emergency stop button, the machine should not start until the normal start control is operated.Operators should be given comprehensive training and instruction to ensure they are completely familiar with the machine, its controls, guards and safety devices, hazards associated with the machine and any other control measures. Extra care should be taken to ensure that each operator fully understands and can demonstrate the safe operation of the machine. Furthermore, extra attention should be paid to young and inexperienced workers and workers returning from absence. Supervision needs to be provided, based on the

competence of the operator (e.g. direct and constant supervision for a new worker) and complexity of the task being performed.

4.2.3 Inspection and Maintenance

Inspection and Maintenance of the machine, including guards and other critical safety parts, must be done regularly. For guards and safety devices, this should be done at the start of each day or shift and whenever there is a change to the machines working configuration.

Maintenance activities should only be carried out when   the machine is fully isolated and locked-out from all power (electrical, hydraulic and pneumatic) sources and appropriate warning signs should be securely attached to the controls.

4.2.4   Safety procedures

Safe work procedures should be written to cover such things as inspection and maintenance, cleaning, safe operation of the machine, emergency situations, reporting faults and defects immediately. Of particular importance, as part of safe work procedures, is to ensure:

- Use of gloves with fingertips and the wearing of loose fitting clothing are prohibited.
- Work pieces are held far enough back from the edge being fed into the rollers to allow for in feed speed.
- The area around the machine is well-lit and free of materials which may cause slips, trips and falls.

5. TESTING ANALYSIS

5.1 PARTS OF BENDING MACHINE

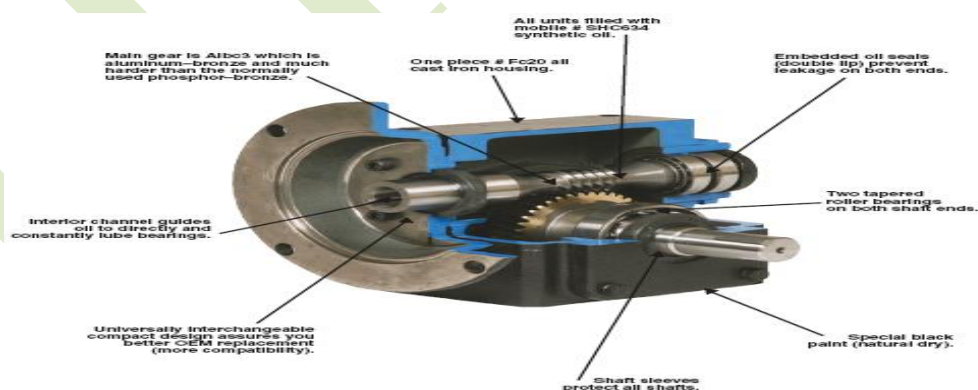### 5.1.1 Speed Reduction Gear Box

Fig 4. Sectional view of speed reduction gear box

In order to select a gearbox speed reducer, you will need to determine the required torque service factor for the application. The table below will assist in determining the service factor for service factor above 1.0; multiply the required torque by the service factor.• One-piece gear case, without external ribs, is made of close-grained cast iron and provides for rigid gear and bearing support .It also offers excellent heat dissipation.

• Carbon steel shafts for greater strength .

• Double lip, spring-loaded seals guard against oil leakage and prevent dirt from entering.

• Stepped shafts with oversized ball and tapered roller bearings.

• High tensile strength cast bronze worm wheel and hardened and ground alloy steel worm made integral with the shaft for long and trouble-free life.

• Oil sight gauge for ease of maintenance (not available on sizes 25 and 34).

• Factory oil filled.

• Every unit test runs prior to shipment.

• Universal mounting with bolt-on feet.

• Highly modifiable design.

5.1.2. Mechanical Ratings and Service Factors

Mechanical ratings measure capacity in terms of life and/or strength, assuming 10 hours per day continuous running under uniform load conditions, when lubricated with approved oil and working at a maximum oil temperature of 100°C, for normal application lubricant equivalent to ISO VG 320 should be used. See publication G/105 for details.

Formula: Equivalent load = actual load x service factor.

5.1.3. Details of gear box used in sheet bending machine:

TABLE 7.3 Details of gear box used in sheet bending machine

Manufactured by	Elecon mech
Shafts inner diameter	32 mm or 4"
Shafts outer diameter (worm wheel)	45mm
Lubrication oil	90 No.
Speed reduction ratio	40:1
Cost of gear box	35000 /-rs

5.2. Tyre Coupling F-60

F-60 couplings provide all the desirable features of an ideal flexible coupling, including Taper-Lock fixing. The F-60 coupling is a "torsionally elastic" coupling offering versatility to designers and engineers with a choice of flange combinations to suit most applications.

The flanges are available in either F or H Taper-Lock® fitting or pilot bored, which can be bored to the required size. With the addition of a spacer the coupling can be used to accommodate standard distances between shaft ends and thereby facilitate pump maintenance.

F-60 tyres are available in natural rubber compounds for use in ambient temperatures between −50OCand +50OC. Chloroprene rubber compounds are available for use in adverse operating conditions (e.g. oil or grease contamination) and can be used in temperatures of −15OC to +70OC. The chloroprene compound should also be used when fire-resistance and anti-static (F.R.A.S.) properties are required.

Fig: 5. Tyre coupling

5.2.1 SELECTION

(a) Service Factor

Determine the required Service Factor from table below.

(b) Design Power

Multiply the normal running power by the service factor. This gives the design power which is used as a basis for selecting the coupling.

(c) Coupling Size

Refer to Power Ratings table (page 195) and from the appropriate speed read across until a power greater than that required in step (b) is found. The size of F-60 coupling required is given at the head of that column.

(d) Bore Size

Check from Dimensions table that chosen flanges can accommodate required bores.

5.2.2 CALCULATION

An F-60 coupling is required to transmit 45kW from an A.C. electric motor which runs at 1440 rev/min to a rotary screen for 12 hours per day. The motor shaft is 60mm diameter and the screen shaft is 55mm diameter. Taper Lock is required.

(a) Service Factor

The appropriate service factor is 1.4.

(b) Design Power

Design power = 45 x 1.4 = 63kW.

(c) Coupling Size

By reading across from 1440 rev/min in the power ratings table the first power figure to exceed the required 63kW in step (b) is 75,4kW. The size of coupling is F90 F-60.

5.2.3 POWER RATINGS (kW)

Table: 2.3 POWER RATINGS (kW)

Speed	Type of Couplings						
rev/min	F40	F50	F60	F70	F80	F90	F100
700	1,76	4,84	9,31	18,3	27,5	36,6	**49,5**
720	**1,81**	**4,98**	**9,57**	**18,8**	**28,3**	**37,7**	**50,9**
800	2,01	5,53	10,6	20,9	31,4	41,9	**56,5**
900	2,26	6,22	12,0	23,6	35,3	47,1	**63,6**
960	**2,41**	**6,63**	**12,8**	**25,1**	**37,7**	**50,3**	**67,9**
1200	3,52	9,68	18,6	36,6	55,0	73,3	84,9
1400	3,62	9,95	19,1	37,7	56,5	75,4	99,0
1440	**4,02**	**11,1**	**21,3**	**41,9**	**62,8**	**83,8**	**102**

5.3.Motor Construction

Fig 6. A.C. Motor

5.3.1 Rotor

In an electric motor the moving part is the rotor which turns the shaft to deliver the mechanical power. The rotor usually has conductors laid into it which carry currents that interact with the magnetic field of the stator to generate the forces that turn the shaft. However, some rotors carry permanent magnets, and the stator holds the conductors.

5.3.2 Stator

The stationary part is the stator, usually has either windings or permanent magnets. The stator is the stationary part of the motor's electromagnetic circuit. The stator core is made up of many thin metal sheets, called laminations. Laminations are used to reduce energy loses that would result if a solid core were used.

5.3.3Air gap

In between the rotor and stator is the air gap. The air gap has important effects, and is generally as small as possible, as a large gap has a strong negative effect on the performance of an electric motor.

5.3.4 Windings

Windings are wires that are laid in coils, usually wrapped around a laminated soft iron magnetic core so as to form magnetic poles when energized with current. Electric machines come in two basic magnet field pole configurations: salient-pole machine and non salient-pole machine.

5.3.5 Details of AC electrical motor:

Manufactured by	Hindustan mech
Horse power	7.5
Shaft diameter	38mm
Key dimension	10x5x60
Rpm	1440

6. PEDESTAL BEARING

Fig 7.Pedestal Bearing

Material: Housing, grey cast iron.
Bearing: Ball-bearing steel 100Cr6.
Seal: Rubber NBR.
Surface finish: Housing, painted.

6.1 Description:

Pedestal block bearings consist of a sealed single-row ball bearing with a spherical outer ring which is mounted in housing. Because of the spherical outer surface of the bearing, shaft misalignment can be compensated for. The bearings are manufactured with a plus tolerance. This results in transition or press fits when using shafts with h-tolerances. The shaft is secured by grub screws on the inner ring. In normal applications, pillow block bearings are maintenance-free due to the lifetime lubrication.

Temperature range: -15 °C to +100 °C.

It is a split type of bearing. This type of bearing is used for higher speeds, heavy loads and large sizes.

This bearing facilitates the placements and removal of the shaft from the bearing.

6.2 Selection

Pillow blocks are usually referred to the housings which have a bearing fitted into them and thus the user need not purchase the bearings separately. Pillow blocks are usually mounted in cleaner environments and generally are meant for lesser loads of general industry. Bearing housings are usually made of grey cast iron. However various grades of metals can be used to manufacture the same.

ISO 113 specifies internationally accepted dimensions for Plummer blocks.

Roller Material Details

Fig 8.Roller arrangement

Application:

For shallow hardening applications Metallurgical Properties**:**

Inclusion Rating: A B C D 2.0/1.0 E 45 A

Grain Size: Fine grain size - ASTM No. 6-8

Decarburization & Surface Imperfections: 1 % of size max.

Microstructure: Pearle + Ferrite

 Mechanical Properties:

Coils, Hot rolled: 240 BHN max.

Coils, Hot rolled, Annealed: 180 BHN max

 Helical Gear and Roller Screw

Fig.9 Helical Gear and Roller Screw

Mild Steel I Beam Channel

Fig.10. Mild Steel I Beam Channel

Steel is made up of carbon and iron, with much more iron than carbon. In fact, at the most, steel can have about 2.1 percent carbon. Mild steel is one of the most commonly used construction materials. It is very strong and can be made from readily available natural materials. It is known as mild steel because of its relatively low carbon content.

ADVANTAGES LIMITATIONS

Advantages

- Easy to use

- Low initial cost

- Multi shaped objects can be manufactured

- Low maintenance cost

Limitations

- Skilled workers required for manual operating process

- More time required

- Applicable up to 8 mm thick sheets

7. RESULT DISCUSSION

- ❖ **Power Screw**

Available data
Weight of roller =150 kg
Length of roller =1690mm
Screw diameter (d) = 50 mm
Type of threads: Square threads.
Pitch (p) = 8mm

- ❖ **FORCE ANALYSIS:-**

Mean diameter (d_m)
d_m =d-0.5p
d_m =50- (0.5*8)
d_m =46 mm.
Lead (l) =numbers of threads originating at end*pitch.
 l= 1*8
l= 8 mm.

- ❖ **Lifting load**

$M_t = (W* d_m /2)*\tan (\emptyset+ \alpha)$
Helix angle
$\tan \alpha = (l / \pi \ d_m)$
$\tan \alpha =(8 / \pi * 46)$
$\tan \alpha = 0.05535$
$\alpha = 3.1685°.$

$\tan \varnothing = \ = 0.15$

$\varnothing = 8.531°$.

$M_t = (W * d_m /2) * \tan (\varnothing + \alpha)$

$M_t = \{[(150*9.81)*46]/2\} * \tan (8.531+3.168)$

$M_t = 7008.24$ N-mm.

$M_t = 3504.12$ N-mm is the load acting on one screw.

❖ **Lowering load:**

$M_t = (W * d_m /2) * \tan (\varnothing - \alpha)$

$M_t = \{[(150*9.81)*46]/2\} * \tan (8.531-3.168)$

$M_t = 3177.19$ N-mm

$M_t = 1588.59$ N-mm is the load acting on one screw.

As the lowering load is positive the screw is self locking .i.e. as $\varnothing > \alpha$ screw is self locking.

❖ **Design Of Gear**

Available data

Helix angle (Ψ) =19°.

Module m_n = 5.

Virtual numbers of teeth

$Z' = (Z/\cos^3 \Psi)$

$Z' = (15/ \cos^3 19)$

$Z' = 17.74$

Lewis factor

$(Y) = 0.302 + \{[(0.308-0.302)*(17.74-17)]/ (18-17)\}$

$Y = 0.3064$

$\sigma_b = S_{ut} /3$

$\sigma_b = 550/3$

$\sigma_b = 183.33$ N/mm^2 .

Face-width b= 45 mm.

Beam strength (S_b)

$S_b = m_n * b * \sigma_b * Y$.

$S_b = 5*45*183.33*0.3064$.

$S_b = 12639$ N.

❖ **Wear strength (S_w)**

Ψ, σc, θ e $\varnothing$ d_m, α , π, °,

$S_w = (b*Q*d_p *K)/ (\cos \Psi)$

$Q = (2*Zg)/ (Zg + Zp)$

$Q = (2* 51)/ (51+15)$

$Q = 1.5454$

$d_p = (Zp * m_n)/(\cos \Psi)$

$d_p = (15*5)/(\cos 19)$

$d_p = 79.32$ mm.

$K = 1.44$ N/mm^2.

$S_w = (45 * 1.5454 * 79.32 * 1.44)/ (\cos^2 19)$

$S_w = 8885.02$ N.

$S_w < S_b$, Therefore design is safe.

$V= (\pi *dp*np)/ (60*10^3)$

$V = (\pi *79.32 *36)/ (60*10^3)$

$V = 0.1495$ m/s.

$Cv = 3/ (3+V)$

$Cv = 3/ (3+0.1495)$

$Cv = 0.9525$

$S_w = (Cs/Cv) *Pt *fos$

$8885.02 = (1.75/0.9525) * Pt * 2$

$Pt = 2417.99$ N.

$Mt = (Pt *dp)/ 2$

$Mt = 95897.67$ N-mm.

$KW = (2 \pi *np *Mt) / (60*10^3)$

$KW = 0.36$.

❖ **SHAFT ANALYSIS**

STEEL (Fe E 580).

$Sut = 770$ N/mm^2.

$Syt = 580$ N/mm^2.

$\tau (max) =(0.5 * Syt) / fs$

$= (0.5 * 580) / 2$

$=145$ N/mm^2.

CALCULATING TORQUE:

$T = 0.18\ Sut$

$= 0.18* 770$

$= 138.6$ N/mm^2.

THE DESIGN IS SAFE.

I. **DESIGN FOR KEY:-**

❖ **FOR KEY 1 :-**

h=5
b=10
l=80
τ (max) = $\sigma c/2$
$\sigma c = 2 * \tau$ (max)
= 2 * 145
= 290 N/mm$^{2.}$
Bu t σc = (4Mt) / dhl
Mt = (σc * dhl) /4
= (290 * 50 * 5 * 80)
= 1450000
τ = (2 * Mt)/ dbl
= (2 * 1450000) / 50 * 10 *80
= 74 < 198
THE DESIGN IS SAFE.
P = 2* Mt /d
= 2* 1450000/50
= 58000 N

❖ **FOR KEY 2:**
h=5
b=6.5
l=75
τ (max) = $\sigma c/2$
$\sigma c = 2 * \tau$ (max)
= 2 * 145
= 290 N/mm$^{2.}$
But
σc = (4Mt) / dhl
Mt = (σc * dhl) /4
= (290 * 50 * 5 * 75)
= 1350000
τ = (2 * Mt)/ dbl
= (2 * 1350000) / 50 * 6.5 *75
= 111.53 < 198
THE DESIGN IS SAFE.
P = 2* Mt /d
= 2* 1350000/50 = 54000 N

8. CONCLUSION

As compare to the manually operated sheet bending machine the power operated sheet bending machine is better. The productivity of power operated sheet bending machine is higher. The part of machine is able to handle the heavy load on machine. The time required to complete bending operation is less and the requirement of extra worker's reduced. Power operated sheet bending is less time consuming process with high productivity.

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