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AUGMENTATION PROGRESSION ON PIN SHEARING MACHINE THROUGH VALUE INDUSTRIAL METHODOLOGY

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Abstract

In today's global business scenario, auto parts manufacturing companies are facing more competition in the market for survival. Delivering high quality products, short lead time with low cost are very high demands to achieve competitive edge to these organizations. Companies need to continuously improve quality of their products and services in addition to product cost reduction. To achieve these aspirations, new technology addition and as well as value analysis and value engineering tools are widely used globally. In the present work, Value engineering performed on pin shearing machine is presented which is widely used in needle roller bearing parts manufacturing, chain part manufacturing and electrode part manufacturing sectors . Pins are produced through extending wires from a roll or coil in order to straight and to cut require dimensions (length) and controlled by spring loaded mechanical stopper, Due to continuous feeding as well as high speed operation, this spring loaded mechanical stopper didn't properly responding, it leads to inconsistent of accuracy and increase in downtime of machine. Higher scope on this machine was concentrated due to the possibility of increasing the production rate of the machine and also possible to reduce the down time of machine. Value engineering tools and

Benchmarking unit was used for achieving our objective. Alternative method of coil feeding concept was developed to eliminate the mechanical stopper as well as to improve the product output and product constancy using function structure analysis. It was found that start and stop coil feeding mechanism was appropriate. The proposed alternative coil feeding design concept was validated through FEA for operating conditions. Prototypes were assembled and tested as per machine manufacturing standard.

Keywords: Value Engineering, Benchmarking, FEA, Bearing, Quality

1. Introduction

Pin shearing machines are widely used to extend wires from a roll or coil in order to straight and to cut require length [4]. These machines are offered with extensive features requiring diverse applications. Some machines are configured for straightening and cutting all kinds of cold drawing rod and other nonferrous metal rod. This machine cut the rod as per requirements in the required dimension and thereafter, works continuously. These machines are available with various features such as different diameter size rod for straightening; different cutting lengths and standard multi-power motor for both straightening and cutting of rod .Machines are complied with three different processes such as feeding, straightening and cutting off as shown in Figure1.

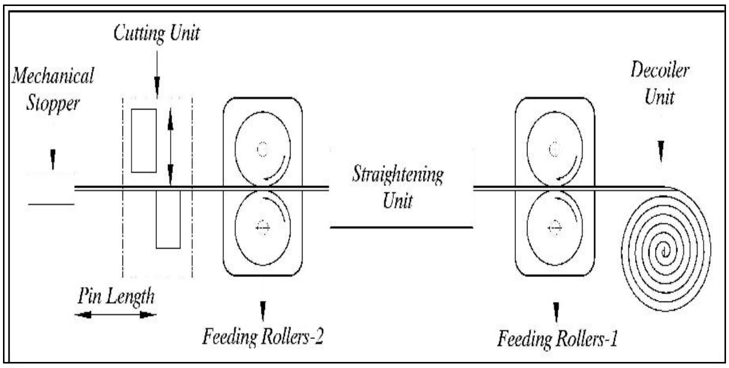

Figure 1. Surface Roughness Profile

The cutting unit is the one in which the cutting action on the rod is provided by the reciprocating shears. The power to the reciprocating shear is provided by the cam arrangement which in turn is connected to the shaft. The feed roller assembly is to provide the necessary pulling force for the rod and purpose of two pairs of rollers are used. The roller is provided with groove which matches with the various diameter of the wire. In this machine two set of feeding roller arrangement used to pull the rod. The straightening is carried out in order to ensure the straightness of a rod and Mechanical stopper is the very important unit since it determines the length of the product. It consists of a passage through which the rod passes and hits the stopper. The stopper is provided with a spring loaded arrangement supported by a sliding contact bearing. When continues rod hits the stopper due to the spring loaded effect it reciprocates horizontally. Shearing machines that are adapted to cut a rod of standardized lengths ranging from 7 mm to 30 mm and with a diameter comprised of 1.5 mm to 6mm. The power to the reciprocating shear is provided by the flywheel and cam arrangement is powered by 1hp motor and driven by a V-belt.

2. Problem Definition

The aim of this work is to improve productivity of shearing machine through down time reduction and increase machine availability as well as by eliminating of rework. Rework is carried out because of product output by quality exceed the specification limit. 5% of products are produced out of specification limit due to spring loaded mechanical stopper and feed rate and stopper not supporting high speed operation. The machine produces different variety of rod length. During the need of manually mechanical stopper and as well as feeding roller gripper is adjusted .so it force additional idle time. Continuous rotation of feeding roller, friction created between rollers and coil, due to high friction create more wear on the feeding rollers. This wear affects the feeding coil speed as well as to roller change frequency.

3. Methodology

Literature survey was carried out about value engineering for the selected project through journals and related documents [2, 10]. New concept model developed based on benchmarking unit and Validation carried out in prototype and implemented on machine. VE- Job plan systematic application of recognized techniques [14]. The job plan is a systematic and organized plan of action for conducting a VE analysis and assuring the implementation of the recommendations.

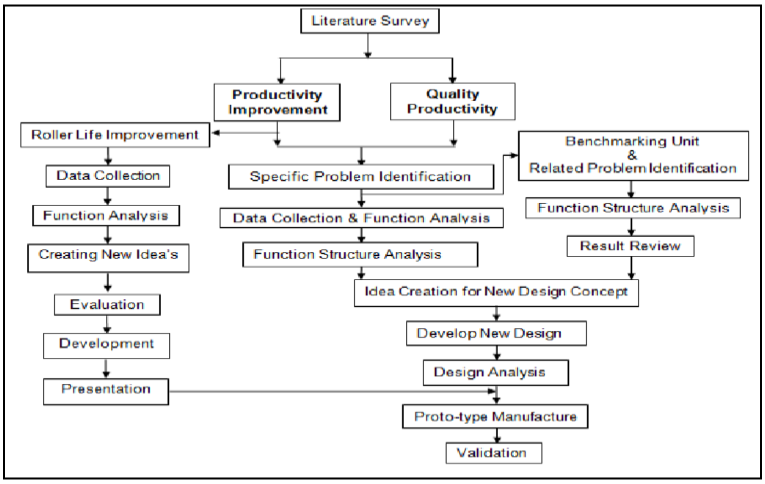

Figure 2. Methodology

4. Feeding Roller Life Improvement Using Value Engineering-Job Plan

4.1 Information phase

Feeding arrangements accompanied with feeding roller which is manufactured with HCHCR material [5]. Number of quantity needed for our machine, and the approximate roller manufacturing cost is about Rs.7000 per roller.

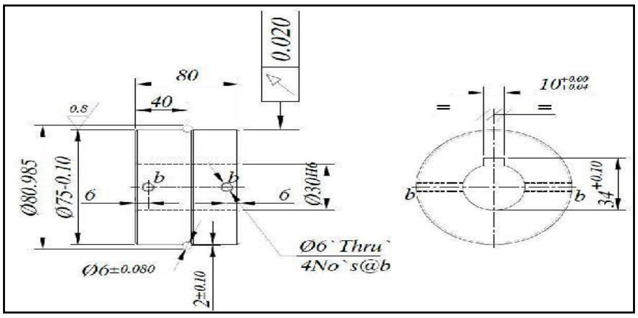

Figure3. Feeding Roller Detailed Drawing

4.2 Function analysis

The function of the roller is defined in two words, as an active verb and measurable noun [2]. The function analysis is shown in Table 1.

Table 1 Function Analysis

	FUNCTION		
ROLLER	VERB	NOUN	TYPE – B/S
	Feed	Length	B
	Facilities	Assembly	S
	Resist	Corrosion	S
	Receive	Torque	S
	Improve	Appearance	S
	Suit	Slot	S

4.3 Creative phase

During brainstorming these ideas were listed:-1) Number of feeding groove increase, 2) Change the material: HCHCR to HSS m42, 3) Increase the roller diameter, 4) Reduce Length of Roller, 5) Coating of Roller: Tungsten carbide, 6) Rubber Roller 7) Gripper feeding.

Alternative: Based on feasible ideas one alternative proposal are finalized. Roller material HSS M42 used and Number of feeding roller groove increase.

4.4 Evaluation phase

For judging the ideas, the following designs were considered:

A - Life
B - Wear Resistance
C - Cost
D - Light Weight
E - Appearance

Each of these design criteria was given a weight age factor. This was carried out as follows: each of the above criteria was Compared with others, and depending on their relative importance, three categories were formed, viz. major, Medium, and minor. A score of 3, 2 and 1 respectively was assigned to each of the levels. The details are as given in the Table II:

Table 2. Weightage Analysis

Weightage analysis	Points
Major difference	3
Medium difference	2
Minor differences	1

Table 3. Paired Comparisons

	B	C	D	E	Raw Score	Final Score
A	A_2	A_2	A_3	A_2	9	10
	B	C_2	B_2	B_2	4	5
		C	D_2	D_2	2	3
			D	D_2	4	5
				E	3	4

From the above paired comparison each parameter weightage calculated. The above ideas were discussed and the best feasible ideas were separated

1. Exiting roller material
2. Alternate for new material with number of groove.

Table 4. Evaluation Matrix

Parameters	Life	Wear	Cost	Light	Appearance	Total
Weightages	10	5	3	5	4	
Existing	2 20	1 5	4 12	2 10	2 8	55
Alternative	5 50	5 25	1 3	2 10	3 12	100

5 – Excellent, 4 – Very Good, 3 – Good, 2 – Fair, 1– Poor,
The evaluation matrix indicates that the selected alterative is better than the existing.

4.5 Recommendation phase

Based on study we will go for new roller design based on new ideas, Material to use HSS M42. Number of groove increased, Length of roller reduced from 90mm to 50mm [13]. New roller details are summarized in figure 4.

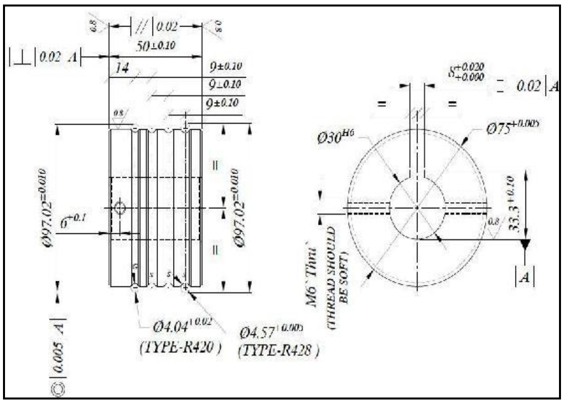

Figure. 4. New Roller Design

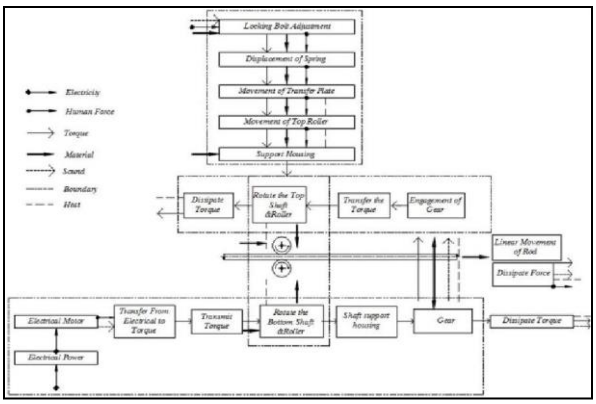

Figure. 5. Function Structure Diagram

5. Existing Feeding Unit

5.1 Data Collection

Data for understanding present status of product and selecting of proper solution for the problem will be achieved by proper information. Data collection improves decision making by focusing on objective information and process details. The main purpose of the feed roller assembly is to provide the necessary pulling force to the rod. Technical specification

Table 5. Technical Specifications

S.No	Description	Details
1.	Feeding speed	36 m/ min
2.	Roller diameter	60 mm
3.	Movement of top roller	10 mm
4.	Power transmission speed ratio	1:1
5.	Roller life	60 tonne
6.	Roller material	HCHCR

5.2 Function Structure Analysis of Feeding Unit

Function Structure Diagrams (FSD) is a graphical representation of the functions a product performs on its inputs and outputs. In a FSD, the overall function is broken down into elemental or atomic sub-functions [2]. As a pre-step to the function structure, a simple activity diagram was created to visualize operation activities. The activities diagrams were collected from the present feeding unit as shown in figure 5.

6. Benchmarking Unit

Stamping press: Stamping press is a metal working machine tool, used to shape or cut the metal by deforming it with a die as shown in figure 6.

Problem Faced: Frequent pilot tool broken, due to cases component damage, rework and productivity loss, causes- due to improper strip length feeding.

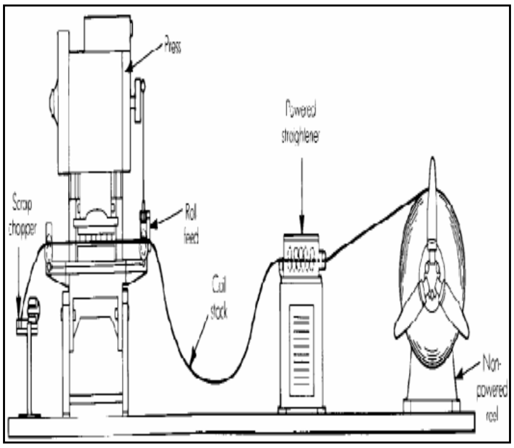

Figure 6. Stamping Process

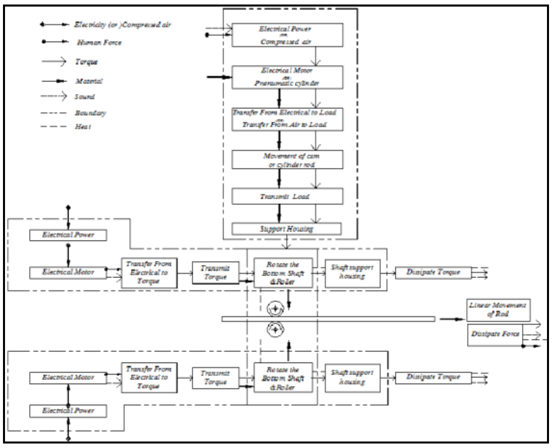

Figure7. FSD of Benchmarking

Solution: SERVO feeder to avoid improper strip length feeding improvement given in Table 6.

Table 6. Improved Comparison Table

S.No	Feeder Unit		
1.	Type of Feeding	Mechanical	Servo
2.	Pilot Tool Life(in	1.8	3.6
3.	Productivity/Tool(in	2.5	3.6
4.	Machine	160	210
5.	Rework &	100	56

6.1 Benchmarking unit function structure analysis

FSD Analysis was carried out for benchmarking feeding unit shown in figure 7.

6.2 Idea creation for new feeding unit

These ideas focused on, each necessary functions and manufacturing cost as shown in Table 7.

Table 7. Ideas of New Design

S.No	Description	Present	Benchmarking	Ideas for New Design
1.	Bottom Roller drive	A.C .Induction Motor	Servo motor	Servo motor
2.	Drive type	Chain drive	Direct drive	Direct drive
3.	Bottom Roller support	Bush	Bearing	Bearing
4.	Top roller drive	Gear Drive	Servo motor	Gear Drive
5.	Gripper load	Spring arrangement with manual	Pneumatic and cam servo unit	Pneumatic Arrangement
6.	Feeding roller rotation	continuous	Start- stop	Start - stop
7.	Machine Max Speed (spm)	300	450	1000
8.	Feeding roller life in tonne	60	50000	200
9.	Feeding length control	Not Controlled	Controlled	Controlled

7. New Model Development

Based on new ideas shown in Table 7, new feeding unit concept model developed with the help of solid works software, Benchmarking unit FSD drawing helps to develop the model each sub assembly wise, while creating a model to co-related with our objectives.

7.1 Design calculations

Feeding Time Calculation: This calculation helps to meet our objectives, and also use to select correct function time of product [11], the force exerted by a single acting pneumatic cylinder can be expressed as,

F = P*A = P π d2/4
F = force exerted (N)
P = gauge pressure (N/m2, Pa)
A = full bore area (m2)
d = full bore piston diameter (m)
F = 4 * 3.14 *80^2/4 = 201 kg.

Based on above calculations, air pressure contributing the output load, air pressure (min. 2 bar to max. 6 bars)

Table 8. Feeding Time Calculation

S. No	Description	Output in Tonne / day	Speed-Rpm	Product/Sec	Per Product Cycle Time in (milli sec)	Feeding Time in(milli sec)
1	Present Machine	3.8	300	5	200	100
2	**Requirement**	**12**	**1000**	**17**	**58.8**	**29.4**

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7.2 New feeding unit concept design

As a primary source of information, specialist and mechanical engineers as well as technical documentation were consulted.

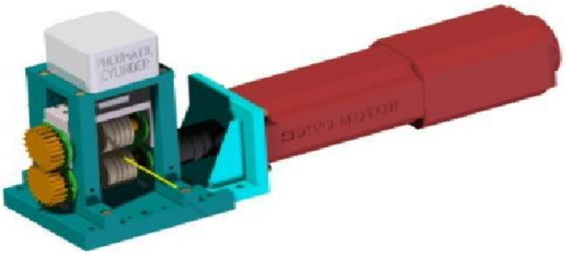

Figure 8. Assembly View

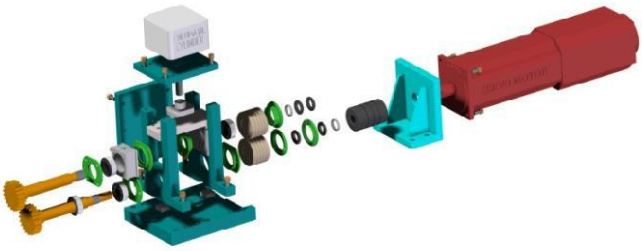

Figure 9 Exploded View

Figure 8 shows that the new feeding unit which assemblies to be developed in this case study. Figure 9 shows the exploded view of new feeding unit.

7.3 Design features

7.3.1 Feeding unit speed

New feeding unit design: Variable motor speed used to drive the new feeding unit at the speed of Min -2.2 m/min to Max 330 m/min (Roller diameter, 70 mm),Motor directly coupled to Bottom roller Assembly. Hence there is no loss of power.

Elimination of mechanical stopper: In new design servo motor used to drive feeding unit, this servo motor is specialized in high-response, high-precision positioning as a motor capable of accurate rotation angle and speed control. So Feeding roller feed the rod in specified length in specified time period of each cycle.

Feeding unit Start and stop for each cycle: Motor directly coupled with feeding unit bottom drive assembly with help of zero back loss coupling, so we can able to control the feeding rod length with high precision, Hence, no need of mechanical stopper.

Coil set up time reduction: Gripper assembly open and close position controlled by pneumatic cylinder, In this new feeding system gripper load controlled by compressed air, uniform load distributed on gripper roller assembly, this arrangement measurable with easy predictable,

Roller change time reduction: Feeding unit housing spited for easy removal and more accurate manufacturing, more space available to remove roller. Separate drive arrangement, so it is easy to synchronization of both units.

7.4 New feeding unit concept validation

Failure mode and effects analysis (FMEA), Structural analysis is the determination of effects of loads on physical structures and their components [1] [3], the results of analysis are used to verity of structures, it reduces the cost & time spends on physical test.

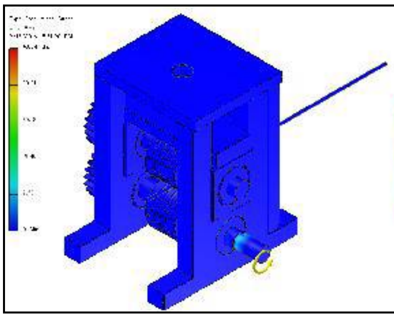

Figure 10. Assembly View

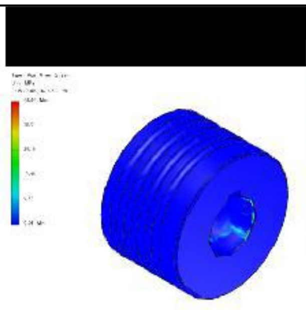

Figure 11. Roller

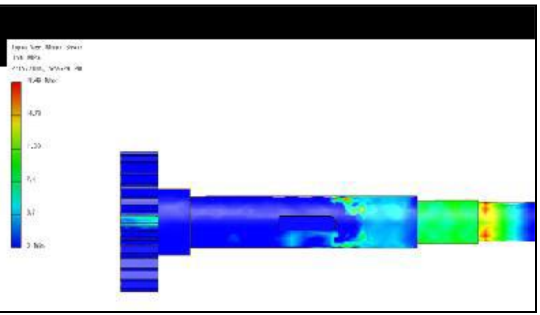

Figure 12. Bottom Shaft

The important results are summarized and given in Table 9. The result and plot indicate that the structural capacity of the feeding unit to with stand the specified load and torque

Table.9.Analysis Result

S.No	Description	Magnitude
1	Maximum Displacement in vertical direction of shaft	0.0053 mm
2.	Maximum stress in the feeding unit assembly	Maximum stress of 18.49Mpa observed near the end portion of the drive shaft, allowable capacity Fy = 80 Mpa.
3	Maximum Von-misses stress in the shaft	2.351 << 0.67 Fy

8. New Feeding Unit Assembly

Assembly of feeding unit carried out as per standard assembly work instruction of machine standard document, assembly photos shown in figure.13.

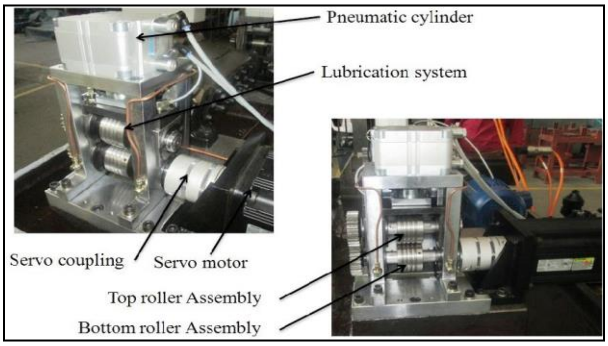

Figure13. Assembled Photos

9. Results Discussion

The result and plot indicate that the product outcome from new feeding unit with standard feeding angle with different output product per sec. Batch of samples collected and then, [6] the process capability is calculated and compared with required specification limit. ($Cp \geq 2.00$, $Cpk \geq 1.67$),

Table 10. Trail Run Results

Sl. No	Feeding angle	Product output (per sec)	Feedin g time in (mille	Run chart (Product Accuracy)	Process Capability
1	Feeding Start – 250 deg to end- 110 deg	8	84		C_p- 2.51 C_{pk} -2.43
2		10	70		C_p - 2.59 C_{pk} – 2.23
3		12	58.3		C_p- 2.30 C_{pk} -2.25
4		14	50		C_p- 2.12 C_{pk} -1.70

9.1 Product Output

New feeding unit output product compared with exiting product output shown in figure14. Based on new method implementation, productivity increased from 5 product / sec to 14 products / sec. Trial taken from this feeding unit 200tonne product produced with the speed of 14 product / second.

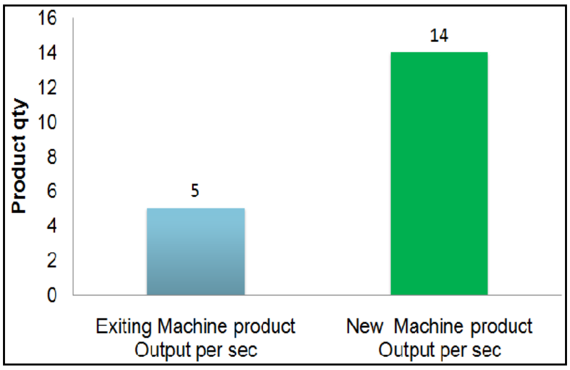

Figure14.Product Output

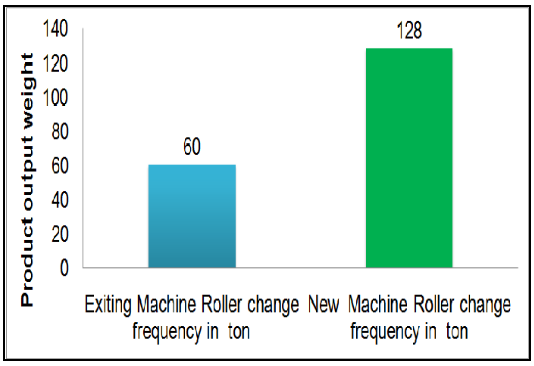

Figure 15. Feeding Roller Life

9.2 Feeding roller life

Feeding roller life is increased, when compared to the existing machine is shown in figure15. Roller life of existing machine is 60ton it improved in new machine as to 128 tonne, due to application of start/stop feature. Material of roller changed from OHNS to HSS M42.

9.3 Product Accuracy

From the trail run results summarized in Table 10, it achieves that the tolerance zone of product accuracy is improved in the range of ±0.05.If there is any deviation in accuracy range, the inbuilt measurement system activate and provide alarm automatically, It leads to Improvement of uniformity of end product.

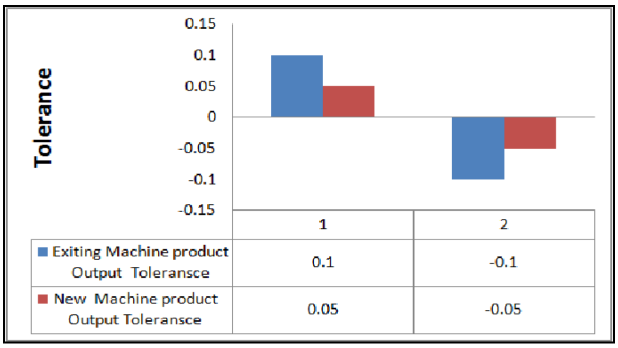

Figure 16. Product Accuracy

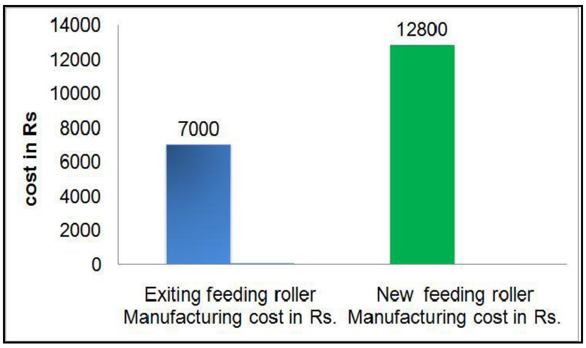

Figure 17.Feeding Roller Manufacturing Cost

9.4 Feeding roller manufacturing cost

In New machine, Feeding roller manufacturing cost is 80% higher than existing roller manufacturing cost, at same time functionality of new feeding roller is 8 times improved than that of existing feeding roller life, it leads to improve the roller change frequency, In new machine, feeding roller material is changed from HCHCR TO HSS M42 for obtain more life of feeding roller [16].

9.5 Model change time

Model change time of new machine is comparatively low, due to eliminating of mechanical stopper and uniform gripper load as well as automatic up and down arrangement, (i.e in existing machine it takes 30 mins, but in new machine it takes only 5 mins for model change.) In existing machine length controlled by Mechanical Stopper as well as trail and error method is used to control product length [8]. But in New machine Length is predictable, and hence it takes only 5 minutes to change the model.

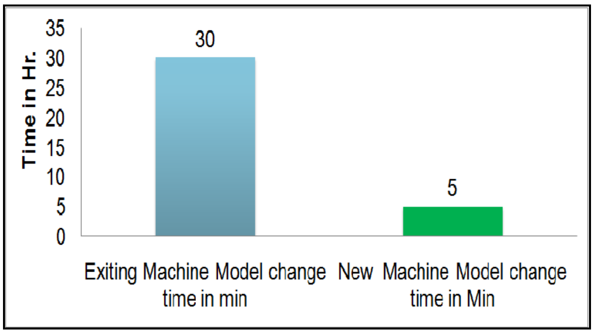

Figure 18. Model Change Time

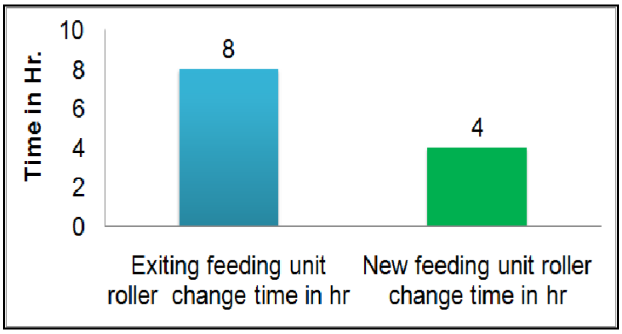

Figure 19. Roller Change Time

9.6 Feeding Roller change time

Roller change time of new machine is comparatively very low (i.e in existing machine it takes 8 hours, but in new machine it takes only 4 hours for Roller change.) In existing machine, chain drive leads to complication in synchronization (it takes much more time for Roller change) of both feeding unit. But in new feeding unit, automatic servo individual drive setup is provided with advanced setting features, Feeding unit gripper roller movement automated with pneumatic cylinder. Feeding roller housing provided with split type, this will help to reduce the roller change.

10. Conclusion

This research applies the value engineering concept to the process improvement in a pin shearing machine, focusing on coil feeding process. In feeding unit VE procedure were implemented to perform functional structure analysis of feeding unit. In order to achieve productivity, product accuracy and quality by using VE Tools. The result shows that, indirectly manufacturing cost of product is able to reduce up to 28%.

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