Abstract

Background/Objectives: The objective of our research work is to increase the productivity of the billet sawing machine.

Methods/Statistical Analysis: In this research work we suggest some modification to the existing machine by redesigning the some parts of the auto loader, main and shuttle vice. The rod resting area and feeder area of the auto loader has been modified by raising the height of the rod resting area and also designed the feeder to hold two rods vertically. And also the dimensions of the main vice and the shuttle vice have been redesigned to hold the two rods vertically. Findings: The proposed billet sawing machine thus enables to cut two rods at the same time in order to reduce the cutting time and also could be improved 50 to 75 % (approx.) of the productivity in modern manufacturing environment than the existing machine.

Keywords: Billet Sawing Machine, Designing, Machining, Materials, Productivity

1. Introduction

Common cutting processes include sawing, shaping (or planning), broaching, drilling, grinding, turning and milling. Although the actual machines, tools and processes for cutting look very different from each other, the basic mechanism for causing the fracture can be understood by just a simple model called for orthogonal cutting. In all machining processes, the work piece is a shape that can entirely cover the final part shape. The objective is to cut away the excess material and obtain the final part. This cutting usually requires to be completed in several steps – in each step, the part is held in a fixture, and the exposed portion can be accessed by the tool to machine in that portion. Common fixtures include vise, clamps, 3-jaw or 4-jaw chucks, etc. Each position of holding the part is called a setup. One or more cutting operations may be performed, using one or more cutting tools, in each setup. To switch from one setup to the next, we must release the part from the previous fixture, change the fixture on the machine, clamp the part in the new position on the new fixture, set the coordinates of the machine tool with respect to the new location of the part, and finally start the machining operations for this setup. Therefore, setup changes are time-consuming and expensive, and so we should try to do the entire cutting process in a minimum number of setups; the task of determining the sequence of the individual operations, grouping them into (a minimum number of) setups, and determination of the fixture used for each setup, is called process planning.

Now a day’s billet sawing machines are most suitable for cold forge shop, steel traders, CNC production centers for auto components and engineering industries. Sawing is defined as the process of cutting billet or work stock to our requirements. It means, cutting bar stock to the required length or size for machining to obtain the desired shape and size. During sawing, the individual tooth cuts the work when either the saw or work feeds. This operation can be controlled by the direction, speed of cutting and number of teeth on the saw. Sometimes, curved cut can also be done. The main thing in sawing process is, the maximum width of cut done on work will be equal to the width of the saw itself. Some features of the billet sawing machines are saw head has
fully automatic programmable with NC Controlled Servo, motor with ball screw for saw feed to get optimum tool life, good Surface finish, face squareness do not require in facing operations, Can be applied carbide tipped and HSS Circular saws and job positioning automatic as per set length.

Improvement of billet conditioning processes, Automation of billet surface inspection, Construction of billet tracking system. A perfect repair model in repairable systems by assuming that the failed system would be repaired as good as new after failures. However in practice, the repairable systems can be brought to one of the possible states following a repair. These states are “as good as new”, “as bad as old”, “better than old but worse than new”, “better than new”, and “worse than old”. The comparative analysis of availability for a redundant repairable system. RAM analysis on a urea production process plant with an aim to minimize its failure, plant maintainability requirement and optimize equipment availability. A more general mathematical model and algorithms for reliability analysis of wind turbines. A three parameter weibull failure rate function is used to model the problem and the parameters are estimated by maximum like hood and least squares.

The stochastic behavior of an electronic system through an embedded markov chain approach in continues time and discrete time scale with the purpose to maximize its steady state availability. An intelligent automated length measurement device composed of the rotary encoder, proximity switches, motor and embedded design consisting microcontroller with digital circuitry etc. this device used as control panel of paper cutting machine, which is used to cut the various kind of paper products, plastic, thin film, leather, slice of nonferrous metal etc. This system can be applicable in paper cutting industry and proves how it can be a low cost solution in the production practice. A mathematical model of the steel industry which manufactures the stainless steel plates and also made an attempt to improve its availability. The failure and repair rates of different subsystem are arbitrary distribute d. Lagrange’s method for partial differential equations is used to solve system governing equations. Availability an analysis of the steel industry helped in identifying the contribution factors and assessing their impact on the system availability. The productivity of the specific company by using line balancing technique. It is acts as a simulation tool to find the solution for Small Medium Enterprise (SME) incapable of competing with large companies manufacturing plant, assembly line with Low skill and knowledge in management. By defining the problem that may happen in the exiting line and give alternative of new assembly line, the problem is solved. A methodology for batch manufacturing organization to work as robust enterprises with energy. They concluded that the robust design concept is used to improve the reinforcement bar production for sustainable development, in a modern steel rolling plant. The anchor head for a specific size. Machine process is carried out via CNC three-axis milling machine (Fanuc control). The machined job through designed jig has high accuracy, surface finish, reduced cost of manufacturing, increasing company’s productivity rate and quality. Dispersing of carbon nanotubes in dielectric with volume fraction of 0.1%, surface roughness decreased about 1μm and approximately 15 percent. Also by mixing carbon nanotubes in dielectric with volume fraction of 0.2%, surface roughness decreased about 1.4 μm and approximately 20 percent. These indicate the good performance of using carbon nanotubes in dielectric.

Most of the saw blades are designed to do their best work in a certain type of cutting operation. There are blades designed for ripping lumber, crosscutting lumber, cutting veneered plywood and panels, cutting laminates and plastics, cutting melamine, and cutting non-ferrous metals. There are also “general purpose” and “combination” blades, which are designed to work well in two or more types of cut. What a blade does best is determined by the number of teeth, the type of gullet, the tooth configuration and the hook angle (angle of the tooth).

In this research work we suggest some modification to the existing sawing machine by redesigning the some parts of the auto loader, main and shuttle vice. The rod resting area and feeder area of the auto loader has been modified by raising the height of the rod resting area and also designed the feeder to hold two rods vertically. And also the dimensions of the main vice and the shuttle vice have been redesigned.

2. Method of the Existing Sawing Machine

At the present sawing machine is built to cut one billet at a time. The process in the existing machine involves loading of rods in auto loader, triggering of rods into the feeder bed, feeding of rod into the cutter and cutting of rod into billet. The loading of the rods over the rod resting tray of the auto loader is done manually by the operator. Nearly 10 to 15 rods are loaded at a time depending upon their diameter. The photo copy of the existing auto loader is shown in Figure 1.
modification. In order to achieve that, rod resting tray, feeder bed, main vice and shuttle vice has been modified. Out of many ideas discussed, altering the some parts of the machine can make the two rods to feed at a same time as it has capacity to cut the two rods quantity.

3.1 Details of the Modified Parts
The following parts are required for modification in order to increase the productivity of the proposed machine the modification required are rod resting tray, Feeder bed, Main vice and shuttle vice.

3.2 Analysis and Contouring the Issues
During the time of modification and analysis the issues and their contouring have been absorbed. In rod resting tray its height should be increased. In feeder bed manually operated power screw should be create with adjustable. Shuttle vice and main vice horizontal jaws dimensions should be modified. Movable jaw is to be modified as tilt and able to hold two rods firmly. There is highest of 20 mm difference between the rods, so there is no bit problem at the end. Feed servo motor is capable to push two rod since rod weight rests on the feeder bed. Index side servo motor is capable to cut two rod of 36 mm diameter since it is 10 HP powered and has many gear reduction.

3.3 New Design Construction and Principle of Working
At the present, the Auto loader has rod resting tray which is made up of the cast iron. It has the 6 structures of identical shapes. In order to increase the productivity, the height of the structure has to increase up to 40 mm as shown in the Figures 4(a) and 4(b) by using welded joint.
It has thickness of 13.5mm. All other dimension are retained as same as old dimension expect the height of extension.

Feeder assembly is one of the parts of the Auto loader. At present, it is design to hold only one rod using the barriers and v clamp. The rod has been triggered from the rod resting tray to this bed using trigger which is operated automatically by hydraulic cylinder. This part has to be modified to hold the two rods vertically. In order to achieve that, adjustable barrier has been designed using power screw which is manually operated. So that it would hold two rods firmly. The end barrier which is already fixed with the help of the welded, in order to achieve our objective, the adjustable barrier has been design using with the help of the power screw method. The feeder bed with adjustable barrier and its exploded view is shown in Figures 5(a) and 5(b) respectively.

The screw rod has the diameter of 24mm and length of 220mm. The yoke has the thickness of 23mm. The left end barrier has also been increased to 90mm from 50mm. The two guide rods are used to arrest the tilt able motion. Yoke is the movable barrier element in feeder bed which is in inverted ’T’ shape. It will move with the help of the screw. Due to the rotation of the screw, translatory motion occurs in yoke. It has thickness of 23mm. Lead screw is a mechanical element which is used to move the adjustable barrier yoke. It converts the rotary motion of screw into the translatory motion of the yoke. It has the diameter of 24mm and rod length of 220mm. Handle is a mechanical element which is used to power the screw manually. It is made up of 8mm thick plate and 20mm rod.

Shuttle vice is used to feed the rod into the cutter. It has the stroke length of 1000mm. It has horizontal fixed and movable jaws and movable vertical jaw. The movement of the jaw has been operated by the hydraulic cylinder which is automated. At present, the dimensions of the horizontal jaws are designed to hold one rod. In order to hold two rod height of jaws has to be increase up to 73mm from 50mm. So that it can able to feed two rods at a time. The dimensions of the newly design shuttle vice’s movable jaws is 73 * 65 * 140mm.

4. Results and Discussion

Main vice is not movable, and it is adjacent to the cutter position. It is used to hold the rod firmly so that while cutting action job should not rotate or else it would break the cutter tool. At present, main vice is designed to hold the one rod. So we have designed it to hold the two rods at a time. The Modified main vice jaw design drawing and model are shown in Figure 6(a) and 6(b) respectively.

In order to eliminate issue of diameter difference we have designed the tilt able vice with increased height up to 73mm of their jaws. It would help the rods to hold firmly even though there is burr in any rods.

4.1 Design of Screw Rod

Screw diameter is 24mm; Length is 140mm PSG DATABOOK 5.43 AND 7.87; Pitch is 3; Major diameter is D = d = 24 ; Pitch diameter is d_p = D/2 = 22.051mm; Minor diameter is d_g = 20.320mm ; Depth of thread h_3 = 1.840mm ; Maximum depth of engagement t_2 or H_1 = 1.624mm; Material selected for screw rod: C45 steel.

\[
\text{Stress area } = \frac{\pi}{4} \left(\frac{d_2 + d_1}{2}\right)^2
\]

\[
= \frac{\pi}{4} \left(\frac{22.051 + 20.320}{2}\right)^2
\]

\[
= 352.490 \text{ mm}^2
\]

Axial Force (P) = \frac{P_s}{\pi \psi d_g^2 t_2 z} ;

Where, Pressure ’P’ for steel = 8 N/mm²

\psi = \text{ratio } 1.2 \text{ to } 2.5 \text{ for solid nuts } = 2 \text{ selected}

Lead S = Pitch \times \text{No. of starts } Z

= P \times Z
4.2 Strength Evolution

4.2.1 Friction Moment on One End $M_f$

$$M_f = P \left( \frac{d_p}{2} \right) \mu$$

$$\mu = \tan \rho$$

The friction angle $\rho$ is $6^\circ$ to $8^\circ$; Say, $\rho = 6^\circ$

Coefficient of friction, $\mu = 0.10$

$$M_f = 600.016 \times \left( \frac{22.051}{2} \right) \times 0.10$$

$$= 661.547 \text{ Nmm}$$

4.3 Torque Transmitted by the Screw

$$M_t = \left[ \frac{d_p}{2} \tan(\beta + \rho) \right] + M_f$$

$$\rho = \tan^{-1} \left( \frac{s}{\pi d_p} \right)$$

Number of starts is selected as 2 since the screw is used for heavy load transmission frequently.

$S = \text{No of starts} \times \text{Pitch}$

$S = 2 \times 3 = 6$

$$\beta = \tan^{-1} \left( \frac{6}{\pi \times 22.051} \right)$$

$\beta = 4.95$

$\beta = 5^\circ$

$$M_t = \left[ 600.016 \times \frac{22.051 d_p}{2} \tan(5 + 6) \right] + 661.547 + 661.547$$

$$= 1947.4653 \text{ Nmm}$$

4.4 Bearing Stress

$$\sigma_c = \frac{2p}{\pi d_p H}$$

$H = \text{height of the nut}$

$H = 2 \times d_p$

$H = 2 \times 22.051$

$H = 44.102$

$$\sigma_c = \frac{2 \times 600.016}{\pi \times 22.051 \times 44.102}$$

$$= 3.927 \text{ N/mm}^2$$

The design is safe.

4.5 Buckling Load

$$F \leq \left( \frac{a \sigma_c}{1 + c \left( \frac{1}{k} \right)^2} \right)$$

Bucking Force, $F = \text{Axial Force} \times n$

$n = \text{factor of safety which can be selected from 3 to 3.5}$

$n = 3$

$$F = 600.016 \times 3$$

$$= 1800.048 \text{ N}$$

$$A = \frac{\pi d^2}{4}$$

$$= \frac{\pi \times 24^2}{4}$$

$$= 452.389 \text{ mm}^2$$

Buckling Stress, $\sigma = 400 \text{ N/mm}^2$ (for steel)

$$c = \frac{1}{0.25} \times \frac{1}{7500} \text{ (for both end free)}$$

$$\frac{1}{k} = \frac{140}{24} = 20$$
\[ (1800.048) \leq \frac{452.399 \times 400}{1 + \frac{1}{0.25} \times \frac{1}{750} \times 20^2} \]
\[ \Rightarrow 1800.048 \leq 149139.230 \text{ N/mm}^2. \]
The design is Safe.

4.6 Shear Stress

\[ \tau = \frac{2p}{\pi d H} \]
\[ H = 2 \times d_p \]
\[ = 2 \times 22.051 \]
\[ = 44.102 \]
\[ \tau = \frac{2 \times 600.016}{\pi \times 24 \times 44.102} \]
\[ = 3.608 \text{ N/mm}^2 \]
The design is Safe.

4.7 Efficiency of the Screw

Efficiency of the Screw \( (\eta) = \frac{(1 - \mu \tan \beta) \tan \beta}{\mu + \tan \beta} \)
\[ \eta = \frac{(1 - 0.10 \tan \beta) \tan \beta}{0.10 + \tan \beta} \]
\[ = 0.4625 = 46.25\% \]

The available data's for rod collection are tabulated in Table 1.

### Diameter Difference of the Rod

Rod 1: 0.1 mm; Rod 2: 0.1 mm; Rod 3: 0.02 mm ; Average difference: 0.0733 mm.

There is a maximum variation of diameter upto 0.1 mm in the rod.

The cutter used here for the machining is the TCT cutter tool which means Tungsten carbide tipped cutter tool. There are 3 types of diameter cutter tool is used. They are as following below in the Table 2.

Table 2. Available cutter tool specifications

| Sl. No. | Description | Dimensions in mm |
|---------|-------------|------------------|
| 1.      | Saw Diameter × Body Thickness × Bore Nos. of Mounting Hole × Hole dia × PCD. | Dia 250 × 2.0 × 32 4/9/50 & 4/11/63 |
| 2.      | Saw Diameter × Body Thickness × Bore Nos. of Mounting Hole × Hole dia × PCD. | Dia 285 × 2.0 × 32 4/9/50 & 4/11/63 |
| 3.      | Saw Diameter × Body Thickness × Bore Nos. of Mounting Hole × Hole dia × PCD | Dia 315 × 2.2 × 40 4/9/50 & 4/11/63 |

From the above table we are suggested to use 315 mm diameter cutter. It has the capacity to cut the two rods at a same time. And some provision is to be made to increase the height of the cutter.

Micro mist cooling system is used for applying a thin film of micro lube to either band saw or circular saw blade with more precision and reliability. It also maintain the temperature of cutter and job at 34°C. Precise dispensing gives the user the ability to eliminate mess associated with flood coolant, recycled chips that are dry, and reduces cutting forces to maximize sawing productivity. ITL micro lube fluid is a premium plant based metal cutting edge of any tool and cleans-up the disposal. ITL Micro lube is 100% environmentally safe.

5. Conclusion

The modification proposed in the machine thus enables to cut two rods at the same time in order to reduce the cutting time and also could be improved 50 to 75 % (approx.) of the productivity than the existing machine.

6. Acknowledgement

The authors gratefully acknowledge the contribution of Govt. of India for Financial Assistance, DST-FIST F.NO:SR/FST/College-189/2013.

We are sincere thanks to I.P. Rings PVT Ltd, Chennai for supporting experimental work.

7. References

1. Taira ONOMM, Yoshimura K, Mikam H. Improvements of billet conditioning processes. Nippon Steel Technical Report. 2007; 96:12–20.
2. Ke J-C, Chu Y-K. Comparative analysis of availability for a redundant repairable system. AMC. 2007; 188(1):332–8.
3. Krivtsov VV. Recent advances in theory and applications of stochastic point process model in reliability engineering. Reliab Eng Syst Safe. 2007; 92(5):549–51.
4. Sharma RK, Kumar S. Performance modeling in critical engineering system using RAM analysis. Reliability Engineering and System Safety. 2008; 93(6):891–7.
5. Guo H, Watson S, Taver P, Xiang J. Reliability analysis of wind turbines with incomplete failure data collected from the date of initial installation. Reliability Engineering and System Safety. 2009; 94(6):1057–63.
6. Uemura T, Dohi T. Availability analysis of an intrusion tolerant distributed server system with primitive maintenance. IEEE Transaction on Reliability. 2010; 59(1):18–29.
7. Lavhate SS, Keskar SR, Unhale VP, Sangale A. Advanced paper cutting machine using ARM7. International Journal of Engineering and Advanced Technology. 2014; 3(4):259–61.
8. Shakuntla AK, Lal SS, Bhatia. Analysis of non-markovian process by the inclusion of supplementary variables. International Journal of Research in Advent Technology. 2014; 2(3):182–91.
9. Palani S, Johnstephen R, Logesh H, Selvam M, Mandal K. Design and development of JIG for making anchor head in three axis vertical milling machine. International Journal of Applied Engineering Research. 2015; 10(83):129–32.
10. Modi A, Sharma R, Jaiswal Y. Mini steel - rolling sequence critical analysis for reinforcement bar production for sustainable manufacturing – A case study. International Journal of Scientific and Technology Research. 2015; 4(3):165–72.
11. Palani S, Ohmnath B, Selvam M, Raghunath H, Manikandan K. Productivity improvement in small medium enterprise by plant relocating through line balancing technique. International Journal of Applied Engineering Research. 2015; 10(83):42–6.
12. Atefi R, Khajeali M, Rasafchi M. Effect of multi-wall carbon nanotubes with different volume fractions on surface roughness in electro discharge machining. Indian Journal of Science and Technology. 2014 May; 7(5).