

# Analysis of Manufacturing Techniques for Optimisation of Sale of Tower Bolts

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**Abstract-** Every household and office requires tower bolts for windows and doors, and such types of items are made of aluminum, steel, stainless steel, brass etc. The consumption of tower bolts is increasing due to construction of new houses and other buildings. The present work aims at increasing the productivity of Tower Bolt by changing its manufacturing technique and thereby reducing the cost of production as well. As mentioned earlier, the material deformation process is non-linear, in the present work manufacturing technology of tower bolt using metal forming method and die and punch is mathematically compared. The manufacturing of tower bolt using a punch and die is a feasible process. Currently the tower bolt is manufactured by using roll metal forming process which produces long lengths that are subsequently drilled and cut to desired size. As a result of proposed methodology, running time has significantly decreased. This reduction is due to increased hourly productivity, which further led to improvement in daily and yearly productivity of Tower Bolt. This has led to increase in the profit for the organization. It has also helped in increasing sales value for the organization. The conventional method for production of Tower Bolt i.e. Roll Metal Forming Process, takes considerable amount of time, but using Punch and Die method the time of production will be decreased considerably. This will also increase profit.

**Index Terms—** Manufacturing Technology, Productivity, Tower Bolt, Rolling Mills

## I. INTRODUCTION

A Tower Bolt is a metal fastening for door or window consisting of a sliding pin or rod and staple into which it fits in. The tower Bolts are available in most popular sizes of 2", 3", 4", 6", 8" and 12" Bureau of Indian standard has prescribed the IS: 204 and IS:205 or Tower Bolts and hinges.

Metal forming is a manufacturing process through mechanical deformation where the work piece is formed or shaped without adding any extra or removing material and its mass remain unchanged. In the metal forming rolling mills the tower bolts are formed into desired shape when the metal sheets are passed through different stations as shown in figure. In the above figure the metal forming mill of eight stations are shown where the tower bolts are manufactured.

Milling is a machining process in which metal is removed by a rotating multiple tooth cutter. As the cutter rotates each tooth removes a small amount of material from the advancing work for each spindle revolution. Milling machine is a special type machine tool by which material is removed by means of a revolving cutter with multiple teeth. Each tooth having a cutting edge which removes metal from the work piece. Milling machines are used to produce parts having flat as well as curved shape.

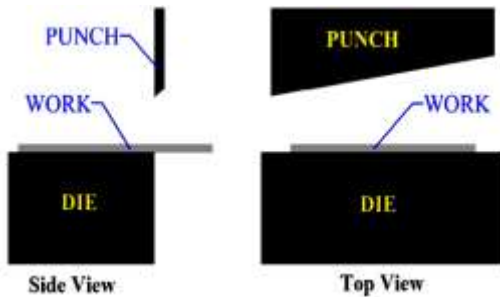


Figure 1: Universal Milling Machine

Working of a milling machine is based on the fact that milling cutter is fed against work piece. This is achieved by developing relative motion with precise control between work piece and rotating milling cutter. Feed motion is generally given to the work piece through its holding device. Milling machine can also hold more than one cutter at a time. The holding device is supported by mechanism that can offer a selective portion of the work piece to milling

cutter for its processing. Indexing is one of the examples of this type of processing.

There are two types of milling operation on tower bolt have been carried out, one of Straddle milling slots for axial movement of knob and other is Mill cross slots for up & down movements of rod. The manufacturing of tower bolts involves the following sequence of operations. Sheet metal cutting operation along a straight line between two cutting edges. Typically used to cut large sheets into smaller sections for subsequent operations



**Figure 2 : straight cutoff of raw worksheet of tower bolt (Source- Ansys Software)**

Clearance in Sheet Metal Cutting

Distance between the punch and die

- Typical values range between 4% and 8% of stock thickness
- If too small, fracture lines pass each other, causing double burnishing and larger force
- If too large, metal is pinched between cutting edges and excessive burr results
- Recommended clearance can be calculated by:

$$c = at \dots\dots\dots(i)$$

where  $c$  = clearance;  $a$  = allowance; and  $t$  = stock thickness

- Allowance  $a$  is determined according to type of metal
- Allowance  $a$  for Sheet Metal Groups Cutting Forces Important for determining press size (tonnage)

$$F = S t L \dots\dots\dots(i)$$

where  $S$  = shear strength of metal;  $t$  = stock thickness, and  $L$  = length of cut edge.

**Defects in Product**

Several researchers have explained the mechanism of vibration in the product [2, 6, 7, 8]. Even a healthy product generate vibration, but the presence of defects increases vibration levels significantly. A large number of factors, the most common of which are fatigue, wear, plastic deformation, corrosion, brinelling, poor lubrication, faulty installation and incorrect design, can cause premature

product failures. The identification of these defects and vibration produced by them is important for condition monitoring of product. The product defects are broadly classified in two categories, i.e. distributed defects and localized defects.

**Distributed Defects:** Distributed defects include surface roughness, waviness, misaligned races and off-size rolling elements [8, 9]. The main causes of distributed defects are manufacturing error, abrasive wear, improper installation [2]. In distributed defects, the contact force between rolling elements and raceways varies which results in vibration. Vibration response due to distributed defect is mainly used for the quality inspection and condition monitoring of product.

**Localized Defects:** This category of defects includes pits, cracks, spalls that may develop over the rolling surfaces. Of these, spalling is the dominant mode of failure. Actually, fatigue crack begins below the surface and propagates towards the surface until the material fails and leaves localized defects. Bentley [10] in his paper showed that 90% of the total product faults involves damage of the inner ring, outer ring and rolling elements due to localized defects.

**Sources of Vibration**

The components of rolling contact product – i.e. inner raceway, outer raceway, rolling elements, cage – interact through a combination of rolling and sliding to produce complex vibration signatures. The factors on which level of vibration depends are, energy of impact, the point at which vibration is measured and the product construction. The various sources of vibrations are as follows:

**Variable Compliance**

Even a geometrically perfect product generate vibration under radially acting, load, but it does not indicate poor quality of product. Such type of vibration is called variable compliance. To support external loads, finite no of product are used whose position continuously varies with time with respect to the line of action of the load resulting in vibration. Vibration due to varying compliance depends on the number of rolling element product supporting the Pankaj Gupta and M. K Pradhan / Materials Today: Proceedings 4 (2017) 2085–2094 2087 external load and running clearance. More is the number of loaded rolling element, lesser is the vibration. Variable compliance increases with the running clearance in radially loaded or misaligned product, as it determines the extent of loaded region. Variable compliance vibration can be reduced to insignificant levels by using ball product with an accurate level of pre- axial loads.

II. METHODOLOGY

It has been observed that the material deformation process is





**(Task -I) Remove burs:**

if 1 piece is prepared in 30 sec,  
 than  $60/30 = 2$  pieces will be produced in one minute and  
 $2 \times 60 = 120$  pieces will be produced in one hour

if the working hour is 8 hours then total production will be  
 $(28800-175)/60 = 477.083$  piece per day.

**(Task -J) Polish by buffing:**

if 1 piece is prepared in 20 sec,  
 than  $60/20 = 3$  pieces will be produced in one minute and  
 $3 \times 60 = 180$  pieces will be produced in one hour

if the working hour is 8 hours then total production will be  
 $(28800-205)/60 = 476.583$  piece per day.

**(Task -K) Stamp makers brand:**

if 1 piece is prepared in 10 sec,  
 than  $60/10 = 6$  pieces will be produced in one minute and  
 $6 \times 60 = 360$  pieces will be produced in one hour

if the working hour is 8 hours then total production will be  
 $(28800-225)/60 = 476.25$  piece per day.

**(Task -L) Packing and delivery:**

if 1 piece is prepared in 20 sec,  
 than  $60/20 = 3$  pieces will be produced in one minute and  
 $3 \times 60 = 180$  pieces will be produced in one hour

if the working hour is 8 hours then total production will be  
 $(28800-235)/60 = 476.0833$  piece per day.

Proposed manufacturing steps of tower bolt by using die & punch method:

**Table 3: Plant and Machinery**

Requirement of Plant and Machinery for manufacturing of tower bolt by roll forming method		
Machine name	Quantity Nos	Value (Rs. lakhs)
Rolling mills	1	4
Cutter bench grinder	1	0.1
Vertical Milling machine	1	0.8
Universal Milling machine	1	1.2
Drilling machine	1	0.15
Drilling machine	1	0.15
Metal polishing /finishing machine	1	0.5
Stamp marking machine	1	0.2
<b>Total</b>		<b>6.38</b>

**Table 4: Total Raw Material Cost**

Materials	Quantity & rate (Including Wastage 3%)	Value (Rs. lakhs)
Stainless steel strips	13.35 Mt@50000/Mt	6.675 lakhs
Steel wire	1200 kg@25/kg	0.3 lakhs
<b>Total Raw material cost</b>		<b>6.975 lakhs</b>

**Requirement of Land & Building:**

A rented place with 1500 square fit area is required. The monthly rent is estimated at Rs.2500 and also an advance estimated of Rs.30000.

Miscellaneous Utilities

Power: The total power requirements will not more than of 10 HP.

Water: Water is required only for human consumption.

**Table 5: Man Power**

Category	Nos	Monthly Salary	Total Salary	Annual Salary
Manager	1	8000/-	8000/-	96000/-
Operators	4	5000/-	20000/-	240000/-
Assistants	2	4000/-	8000/-	96000/-
Unskilled	3	3500/-	10500/-	126000/-
Security	1	5000/-	5000/-	60000/-
<b>Total</b>			<b>51500/-</b>	<b>618000/-</b>
If Add 20% benefits				123600
<b>Total</b>				<b>741600/-</b>

**Depreciation:**

Depreciation is the method of allocating costs to the appropriate period. Although accountants have to follow generally accepted accounting principles (GAAP) for financial statement reporting purposes, they have different allowable methods to consider [Maire Loughran].

**Different methods of depreciation:**

**Straight-line:** This method spreads the cost of the fixed asset evenly over its useful life.

**Declining-balance:** An accelerated method of depreciation, it results in higher depreciation expense in the earlier years of ownership.

**Sum-of-the-years' digits:** Compute depreciation expense by adding all years of the fixed asset's expected useful life and factoring in which year you are currently in, as compared to the total number of years.

**Units-of-production:** The total estimated number of units the fixed asset will produce over its expected useful life, as compared to the number of units produced in the current accounting period, is used to calculate depreciation expense.

The salvage value is obtained by the following formula:

$$= (1 - i)$$

where:

S = salvage value

P = original price

i = nominal depreciation rate

y = age in years

### The Straight-Line Depreciation Method

When using the straight-line method, the salvage value reduces the depreciable base. Total machine cost is Rs. 638000

The expected useful life is 10 years. If the rate of depreciation is 10% Then the salvage value is

$$S = (1 - i)$$

$$S = 638000(1 - 10\%)10$$

$$S = \text{Rs. } 222456$$

**Table 6: Yearly Expenses Calculation**

Consumables and Packing per annum (Rs. lakhs)	Rs.2.0 lakhs
Power and Fuel (Rs. lakhs)	Rs.1.5 lakhs
Wages & salaries (Rs. lakhs)	7.416 lakhs
Repairs & Maintenance	0.5 lakhs
Depreciation (Straight line Method)	0.415543 lakhs
General & administration Expenses	1 lakhs
Selling expenses	3% on Sales

**Table 7: Expected Cost of Project**

Particulars	Cost in lakhs
Land & Building (Advance)	0.75
Plant & Machinery	6.38
Other Misc. assets	0.50
Pre -Operative expenses	1.00
Margin for working capital	1.5

**Table 8: Cost of Production & Profitability Statements**

	1 <sup>st</sup> Years	2 <sup>nd</sup> Years	3 <sup>rd</sup> Years
Installed Capacity of Tower Bolts in Dozens	11900	11900	11900
Utilizations	70%	80%	90%
Production/Sales of Tower Bolts (Dozens)	8330	9520	10710
Selling Price/Dozen of Tower Bolts (in Rupee)	Rs.220 per dozen		
<b>Sales Value of Tower Bolts (Rs.lakhs)</b>	<b>18.326</b>	<b>20.944</b>	<b>23.562</b>
<b>Cost of Production</b>			
Raw Materials Stainless steel sheet & steel rod	4.8825	5.58	6.2775
Consumables and Packing per annum	1.4	1.6	1.8
Power and Fuel	1.05	1.2	1.35
Wages & salaries	5.1912	5.9328	6.6744
Repairs & Maintenance	.5	.5	.5

Depreciation (Straight line Method)	0.415543	0.415543	0.415543
<b>Total Production cost</b>	<b>13.439</b>	<b>15.228</b>	<b>17.017</b>
Admin. & General expenses	0.7	0.8	0.9
Selling expenses	0.5498	0.6283	0.7069
<b>Total</b>	<b>14.6888</b>	<b>16.6563</b>	<b>18.6239</b>
Profit	3.6372	4.2877	4.9381

**Table 9: Breakeven Level Analysis**

Fixed cost	Value in Rs. Lakhs for year-1	Value in Rs. Lakhs for year-2	Value in Rs. Lakhs for year-3
<b>Based on Utilization %</b>	70%	80%	90%
Wages & Salaries	5.1912	5.9328	6.6744
Repairs & Maintenance	.5	.5	.5
Depreciation	0.415543	0.415543	0.415543
Admin. & General expenses	0.7	0.8	0.9
<b>Total</b>	<b>6.8</b>	<b>7.65</b>	<b>8.49</b>

<b>Profit for Roll Forming Method</b>	3.6372	4.2877	4.9381
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#### Based on 70% Utilization

$$\text{Breakeven level} = \frac{\text{Fixed cost} * \text{Utilization \%}}{\text{Fixed cost} + \text{Profit}}$$

$$\frac{6.8 * 70}{6.8 + 3.6372} = 45.6\% \text{ of installed capacity}$$

#### Based on 80% Utilization

$$\frac{7.65 * 80}{7.65 + 4.2877} = 51.27\% \text{ of installed capacity}$$

#### Based on 90% Utilization

$$\frac{8.49 * 90}{8.49 + 4.9381} = 56.90\% \text{ of installed capacity}$$

#### PROFITABILITY RATIOS:

##### Based on 70% Utilization

$$\frac{\text{Profit}}{\text{Sales Value}} = \frac{3.6372}{18.326} * 100 = 19.84$$

##### Based on 80% Utilization

$$\frac{\text{Profit}}{\text{Sales Value}} = \frac{3.6372}{18.326} * 100 = 19.84\%$$

##### Based on 90% Utilization

$$\frac{\text{Profit}}{\text{Sales Value}} = \frac{4.9381}{23.562} * 100 = 20.95\%$$

**Table 10: Requirement of Plant and Machinery for Manufacturing of Tower Bolt by Die & Punch Method**

Requirement of Plant and Machinery for manufacturing of tower bolt by die & punch method		
Machine name	Quantity Nos	Value (Rs. lakhs)
Sheet Metal cutter	1	0.25
Press for Blank preparation	1	0.5
Die and Punch machine	1	1.0
Drilling machine	1	0.15
Metal polishing /finishing machine	1	0.7
Stamp marking machine	1	0.5
<b>Total</b>		<b>3.1</b>

Requirement of Raw Material: The Raw materials required for manufacturing Stainless steel bolts is steel rods and a Stainless steel plates.

**Material cost:**

Assume that the length of stainless strip bundles = 30m (1181.1 inches) Width of stainless strip 1.5 inches & thickness is 2mm (0.07874) Density of stainless steel is 7800 kg/m<sup>3</sup>

Weight of stainless steel strip bundles = 17.77kg/bundles

Total stainless steel strip bundles =1508.68 required for annual production Total weight of stainless steel strip bundles = 1508.68 x 17.77 = 26.8Mt

**Table 11: Total Raw material cost**

Materials	Quantity & rate (Including Wastage 3%)	Value (Rs. lakhs)
Stainless steel strips	26.8 Mt@50000/Mt	13.4 lakhs
Steel wire	2000 kg@25/kg	0.5 lakhs
<b>Total Raw material cost</b>		<b>13.9 lakhs</b>

**Requirement of land and building :**

A rented place with 1500 square fit area is required. The monthly rent is estimated at Rs.2500 and also an advance estimated of Rs.30000.

**Miscellaneous Utilities**

**Power:** The total power requirements will not more than of 8 HP.

**Water:** Water is required only for human consumption.

**Man power**

Category	Nos	Monthly Salary	Total Salary	Annual Salary
Manager	1	8000/-	8000/-	96000/-
Operators	3	5000/-	15000/-	180000/-
Assistants	1	4000/-	4000/-	48000/-
Unskilled	3	3500/-	10500/-	126000/-
Security	1	5000/-	5000/-	60000/-
<b>Total</b>			<b>42500/-</b>	<b>510000/-</b>
If Add 20% benefits				102000
<b>Total</b>				<b>612000/-</b>

The salvage value is obtained by the following formula:

$$= (1 - i)^y$$

where:

S = salvage value

P = original price

i = nominal depreciation rate

y = age in years

The Straight-Line Depreciation Method

When using the straight-line method, the salvage value reduces the depreciable base. Total machine cost is Rs. 310000

The expected useful life is 10 years. If the rate of depreciation is 10% Then the salvage value is

$$S = (1 - i)^y$$

$$S = 310000(1 - 10\%)^{10}$$

$$S = \text{Rs. } 108090.3$$

**Yearly expenses calculation**

Consumables and Packing per annum (Rs. lakhs)	Rs.2.5 lakhs
Power and Fuel (Rs. lakhs)	Rs.1.2 lakhs
Wages & salaries (Rs. lakhs)	6.12 lakhs
Repairs & Maintenance	0.4 lakhs
Depreciation (Straight line Method)	0.2019 lakhs
General & administration Expenses	1 lakhs
Selling expenses	3% on Sales

**Expected Cost of Project**

Particulars	Cost in Lakhs
Land & Building (2500/- Rent + 30000/-Advance)	0.6
Plant & Machinery	3.1
Other Misc. assets	0.50
Pre -Operative expenses	1.00
Margin for working capital	1.5

**Cost of production & profitability statements**

	1 <sup>st</sup> Years	2 <sup>nd</sup> Years	3 <sup>rd</sup> Years
Utilizations	70%	80%	90%
Installed Capacity of Tower Bolts in Dozens	23887.5	23887.5	23887.5
Selling Price/Dozen of Tower Bolts (in Rupee) Rs.220 per dozen			
Production/Sales of Tower Bolts (Dozens)	16721.25	19110	21498.75
<b>Sales Value of Tower Bolts (Rs.lakhs)</b>	<b>36.78</b>	<b>42.04</b>	<b>47.29</b>
<b>Cost of Production</b>			
Raw Materials Stainless steel sheet	4.88	5.58	6.28
Consumables and Packing per annum	1.75	2.0	2.25
Power and Fuel	.84	.96	1.08
Wages & salaries	4.284	4.896	5.508
Repairs & Maintenance	.5	.5	.5
Depreciation (Straight line Method)	0.2019	0.2019	0.2019
<b>Total Production cost</b>	<b>12.46</b>	<b>14.14</b>	<b>15.82</b>
Admin. & General expenses	0.7	0.8	0.9
Selling expenses	1.1034	1.2612	1.4187
<b>Total</b>	<b>14.2634</b>	<b>16.2012</b>	<b>18.1387</b>

Fixed cost	Value in Rs. Lakhs for year-1	Value in Rs. Lakhs for year-2	Value in Rs. Lakhs for year-3
<b>Based on Utilization %</b>	70%	80%	90%
Wages & Salaries	4.284	4.896	5.508
Repairs & Maintenance	0.5	0.5	0.5
Depreciation	0.2019	0.2019	0.2019
Admin. & General expenses	0.7	0.8	0.9
<b>Total</b>	<b>5.6859</b>	<b>6.3979</b>	<b>7.1099</b>

<b>Profit for Die and punch method</b>	<b>22.5166</b>	<b>25.8388</b>	<b>29.1513</b>
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**Based on 70% Utilization**

$$\text{Breakeven level} = \frac{\text{Fixed cost} * \text{Utilization \%}}{\text{Fixed cost} + \text{Profit}}$$

$$\frac{5.6859 * 70}{5.6859 + 22.5166} = 14.11\% \text{ of installed capacity}$$

**Based on 80% Utilization**

$$\frac{6.3979 * 80}{6.3979 + 25.8388} = 15.87\% \text{ of installed capacity}$$

**Based on 90% Utilization**

$$\frac{7.1099 * 90}{7.1099 + 29.1513} = 17.65\% \text{ of installed capacity}$$

**PROFITABILITY RATIOS:**

**Based on 70% Utilization**

$$\frac{\text{Profit}}{\text{Sales Value}} = \frac{22.5166}{36.78} * 100 = 61.21\%$$

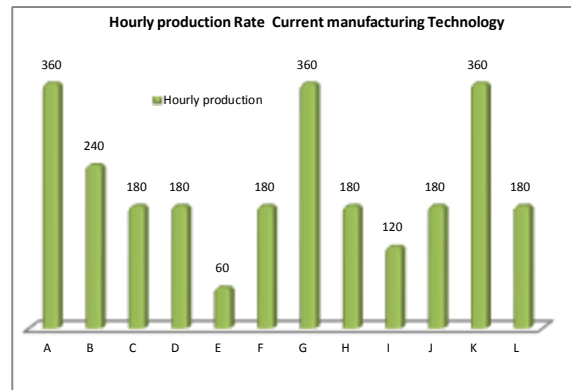
**Based on 80% Utilization**

$$\frac{\text{Profit}}{\text{Sales Value}} = \frac{25.8388}{42.04} * 100 = 61.46\%$$

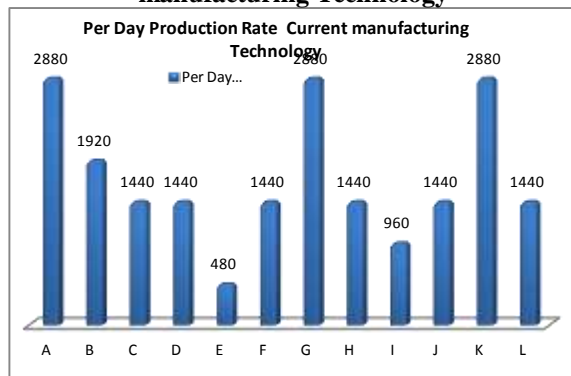
**Based on 90% Utilization**

$$\frac{\text{Profit}}{\text{Sales Value}} = \frac{29.1513}{47.29} * 100 = 61.64\%$$

**III. RESULT AND DISCUSSION**



**Figure 3: Hourly production Rate Current manufacturing Technology**



**Figure 4: Per day production Rate Current manufacturing Technology**

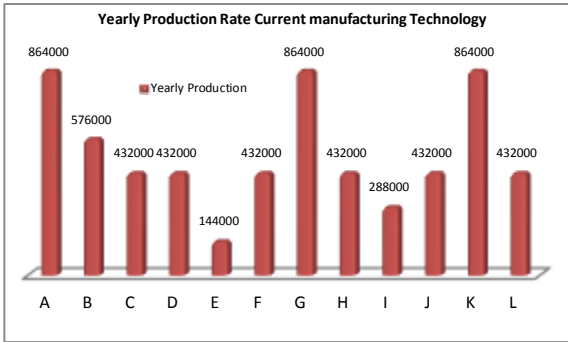


Figure 5: Yearly production Rate Current manufacturing Technology

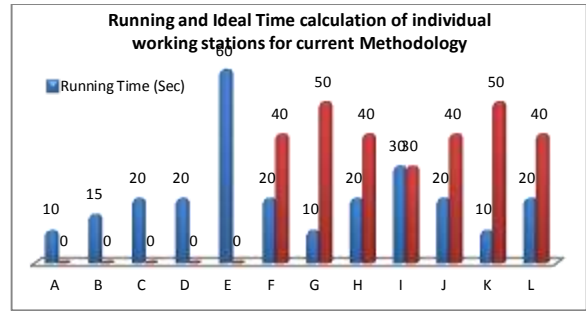


Figure 9: Running and Ideal Time calculation of individual working stations for current Methodology

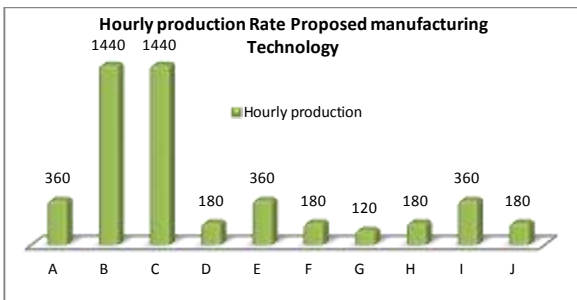


Figure 6: Hourly production Rate Proposed manufacturing Technology

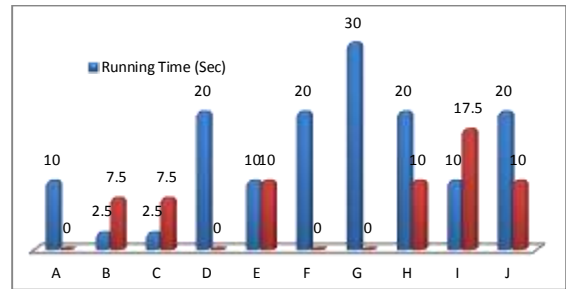


Figure 10: Running and Ideal Time calculation of individual working stations for proposed Methodology

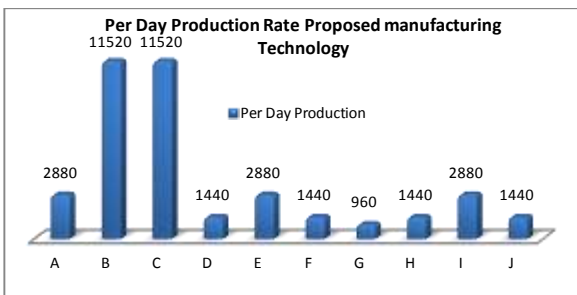


Figure 7: Per day production Rate Proposed manufacturing Technology

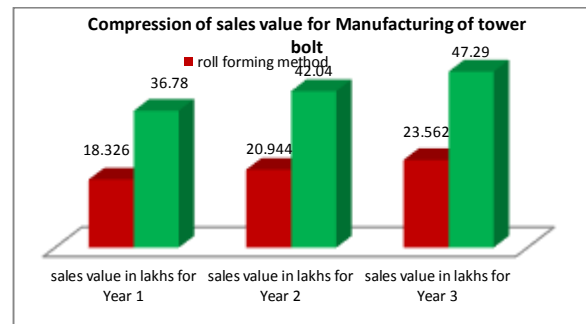


Figure 11: Compression of sales value for Manufacturing of tower bolt

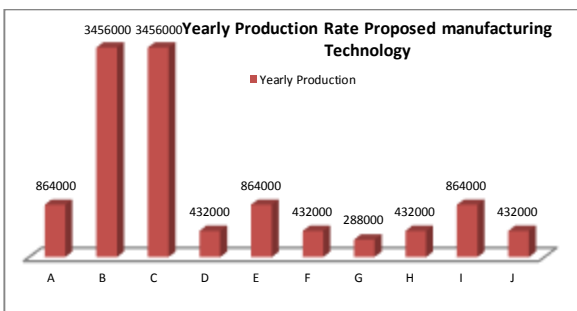


Figure 8: Yearly production Rate Proposed manufacturing Technology

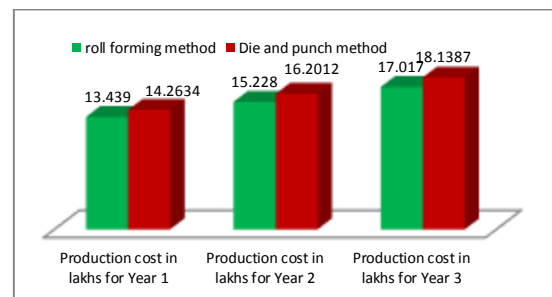
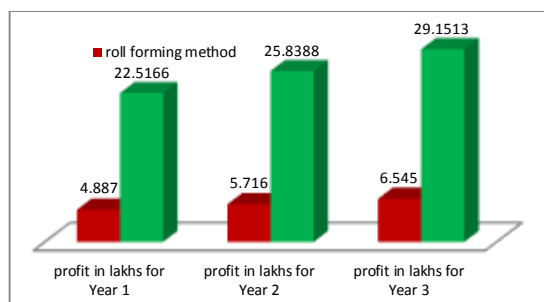


Figure 12: Compression of Production cost for Manufacturing of tower bolt



**Figure 13: Compression of profit for Manufacturing of tower bolt**

#### IV. CONCLUSION

The present work aims at increasing the productivity of Tower Bolt by changing its manufacturing technique and thereby reducing the cost of production as well. As mentioned earlier, the material deformation process is non-linear, in the present work manufacturing technology of tower bolt using metal forming method and die and punch is mathematically compared. It can be concluded that the manufacturing of tower bolt using a punch and die is a feasible process. Currently the tower bolt is manufactured by using roll metal forming process which produces long lengths that are subsequently drilled and cut to desired size. As a result of proposed methodology, running time has significantly decreased. This reduction is due to increased hourly productivity, which further led to improvement in daily and yearly productivity of Tower Bolt. This has led to increase in the profit for the organization. It has also helped in increasing sales value for the organization. The conventional method for production of Tower Bolt i.e. Roll Metal Forming Process, takes considerable amount of time, but using Punch and Die method the time of production will be decreased considerably. This will also increase profit.

The data verifying this is as follows. The yearly production of Tower Bolt using conventional method, with constraints of eight hour shifts and machines operating three hundred days a year, is 144000 units.

Under same conditions, the production using proposed method is 288000 units. The production cost in first method increases from 13.439 lakhs in first year to 15.288 lakhs in second year and 17.017 lakhs in third year.

Comparing this with the second method, it is 14.2634 lakhs in first year, 16.2012 lakhs in second year and 18.1387 lakhs in third year. The profit in using first method is 4.887 lakhs in first year, 5.716 lakhs in second year and 6.545 lakhs in third year, whereas it is 22.5166 lakhs in first year, 25.8388 lakhs in second year and 29.1513 lakhs in third year, using second method. These have been calculated when only 70%, 80% and 90% of the potential of the manufacturing plant has been utilized for production, respectively. The sales value using first method is 18.326 lakhs in first year, 20.944 lakhs in second year and 23.562 lakhs in third year, but there is a

significant increase in it when second method is used which is 36.78 lakhs in first year, 42.04 lakhs in second year and 47.29 lakhs in third year.

On comparing data, the production cost is more using proposed method but, the profit is almost five times in this method. The sales value also increases considerably which is 47.29 lakhs in third year, in conventional method this amount is only 23.562 lakhs in third year. Thus we see that Punch and Die method is more profitable than Roll Metal Forming Process.

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