

Design and Analysis of Multipurpose Machine for the Productivity of Sheet Metal Process

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Abstract

The Transonic Wind Tunnel is used to test aircraft models at speeds from Mach number 0.2 to 1.4. Transonic flows consist of mixed subsonic and supersonic flow regions. Shocks can occur in these flows but often do not have a strong enough pressure gradient to assume flow properties similar to those of supersonic flows. These regions are difficult to model mathematically because they have characteristics of subsonic and supersonic flows. In this regard, the paper is aiming towards the design and analysis of the transonic wind tunnel performance by considering two phases namely automated design and its evaluation. Modern optimization software is combined with isentropic relations; simulations are analyzed to design a Mach 1.2 nozzle with maximum test length. The optimal design has an unconventional shape described as compound curvature, which makes the contour appear slightly wavy in AutoCAD. The same is evaluated and found satisfactory for the proposed modification of the test section in the wind tunnel in fluent analysis.

Index terms— transonic, mach number, AutoCad, fluent, hypermesh, analysis.

1 Introduction and Background

Manufacturing is the process of converting raw material into semi or finished goods. There are many manufacturing processes found in production process. Depending on the manufacturing process industries use numerous machines to convert raw materials into products. Since to increase the productivity and profit of the industries, manufacturing machines/equipment should be properly designed and manufactured. However the methodology of rapid machine design attempts to shorten design-to-manufacture time of production equipment by using advanced engineering tools such as Computer Aided Design systems (CAD), mathematical and Finite Element Analysis (FEA) during the conceptual design phase. Since identifying and to apply the best design concepts, overall development time can be shortened. However, in this paper the new approach to conceptual design can be applied at any phase during the concept generation, whether it is the design as a whole or a component in particular. As components are already part of the machine assembly, changes in their design are automatically updated in the whole skeleton. However, currently, number of sheet metal machines have been designed and fabricated to manufacture different sheet metal products. Main while most machines are performs single operations [P. S. Thakare 20012] and limited production performances. Those machines have their own disadvantages, till sheet metal machines have limited functions which could cause the productivity, the efficiency, versatility and competitiveness the sectors. however the main challenges that are seen on single purpose machines were higher machine cost, reduce sheet metal process productivity, poor production time and non-versatile. As the result multipurpose sheet metal machine need to be designed and fabricated in order to reduce machine cost and increase sheet metal process productivity and improve competitiveness of the sectors.

Since, the main objective of the study is to design analysis and fabricate multipurpose sheet metal machine so as to improve the productivity and competitiveness of sheet metal manufacturing sectors. The design and analysis process were includes select proper materials for production of multipurpose sheet metal machine, mathematical

44 design, analysis and fabrication of multipurpose sheet metal machine, and productivity and economic analysis
45 were considered.

46 2 a) Research Methodology

47 The study was conducted through literature review of research articles, books, magazines, manuals and electronic
48 sources which are discussed related to design, manufacturing and mechanics of sheet metal production process.
49 The analysis was done with mathematical methods and the analysis considers attempts to analyze, investigate
50 optimum capacity multipurpose sheet metal machine, so as to improve the productivity and comparativeness
51 of sheet metal production sectors. The study attempts to analyze the deflection, material types, the effects
52 of stresses, wear resistance, ultimate strength of the machine, thermal effect natural frequencies under subjected
53 loads using mathematical analysis were done. Since, the design, manufacturing productivity, economic analysis
54 and evaluation of the project was done using the selected empirical analysis. In addition detail and assembly
55 drawing of the machine is done using Solid work or Catia Software). Finally the conclusion and recommendation
56 of the study was done.

57 3 II.

58 4 Literature Reviews a) Introduction

59 Sheet metal fabrication plays an important role in the metal manufacturing world (Cloutier, 2000). Since, sheet
60 metal process is metal formed into thin and flat pieces. It is one of the fundamental forms used in metalworking,
61 and can be cut and bend into a variety of different shapes. Thicknesses can vary significantly, although extremely
62 thin pieces of sheet metal would be considered to be foil or leaf, and pieces thicker than ¼ inch or a centimeter
63 can be considered plate. (Xiaoyun Liao, 2007]. There are many special purposes machines used in this industry
64 to make products. However, the proper selection of the machines depends upon the type of the work under-
65 taken by the particular industry. Since, there are many examples of sheet metal work, which can be seen in our
66 everyday lives. Although, the metals generally used for sheet metal work include black iron sheet, copper sheet,
67 tin plate, aluminum plate, stainless sheet and brass sheet. On the other hand sheet metal is used and applicable
68 in the production of materials ranging from tools, to hinges, automobiles, airplane wings, medical tables, roof for
69 building etc. In terms of process type sheet metal fabrication ranges from deep drawing, stamping, forming, and
70 hydro forming, to high-energy-rate forming (HERF) to create desired shapes (Cloutier, 2000). However, sheet
71 metal is usually produced in sheet thickness less than 6mm by reducing the thickness of a long work piece by
72 compressive forces applied through a set of rolls. This process is known as rolling (Xiaoyun Liao, 2007]. Due to
73 the versatility, sheet metal process is a metal forming process which is spread throughout the world (Michael
74 Lindgren 2009]. Since sheet metal forming is one of the most important semi finished and finished products used
75 in the steel industry, and sheet metal forming technology is therefore an important engineering discipline within
76 the area of mechanical engineering.

77 Consequently, currently, sheet metal forming products have numerous applications, for example in manufac-
78 turing industries, buildings, airplanes and the automotive sector as well as infrastructure and domestic appliances,
79 (Anas Muzamil 2009]. Since sheet metal process is a highly productive process and its use increases every year,
80 (P. Roche 2006]. Although, the main feature of sheet metal is its ability to be formed and shaped by a variety of
81 processes. Thus, each process does something different to the metal giving it a different shape or size (Xiaoyun
82 Liao, 2007]. The following are the common type of sheet metal process that performed using different type of
83 sheet metal machines.

84 5 b) Shape Rolling

85 Shape rolling of sheet metal is the bending continually of the piece along a linear axis. This causes alteration of
86 the original form of the sheet as it passes through a pathway of series of rollers. Such work tool as shape rolling
87 machine is found to be very useful in manufacturing processes for used parts in various industries like inner
88 and outer panels and stiffeners in automotive and agricultural industries, small metal workshops to roll round
89 and conical profiles for stoves, cylinders (flue pipe, water pipes), basic machine elements with curved surfaces,
90 buckets, bins, gear box cover, mud guards, drinkers and feeders for poultry, feed mixers etc. The machine rolls
91 sheet metal up to 1.5 mm thick and 1m wide and rolls complete cylinders down to 75 mm diameter with 55
92 mm diameter rollers. Since considering high cost of tools and products in sheet rolling processes, detection and
93 controlling factors for producing precise product are important. In most processes, geometry and configuration
94 of rolling components could be obtained from the geometry of product at the end of loading. Therefore elastic
95 recovery (known as spring back) formed part of the unloading process, and it is the most important factor in
96 deviation of final products from desired geometry.

97 Also spring back is influenced by a combination of various process parameters such as tool shape and dimension,
98 contact friction condition, material properties, thickness, were investigated and considered (Alie Wube Dametew
99 & Tafesse Gebresenbet, 2016]. Since in this study the design and evaluation of a shape rolling machine with
100 simple crank mechanism, higher roller diameter were analysis.

101 Cutting/Shearing: Sheet metal can be done in various ways from hand tools called tin snips up to very large
 102 powered shears. With the advances in technology, sheet metal cutting has turned to computers for precise cutting
 103 and shearing.

104 Punching Process: Punching is the process of using a machine to press a shape through a sheet of metal
 105 and into a die cutter to create that shape in the metal. These machines are single purpose type use, manual
 106 type, hydraulic, pneumatic, or electrical power to press the shape with enough force to cut the metal. [K.
 107 ??bdel-Malek,2008]. Since punching can be better understood as pressing the material against a die with a huge
 108 force, this force pushes the material into the die shape and sheers of excess material. [K. ??bdel-Malek, 2008].
 109 Improved and effective punching machine is designed in these projects.

110 Bending Process: In engineering mechanics, bending (also known as flexure) characterizes the behavior of a
 111 slender structural element subjected to a lateral load. Since, a structural element subjected to bending is known
 112 as a beam. Although, closet rod sagging under the weight of clothes on clothes hangers is an example of a beam
 113 experiencing bending. [K. ??bdel-Malek,2008].However, bending produces reactive forces inside a beam as the
 114 beam attempts to accommodate the flexural load; in the case of the beam, the material at the top of the beam
 115 is being compressed while the material at the bottom is being stretched ??Xiaoyun Liao, 2007] . In this study
 116 comparative study of single and multipurpose sheet metal machine has been done. From the results, it is cleared
 117 that, productivity of three in one sheet metal machine is higher than that of single purpose. The result also shows
 118 that total cost for manufacturing metal sheets using three in one machine is 10.43% lower than single purpose
 119 machine. Although, the status of sheet Metal forming industry in Ethiopia is not going as it is expected, because
 120 of high cost of machine, problem of skill man power, ?? MOST,2013]. But ,in this time of globalization, the
 121 production of sheet forming process use single purpose machines which requires more money, time and labor for
 122 atomization of the process. All the machines for using in sheet metal forming process still a single purpose which
 123 results low productivity. In order to increase the productivity of sheet metal process, versatility of sheet forming
 124 machine is important issue for engineers. However this project deals with the design, analysis and fabrication of
 125 five in one sheet metal machine (multipurpose sheet metal machine) is done. Five in one sheet metal machines
 126 are perform number of operations within a single machine that is rolling, bending, cutting/ shearing, punching
 127 beading and circular shear operations are done within a single Machine. properties at the location of the roll
 128 bend. To achieve bending, the work material must be subjected to two major forces; frictional force which causes
 129 a no-slip action when metal and roller came in contact and a bending force acting against the forward speed and
 130 the torque applied to move the material (Figure ??). At least two rollers were involved in flat rolling depending
 131 on the thickness and properties of material while three or multiple roller system is required in shape rolling.
 132 A work material under bending load is subjected to some form of residual stress and deformation as it bends.
 133 Since, materials at the outer bend radius undergo tensile plastic deformation while the material at the inner
 134 bend radius undergoes compressive plastic deformation. However, at least two rollers were involved in flat rolling
 135 depending on the thickness and properties of material while three or multiple roller system is required in shape
 136 rolling. A work material under bending load is subjected to some form of residual stress and deformation as it
 137 bends. Materials at the outer bend radius undergo tensile plastic deformation while the material at the inner
 138 bend radius undergoes compressive plastic deformation.

139 6 Type of sheet bending

140 ?

141 7 $L_b = \frac{rT}{k}$

142 (

143 where, L_b = bend allowance; θ = bend angle; r = bend radius to neutral axis; k = constant for material, for
 144 $r < 2T$; $k=0.33$; for $r > 2T$, $k=0.5$, T =thickness of material.

145 The strain on the outermost fibers of the bend is evaluated by Equation (??) given by Jack (2003): $\epsilon = 1$
 146 $2\theta \frac{r}{T} + 1$

147 Maximum bending force is calculated by Equation (3) given below (Jack, 2003): $P = k \frac{L}{w} \frac{UTS}{2} \left(\frac{1}{2} \left(\frac{L}{a} \right)^2 \right)$
 148 $UTS = 2 \frac{P}{L} \left(\frac{L}{a} \right)^2 + 24 \frac{P}{L} \left(\frac{L}{a} \right)^3 + 12 \frac{P}{L} \left(\frac{L}{a} \right)^4$

149 , where, P = maximum bending load; k = constant for particular die from 0.3 to 0.7; σ_y = yield stress for
 150 material; σ_{UTS} = ultimate tensile stress for the material; L = length of bend (along bend axis); w = distance
 151 between reaction supports When the rollers are in contact with the load, there is a frictional force existing, and
 152 an applied force, F and a slip between rollers and the load, which is not constant over the entire surface area
 153 of contact (Wagoner and Li,2007). An assumption of no reduction in size of material thickness during rolling
 154 makes, the thickness uniform i.e. $a = L$. For large diameter bending $L > a$. Thus
 155 the maximum force is given by Hugh Since, considering the two strain components; the elastic strain (ϵ_e) and
 156 plastic strain (ϵ_p), the total axial strain (ϵ_x) can be written as, $\epsilon_x = \epsilon_e + \epsilon_p = A \frac{L}{a} \left(\frac{1}{2} \left(\frac{L}{a} \right)^2 \right)$
 157 $\epsilon_x = 2 \frac{P}{L} \left(\frac{L}{a} \right)^2 + 24 \frac{P}{L} \left(\frac{L}{a} \right)^3 + 12 \frac{P}{L} \left(\frac{L}{a} \right)^4$
 158 $\epsilon_x = 2 \frac{P}{L} \left(\frac{L}{a} \right)^2 + 24 \frac{P}{L} \left(\frac{L}{a} \right)^3 + 12 \frac{P}{L} \left(\frac{L}{a} \right)^4$
 159 $\epsilon_x = 2 \frac{P}{L} \left(\frac{L}{a} \right)^2 + 24 \frac{P}{L} \left(\frac{L}{a} \right)^3 + 12 \frac{P}{L} \left(\frac{L}{a} \right)^4$

9 C) DESIGN OF PIPE BENDING MACHINE

160 Where, b and t are width and thickness of the sheet respectively; ϵ_e = elastic strain; ϵ_p = plastic strain;
161 E = Young's modulus and ν = Poisson's ratio. Bend radius after spring back can be written as Where, r_1 and
162 r_2 are bending radius before and after spring back respectively. Knowing the thickness and width of sheet plate
163 and considering material's behavior, analysis of V-bending for various bending angle and radius become possible.
164 The power required to roll the material is given by where, P = power in watts required to roll the sheet and n =
165 speed in rmin^{-1} . The spring back effect in bending is compensated by the following Equation (11) ??Jack, 2003).
166 where, r_1 before = r_2 after $r = 1$ for flat sheet; ϵ = Bending strain.

167 8 b) Results and discussion of roller design

168 The result table below indicates the maximum bend radius obtainable as an approximate radius of roller for
169 a typical material length of 500-630 mm is 2.5 mm. The largest measured diameter of complete cylinder the
170 machine can handle (roll) is 184 mm using the given diameter of rollers. At reduced roller aperture of 2.5 mm,
171 the material folded over and the radius of cylinder reduced. This result showed a remarkable improvement over
172 Rob's report of 75 mm diameter. The maximum bend radius when the aperture is closed is approximately the
173 circumferential distance round the roller. The spring back effect on the rolled plate is noticeable as the rolling
174 aperture decreases the bend radius considerably decrease. This effect can be increased by stretching out the
175 material as it rolls or increasing the aperture width. Alternatively, variable roller diameters could be used when
176 handling materials of varying length. Other dimensions can be obtained by varying the width of aperture until
177 the bend radius approaches a straight line depending on the length of work material. The maximum width of
178 material that can be handled with significant bend radius is, 123 mm and the length is 500-630 mm.

179 Besides, the maximum width (machine capacity) of strip of material the machine could handle is 1,050 mm
180 for tinplates and mild steel with thickness not exceeding 2 mm. Although, when the machine was used to roll
181 mild steel plate of 2.5 mm thickness, the bearing blocks showed evidence of possible failure. The wooden bearing
182 blocks could not support the bending stress exerted by the materials with higher thickness than 2 mm and as
183 a result the machine usage can only be restricted to light gauge metal work and thus find use in tinsmith and
184 welding workshops. Slip friction in rolling was eliminated between the rollers and the load by keeping the contact
185 surfaces smooth and free of lubricants and dirt. Since, the average number of operators required to operate the
186 rollers at a given operation is shown in Table below with their average weights. Material thicker beyond 2 mm
187 sheet thickness requires two operators while 3 mm thickness material could not be conveniently roll due to the
188 required bending force and the strength of the material used in construction. The bearing capacity of wood
189 cannot support such material thickness. The analysis result shows that, the average percentage acceptance of
190 the machine by the artisan is 70.59% ($n=24$) indicating that the technology is acceptable. Fifteen percent of the
191 welders and 40% of tinsmiths were well acquainted with the functions of the machine. A total of 73.53% ($n=26$)
192 of the respondents are not acquainted (technology awareness) with the shape rolling technology while

193 9 c) Design of pipe Bending Machine

194 Companies considering the purchase of tube bending equipment are faced with an extensive set of alternatives. It
195 is important that a potential purchaser research his needs and the various equipment available. The manufacturer
196 who gives special attention to details will gain a significant edge over his competition. In this discussion we will
197 investigate some of the more popular options available for tube bending, their benefits, limitations, cost and
198 applications. Although, the design of pipe bending machine has undergone many changes, development and
199 improvements over a period of time. Pipe bending requires mechanical force which acts on the pipe either
200 directly or indirectly. This was done manually with the operator providing the effort required for bending the
201 pipe. The major setback was the energy, time and effort expended in accomplishing the task. This means that the
202 quality of bend would depend on the strength and skill of the operator. Though relatively cheaper, manual pipe
203 bending falls short of dimensional accuracy and uniformity. Many versions of pipe bending machine have been
204 developed aimed at eliminating human effort (www.paramount-roll.com). In one arrangement, the mechanical
205 force required for bending is provided by a hydraulic ram powered by combustible fuel in an internal combustion
206 engine, or by electricity. In this case, the hydraulic pump which pumps hydraulic into the ram is powered by
207 an electric motor. By early 80's, the development of mechanized pipe bending machine came into existence In
208 general, the bending process uses mechanical force to push the pipe against a die: this way, the pipe is forced
209 to get conformed to the shape of the die. In many cases, the end of the pipe is rolled and rotated around the
210 die, while the pipe itself is firmly held in place (Fig.) ii. Power Requirement A gradual application of effort will
211 bend the pipe quite smoothly. This means that very small velocity will be required. An available motor capacity
212 standard is therefore selected and reduced to appropriate speed output.

213 Choosing a motor of 1. Since, from the analysis we observed that, the pipe bending can be achieved in both
214 ways (either in upward or downward direction) up to 4.25 mm pipe thickness could be bent manually depending
215 on the operator's physical strength. During the bending process, the slight deviation from intended angle of
216 bend was occurred due to spring back action of the pipe, which obviously reduces with decrease in angle of
217 bend. However, wrinkles and bulging of the pipe during bending were noticed in pipes of lesser thickness. in this
218 machine with a semi-circular bell, angles between 80 o to 180 o were obtainable, below which the bent pipe was
219 observed to follow the bell's contour to give a U or C shape. Since, to obtain a lower bend angle, a different bell

220 specially made for 45 o is used. For pipes of lesser thickness, a mandrel should be introduced in order to prevent
221 collapse. The provision for manual bending makes it possible to use the machine in rural areas where there may
222 be no power supply.

223 10 i) Bending Design

224 Bending is a metal forming process in which a force is applied to a piece of sheet metal causing bending of it to
225 an angle and forming the desired shape (Manar, 2013). While, the operation is typically performed on a machine
226 called a press brake which can be manually or automatically operated. Though, to bend sheet metal, a bottom
227 tool (die) is mounted on a lower, stationary beam (bed) and a top tool (punch) is mounted on a moving upper
228 beam (ram). Since the design and analysis of this study is considered this points properly, to achieve optimum
229 bending products. However the bending design consists and considers the f parameters given in the

230 11 j) Maximum Folding Force

231 The force required to perform folding depends on the strength, thickness, and length of the sheet metal (Groover,
232 2010). However, the maximum folding force can be estimated by means of the following equation: $F =$
233 clamping beam exerts a force that holds down the sheet metal onto the folding bed. The hold down force when
234 performing folding operation is 50% the required folding force. Since it is applied across two ends of the machine.
235 Therefore the clamping force is given by: Clamping force = 0.5 x folding force, Clamping force = 0.5 x 294.6 kN,
236 Clamping force = 147.3 kN.

237 The clamping beam is designed such that it is welded onto side plates that are connected to a clamping
238 mechanism. The clamping mechanisms are located on both sides of the clamping beam, but the clamping knob
239 is only located on one end. The adjusting screws on the clamping mechanism of bending machine must resist the
240 clamping force they are exposed to. Since, the load is shared equally on either side of the clamping mechanism,
241 therefore is equal to half the clamping force that is 73.65 kN. Allowable stress levels to 75% of proof strength are
242 to be used in the clamping mechanism bolts. The selected material for the clamping mechanism according to the
243 Society of Automotive Engineers (SAE), is grade 4 with no head marking and proof strength of 65 ksi. Then the
244 allowable stress is also given as $\sigma = 0.75 \times \text{proof strength}$, Since $\sigma = 0.75 \times 65000 \text{psi} = 48759 \text{psi}$

245 In addition, the force applied on each side of the clamping mechanism is 73.65 kN = 16.55 klb i .

246 Therefore the required tensile area to which the force should act is: $A_t = \frac{F}{\sigma} = \frac{16550 \text{ lbf}}{48750 \text{ psi}} = 0.339 \text{ in}^2$

247 , Since, $A_t = 0.339 \text{ in}^2$. Thus, tensile stress area of 0.339 in² requires a diameter of 7/8 inches, which is
248 equivalent to 22.22 mm. Hence the diameter of the clamping mechanism column should be 22.22 mm with a
249 coarse thread of 9 threads per inch. Taking moments and resolving forces at determined points along the folding
250 beam and factoring a safety factor of $n = 3$, and an allowable stress of 350 Mpa, t , is found to have the following
251 value; $t = 0.015$ or $t = -0.015$. Therefore the thickness of the folding beam is 15 mm.

253 12 IV.

254 13 Productivity Analysis

255 Increase in productivity is the key factor for prosperity at all levels. It is the relationship between the result
256 obtained and the factors employed to achieve the result. Productivity is the relationship between outputs to
257 input. It is an indication of an enterprise capability. In case of the defined machine, the output highly depends
258 upon the working skill of the employed persons. If he is having long experience of working over the machine then
259 definitely his rate of making pipes would be higher than the rate of person who is new to machine. As per the
260 definition of productivity, we have a simple relation for it and it is given by For Power operated machine. Since
261 our multipurpose machine is power operated , then it is productive. in a single operation , the productivity is
262 double for manual operated machine, but our machine V.

263 14 Conclusion and Recommendation a) Conclusion

264 In this study the design and analysis of multipurpose sheet metal machine is done using mathematical methods.
265 During the analysis and design process different parameters were considered for improving the productivity and
266 performance of sheet metal forming process. As well comparative study of manually operated multipurpose
267 machine and power operated sheet bending machine has been done. the multipurpose machines are very efficient
268 in rolling, bending, grooving and beading of metallic components. The machine is cost effective based on the
269 materials of and simplicity of the design of component parts. Operational mode meets the level of technical
270 knowhow of the artisans. Also, productivity of both the machines has been calculated. From the results, it is
271 cleared that, productivity of power operated sheet bending machine is higher than manual type. As a result a
272 multipurpose power operated machine is much, much efficient, effective and productive on compared to manual
273 operated machine. Since the design and analysis of this study was meet the objectives properly. Since, sheet
274 metal manufacturing industries improve their financial performance and productivity by using these type of
275 multipurpose machines rather than single purpose machine.

276 **15 b) Recommendation**

277 This multi type machines have numerous advantages including, optimum machine cost, high production capacity
278 and productive, efficient and effective and contributes the comparativeness of the sectors. Since, sheet metal
279 manufactures could be use such type of machines to improve their performance and productivity. Further
280 recommend that, researchers further study to add the function of such type of machines, hence this used as a
base for the researchers.¹

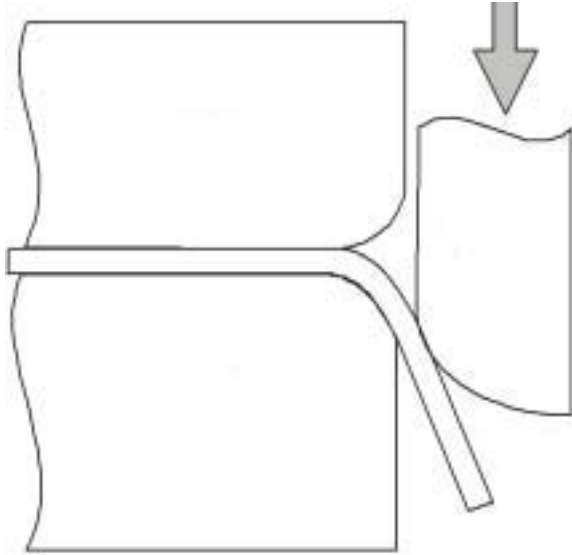


Figure 1:

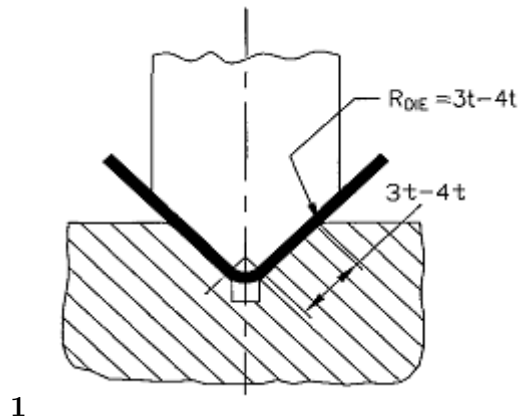


Figure 2: Figure 1 :

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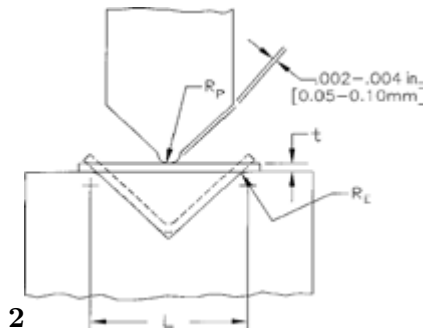


Figure 3: Figure 2 :

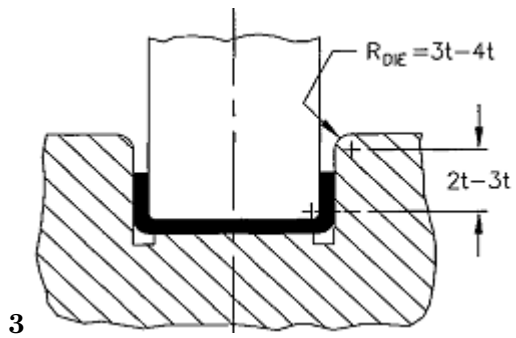


Figure 4: Figure 3 :

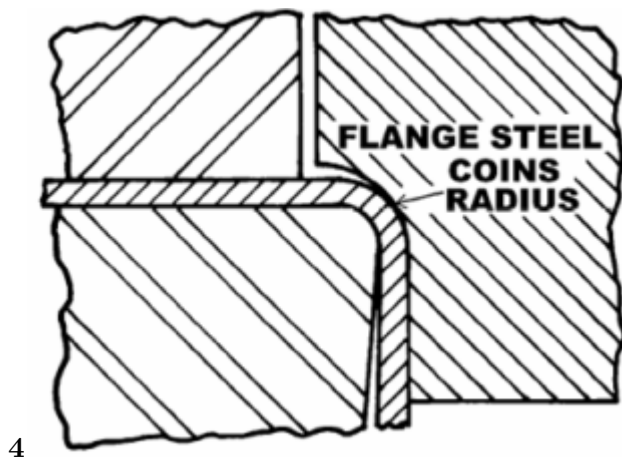


Figure 5: Figure 4 :

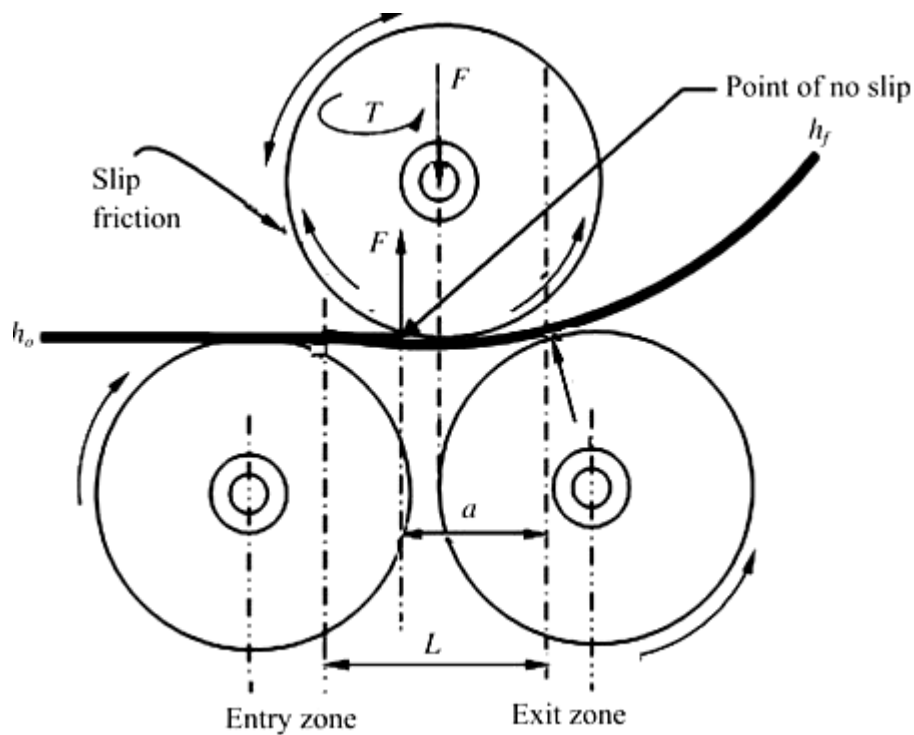


Figure 6:

$$\rho' = \frac{1}{\frac{1}{\rho} - \frac{12M(1-V^2)}{bt^3E}}$$

5

Figure 7: Figure 5 :



Figure 8:

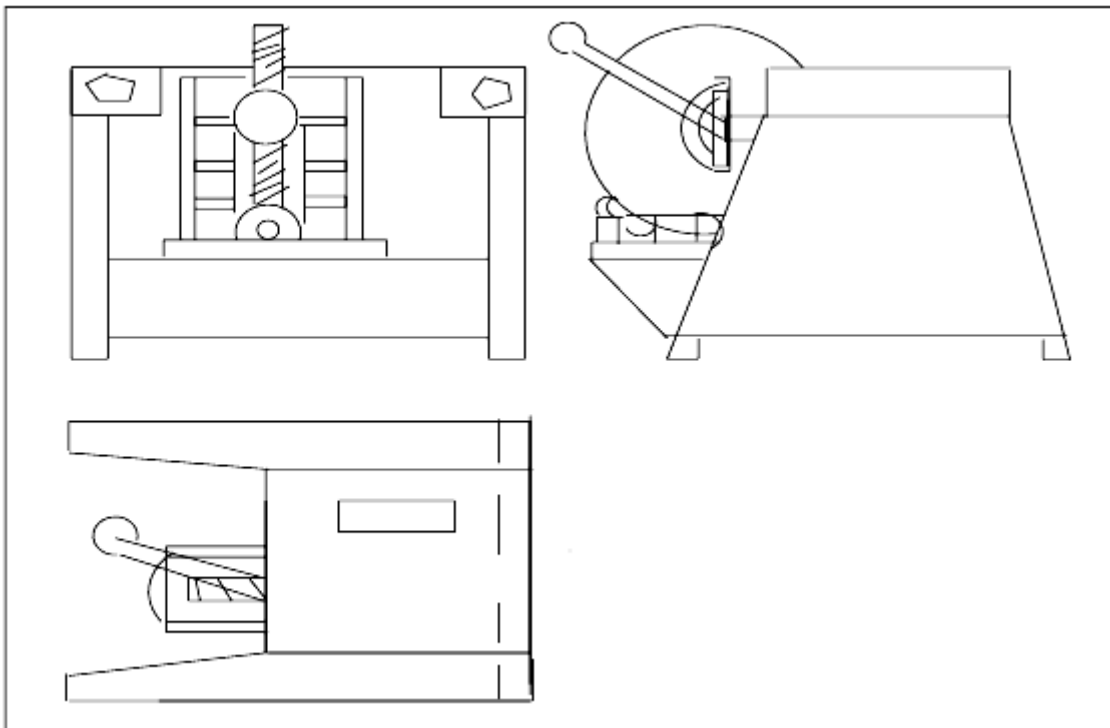


Figure 9: (1 ?

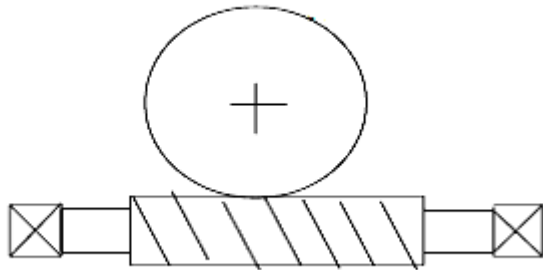
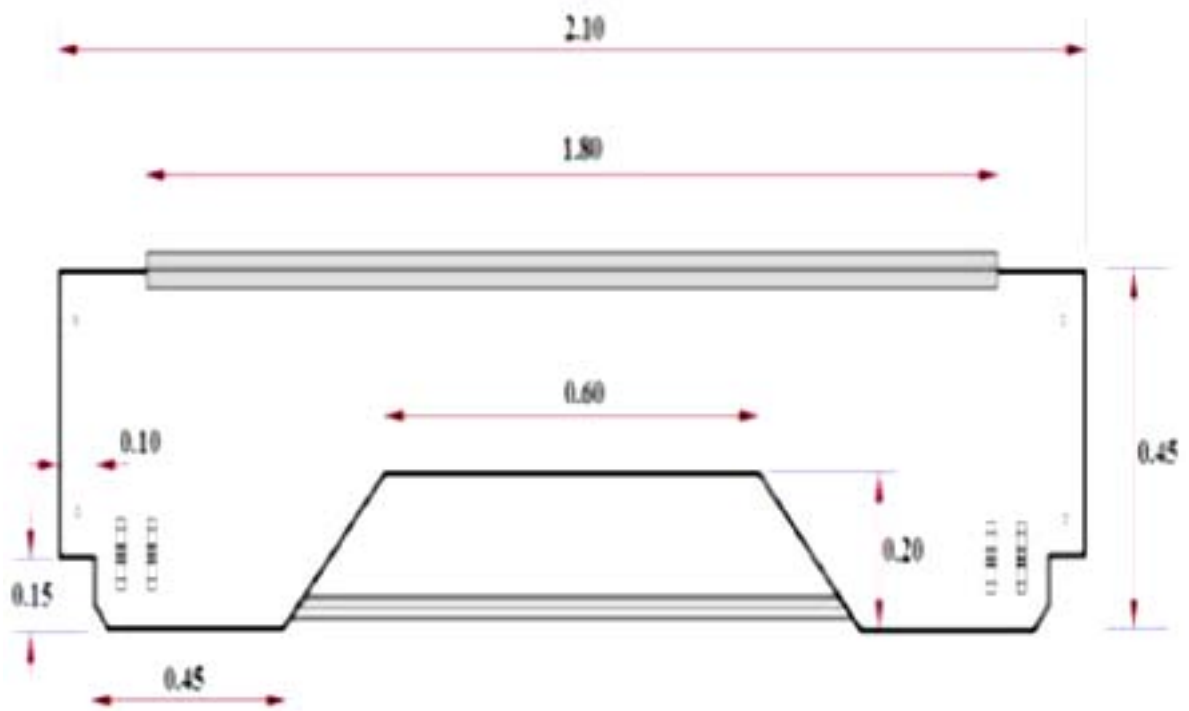


Figure 10:



6



Figure 11: Figure 6 :

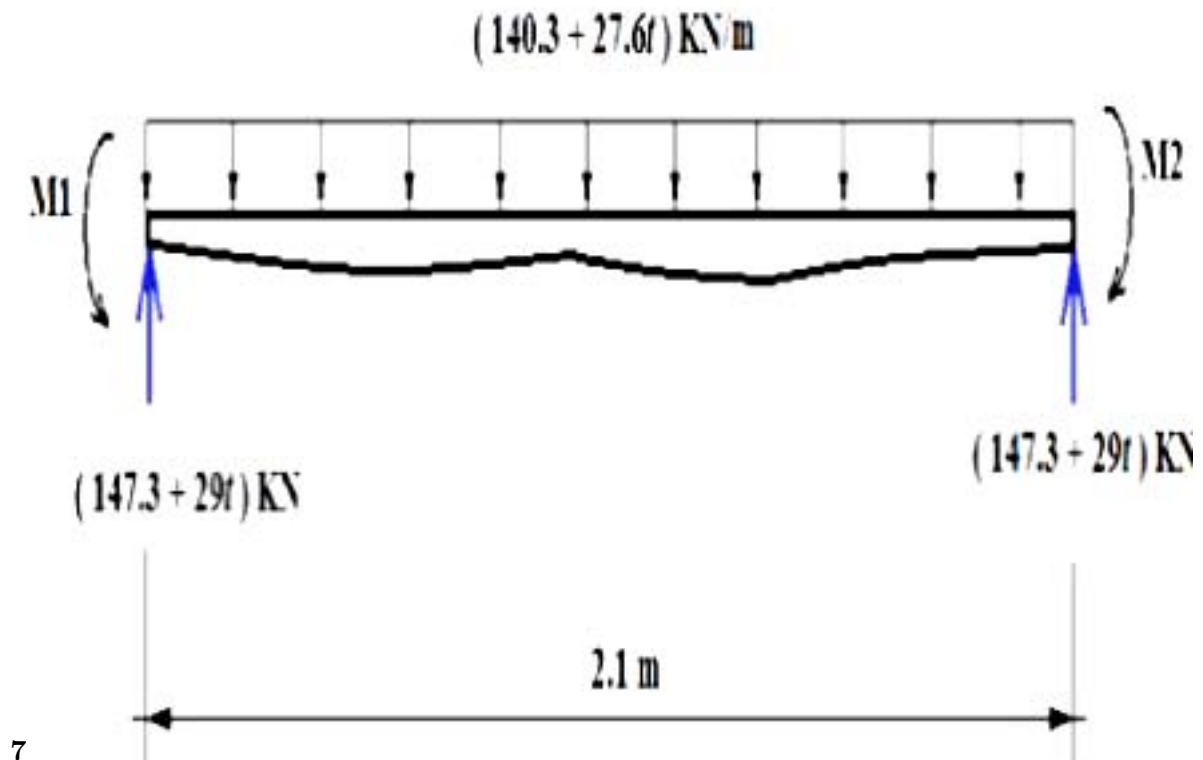


Figure 12: Figure 7 :

1

Diameter of the Roller in mm	Material Length in mm	Roller aperture/before	Roller aperture/after bending in mm	Roll gap in mm	Bending radius in mm	Product shape
76	500-630	10mm 8mm 7.0mm	8 5.5 2.5	2 2.5 3	123 100 55	Semi-circle Full circle Double folded circle

Figure 13: Table 1 :

2

Material Type	Material Thickness in mm	No, operations	AV.Wet operator kg	Max width of work in mm	Length of the material
Aluminum sheet	3 1.5	1 1	65 65	1050 1050	1200.00 1200.00
Galvanized sheet	1 2	1 2	71 69.8	525 525	800.00 800.00
Milled steel sheet metal	1 2 3	1 2 2	65 72 72	1050 500 300	1200.00 600.00 400.00

Figure 14: Table 2 :

below

() Volume XVII Issue V Version I A
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Figure 15: table below .

3

Maximum bending length	1800 mm
Maximum bending thickness	2mm
Tensile strength of sheet metal Mild steel	248 MPa
Clearance between folding beam and clamping beam	2 mm
Maximum folding angle	1050
Frame material	Structural Steel
Folding beam and clamping beam material	Machine Steel

Figure 16: Table 3 :

282 [Establishment of A Framework on Selection, Importation, Utilization, and Disposal of Green Technologies in Ethiopia (2013)]
283 *Establishment of A Framework on Selection, Importation, Utilization, and Disposal of Green Technologies in*
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