Design And Development of Circlip Locking Machine

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Abstract— **The future of manufacturing industry lies in reducing the manufacturing lead times, improving the performance, reliability and consistency in production. Automation is one of the best alternatives considering the consistent quality outputs justifying the cost of automation. India is being looked upon as an economic option for manufacturers to meet their ever increasing demands we should shed our conventional approach and adapt ourselves with automation. Automation is a use or application of integrated mechanical, electronic and computer based system in the operation and control of production system. Automation is connected to Production system . There are a need of Automation to the company So the Automation is used to Increase the Productivity, To reduce the cost of production, To improve the Product Quality, To mitigate the Effect of Labourshortage, to reduce the production time, to have a better control over manufacture activity ,to improve the worker safety . In this context this work is an attempt to show some details about the Engineering approach along with a case of a Circlip locking Technique. The problem was identified at Assembly line . in old method there will be by using plier expands the circlip and then place in to the grove. So many effort will be required for this task . so many time will be required for this, for that purpose change the production technique for circlip locking in bush first design the model in a CATIA software and then development will be takes place. This machine is used to install the new production technique in industry; in this machine there will be reduced the material handling. Improve the ergonomics concept. Both hand in engaged condition for that human safety should be consider paper presents a theory on design and manufacturing aspects of special purpose machine which helped the company to meet the customer's requirement.**

Keywords— **Productivity, Semi Automated Machine, Process Quality**

I. INTRODUCTION

Productivity is generally defined as the ratio of aggregate output and aggregate input [1]. In any firm or industry, productivity is a concept that measures the efficiency with which inputs are transformed into valuable output in a production process. Similarly, it can be defined as the combination of efficiency and effectiveness of a production process that aims to maximize output while minimizing the use of inputs.[2]Productivity measures the relationship between outputs such as goods and services produced, and inputs that include labour, capital, material and other resources[3]

The circlip locking machine concept, with its ability to machine many features simultaneously, remains effective for Assembled large quantities quickly. That's why old technique would be removed and pneumatic operated machine install. Project is based on a Semi Automation. In this project machine is designed and developed so there are various mechanism are connect to each other. In this project there are Design parts, Manufactures this part on machinery and then assembled to each other and then create machine. At a running condition thatactivity worker taking plier assembling that circlip in that grove of plastic as well as metal bush. So while the assembling that circlip the fingers of worker get stretched so the human effort required is more and then time requirement get rises .Above maintained and upcoming problem are will be solved in semi-automated machine.

Some major considerations in developing a semi-automated machine

- To reduce cost per component
- To avoid manual work
- To improve existing method
- Supplier pressure to meet the ever growing demand.
- To eliminate operator fatigue.
- Fool proofing the processes to eliminate chances of rejection.
- Reduce lead time.
- Maintain consistency in production

Special purpose machine are aimed at reducing the cycle times and control unnecessary costs thus increasing the profits [4]. Harvey [5, 6] in their study has discussed the principle factors which affects productivity.

In addition to technology, there are also other means for improving productivity like, re – organisation of resources, effective management of human resources , improving the quality work, reducing the amount of maintenance needed, making sure that delays do not occur etc. are only some examples. These methods are all within the wide definition of management. [8] The technique utilized by us will enable the worker to complete the component with minimum work & tool handling. Thus improves efficiency of labor. Also fatigue of worker has been reduced to considerable extent due to ease & simplification of operation by programmable logic controller unit with the use of hydraulic accessories.

In many industry there will be need of circlip for locking bush; so there will be different type of bush of lots of diameter; as fig show bush but we will referred the particular diameter of bush such as Ø 50, place the circlip in to the grove that is the main target;so the bush are many verity ;it is in metal or also in a plastic but we are selected the only a same diameter for that purpose we design the following part and then manufactured it and then assembled ;

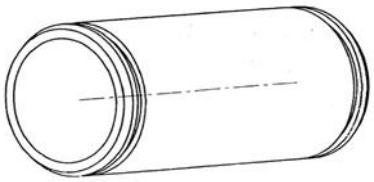


Fig-1 Bush

It consist of base plate , base plate fixture ,unloading fixture ,bush fixture ,press fixture ,cylinder,c channel ,mounting plate .so the working are as follow.

Worker take a job from the Gravity conveyor ;then place on the unloading fixture ; place the bush fixture over the Job then place the circlip over the bush fixture ,then press the solenoid button by two hand; then punch acting on the circlip at the end of the cylinder stroke the circlip are placed in the grove then operation completed ;After completing this operation then remove the bush fixture ;then press the solenoid valve button then unloading fixture are retracted then job get goes in to the bin.

II. Problems involved in present theory and practise:

The problem was identified at work station where the assembly of circlip and bush are assembled manually by using a knife edged plier. Here worker expanding that circlip by using the plier and trying to fit inside the groove if the plastic as well as metal bush. The assembly of this circlip done by single worker so it takes a time near about 20 sec per assembly so to reduce cycle time as well as human effort semi automation is done. The need for developing the machine be summarized as follows:

- To eliminate operator fatigue.
- Reduce manufacturing lead time.
- Maintain consistency in production.

To overcome the problems in existing methodology of manufacturing it was proposed to design and development of circlip locking activity.
The proposed design consists of using “pressing operation” and “unloading mechanism ” on either side of the machine. This design confirms the accuracy in circlip fitment and reduces the overall manual circlip locking time.

Fig. 9 Manual method

III. Methodology

To overcome the problem we develop and design asemi automated machine it consist following parts like base plate, base plate fixture unloading fixture bush fixture for metal and plastic, pressing bush ,actuators, c- channel , mounting plate . pneumatic circuits solenoid valve and 3/2 DCV .

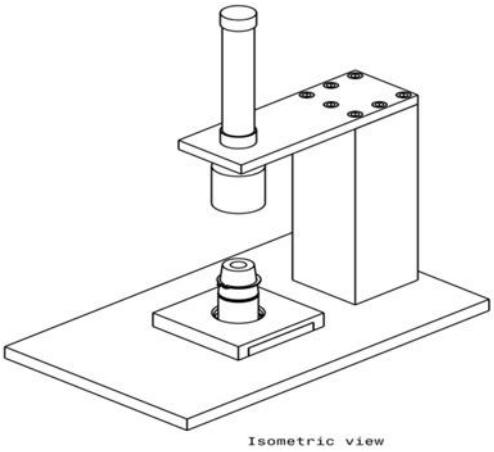


Fig. 2.CAD Design and actual image

ASSEMBLY: firstly we locate the c- channel over the base plate and according to c-channel base plate fixture assembled .And inside that fixture unloading mechanism is assembled with the smaller actuator having stroke length is 150. Which useful to unload the final job safely, after this assembly the grooved metal and plastic bush are placed over the unloading mechanism and on the that bush tapered circlip guiding bush is mounted which will guide the circlip to lock in side the grove of bush . and over the c- channel pressing bush is fixed with bigger actuator having stroke length is 180 . Which will press the circlip and circlip will expand because of tapered bush and at the end of the stroke circlip will fit inside the grove of bush and final job will unload by using unloading mechanism . And here we used a both hand safety operation which done by solenoid operated valve .

1.1 COMPONENT DESCRIPTION

In a CATIA software there are following part is to be drown as below This project is based on semi automation so we are designing and developing the machine. to developed that machine number of component as well as mechanism are designed . so such components are as follow :

- Base plate
- Base plate fixture
- Unloading fixture
- Bush fixture for metal
- Bush fixture for plastic
- Press bush
- Pneumatic actuator for press
- Pneumatic actuator for unloading fixture
- C channel
- Mounting plate
- M8 bolt
- M12 bolt
- Pneumatic circuit

So above 12 part is to be designed in CATIA V5 so this are the part design as shown in below.

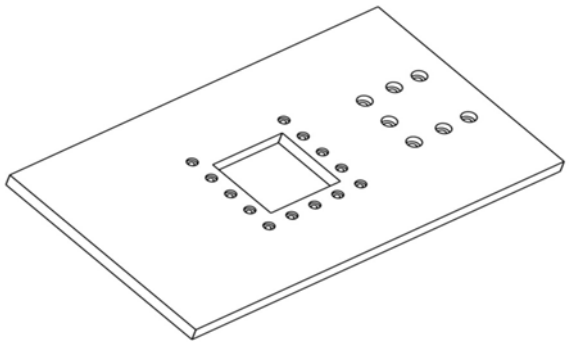


Fig.3 Base Plate

Base plate-

The above fig shows base plate which is 25mm thick material of this plate is MS .The C.S. area of the plate is the 530*320 for the machine . so the various component are connect to his base plate .purpose for selection of this plate is that .so rigid support is required for the other component

Base plate fixture –

The above fig show the base plate fixture this base plate fixture is 150*150 C.S. in this fixture there are middle centre cavity is pocketed .this base plate fixture is place on a base plate .there are a 13 hole are drill and M8 internal thread is created. Below this plate fixture unloading fixture is place. the main function is to perform this fixture is to provide the exact position to the work piece

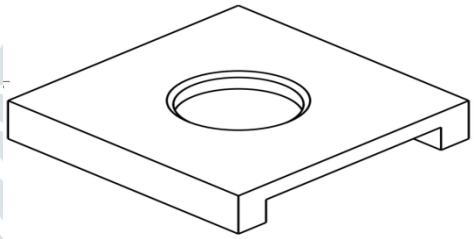


Fig.4 Base plate fixture

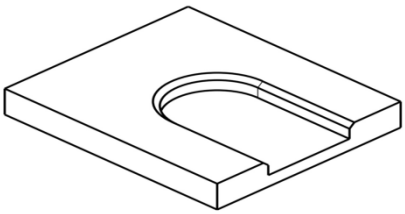


Fig 5.Unloading Slider

Unloading fixture –

Unloading fixture is placing below the plate fixture .the purpose of the unloading fixture is that; when complete operation will performed then remove the job from the plate fixture. This unloading fixture can performed the reciprocating moment by the pneumatic cylinder. The fig shows the unloading fixture.

Bush fixture for metal and Plastic –

The above fig shows the Bush fixture of the metal and plastic. So the purpose of metal and plastic bush fixture is that to placing locking pin over the this fixture . then this fixture is placing over the bush . this bush provide the 82’ angle to this tapered section

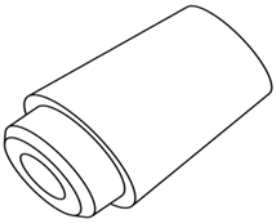


Fig.6 Bush fixture

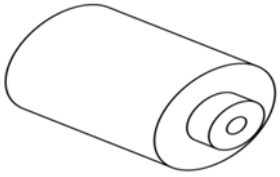


Fig.7 Press bush

Press bush-

The above fig shows the press bush .this part is connect to the pneumatic actuator. This punch is used to placing the locking pin in the grove this press is common to both metal and plastic .

C Channel –

The above fig shows the C channel this channel is connect to the base plate .this is the rigid member . the material of this channel ia M.S. 189mm height and in this c channel there are 7 Drill are created . from upward and downward direction . over this c channel there are mounting plate are place .

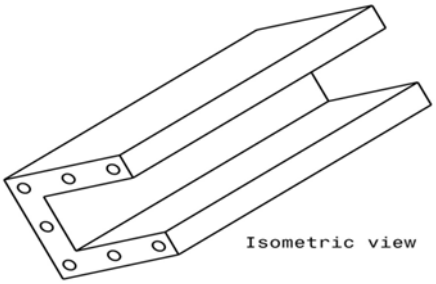


Fig.8.-c-channel

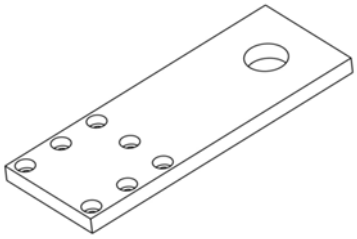


Fig.9 Mounting Plate

Mounting plate-

The above fig show the mounting plate .this plate which is place over the c channel and the cylinder are place over this mounting plate .length of this mounting plate is too small ;because overcome the back pressure of cylinder .

IV. Design For Manufacturing and Assembly Approach-

This concept reveals the fact that design department should work in co-ordination with production department resulting in economic production processes with saving in time and labor enhancing product quality. It can also be simply stated as design for a product with manufacturing and assembly in mind.

-The design should be done in least time with minimum cost of development.

-Smoothen the phases of transition from design to manufacturing and assembly.

-This helps to meet customer demand and achieve competitive position in market.

The design was done with minimum or literally no modifications during design and manufacturing. Thedesign was optimized using CATIA software and its compatibility was also confirmed.

a)Designs For Assembly

Significant cost of manufacturing is decided at the design stage of assembly. The parts in the assembly were actually questioned and challenged for its being in the assembly. The level of accuracy, the shape and size of the components were in question.

b)Design For Manufacturing

It is having a manufacturing approach while designing. The designers tried to minimize total number of parts for simplification and cost reduction.

Again some contradictions can be seen in DFM. Parts design to be multi-functional, modularity in design, minimizing part variation. Since being a SPM one could not enforce modularity or variations in parts design, because these machines are specially meant for a purpose. They are designed for a particular method or process of manufacturing.

V. Design calculation.

Circlip applications, although diverse, can be analysed with a straight forward set of design calculations. There are three main areas that should be considered in most applications.

a) Material Selection
b) Load Capacity
c) Installation Stress

a)Material selection

Standard material of a circlip is Carbon spring steel .Standard finish –phosphate & oil so hardness of circlip is 445 HRC [8] so material of bush fixture and the press bush is harden than the circlip. So selection of material is that EN353 for bush fixture as well as press bush.

b) Load Capacity

Understanding the load capacity of a Circlip assembly requires calculations for both ring shear and groove deformation, with the design limitation being the lesser of the two. The load capacity formulas do not take into account any dynamic or eccentric loading. If this type of loading exists, the proper safety factor should be applied and product testing conducted. In addition, the groove geometry and edge margin (i.e., the distance of the groove from the end of the shaft or housing) should be considered. When abusive operating conditions exist, true ring performance is best determined thorough actual testing.

RING SHEAR-Although not commonly associated as a typical failure of Smalley Retaining Rings, ring shear can be a design limitation when hardened steel is used as a groove material. Ring thrust load capacities based on ring shear are provided within

this catalog's tables of standard rings. These values are based on a shear strength of carbon steel with the recommended safety factor of 3.

Formulae.

$P_R = \frac{D\ T\ S\ \pi}{K}$ Shear strength of circlip material = 200000 psi

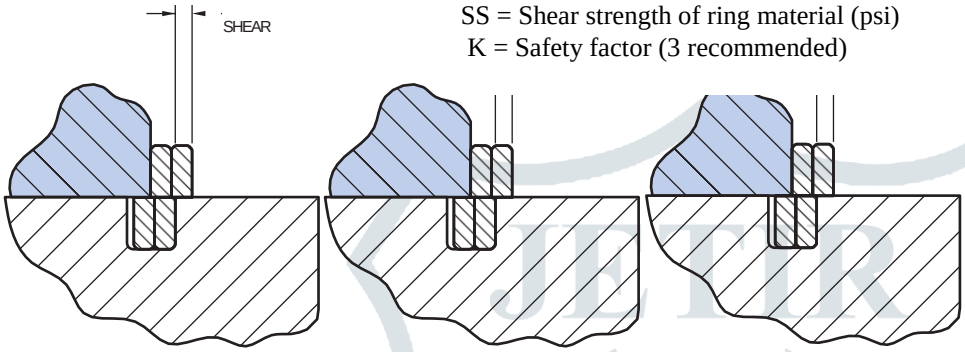
Safety factor = 3

The thrust load based on ring shear above, must be compared to the thrust load based on groove deformation to determine which the limiting factor is in the design .

$P_R = \frac{1.9685\ (0.0590551)\ 200000(\pi)}{3}$

`P_R=24347.3356 lb.

Where:
PR = Allowable thrust load based on ring shear (lb)
D = Shaft or housing diameter (in)
T = Ring thickness (in)
SS = Shear strength of ring material (psi)
K = Safety factor (3 recommended)



GROOVE DE FORMATION (YIELD)-Groove deformation is by far the most common design limitation of Circlip. As permanent groove deformation occurs, the ring begins to twist. As the angle of twist increases, the ring begins to enlarge in diameter. Ultimately, the Circlip becomes dished and extrudes (rolls) out of the groove. As a conservative interpretation, the following equation calculates the point of initial groove deformation. This does not constitute failure which occurs at a much higher value. A safety factor of 2 is suggested. Circlip thrust load capabilities based on groove deformation are provided within this catalog's tables of standard circlip

Formula -

$P_G = \frac{D\ dSy\pi}{K}$

Where,
PG = Allowable thrust load based on groove deformation (lb)
D = Shaft or housing diameter (in)
d = Groove depth (in)
Sy = Yield strength of groove material (psi),
K = Safety factor (2 recommended)

Yield strength of groove material=71100psi
Safety factor (2 recommended)

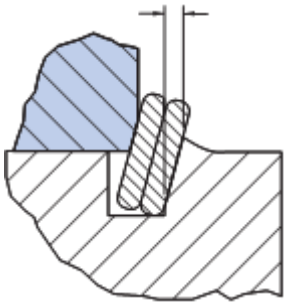


Fig.10PERMANENT GROOVE

$P_{G=} \frac{1.9685\ (0.051)\ 45{,}000\ (\pi)}{2}$

$P_{G=}$11212.3093 lb

Since ring shear was calculated at 24347lb, the groove yields before the Circlip shears. Therefore 11212lb is the load capacity of the Circlip.

C) Stress Analysis

The equations provided are used to check that the elastic stress limit of the ring material is not exceeded by stress due to installation. Standard parts that are assembled manually in the recommended shaft/bore and groove diameters do not require stress analysis. Special rings, or rings being assembled with special tooling, require stress analysis.

To select a safe stress value, it is necessary to estimate the elastic limit of the raw material. The minimum tensile strength, as shown in the materials table of the catalog, can be used as a suitable estimate. As with any theoretical calculation, a closer analysis of the actual application may reveal that these stress values can be exceeded. However, particular consideration must be made to functional characteristics such as installation method, the number of times the ring will be installed and removed, thrust load and/or centrifugal capacity.

After forming, the ring's natural tendency is to return to its original state. This places the inner edge of the radial wall in residual tension and the outer edge in residual compression. To account for the residual stress in the ring when expansion is taking place, only 80% of the minimum tensile strength should be used to compare to the installation stress;.
In special designs, where the installation stress exceeds the material's elastic limit, rings can be produced to diameters which will yield a predetermined amount during assembly. Once installed, the ring will have the proper cling (grip) on the groove.

Where:
S_E = Stress due to expansion (psi)
E = Modulus of elasticity (psi)
b = Radial wall (in)
D_S = Shaft diameter (in)
D_H = Housing diameter (in)
D_I = Free inside diameter, minimum (in)
D_O = Free outside diameter, maximum (in)

Formulae-

(WS-50-S02)

$$S_e = \frac{E\ b\ (Do-D_s)}{(D_S + b)(D_s + b)}$$

FORMULA:

For

$$S_E = \frac{E\ b\ (D-D_S)_I}{(D_I + b)(D_S + b)}$$

For internal

$$S_C = \frac{E\ b\ (D-D_O)_H}{(D_O - b)(D_H - b)}$$

FORMULA:

For

$$S_E = \frac{E\ b\ (D-D_S)_I}{(D_I + b)(D_S + b)}$$

For internal

$$S_C = \frac{E\ b\ (D-D_O)_H}{(D_O - b)(D_H - b)}$$

Se = 20,000,000 (.075) (0.5000-0.485)

(.485 + .075)(.5000 + .075)

Minimum tensile strength of the ring material: psi. 80%, of 92100 psi = 69875.7764 psi.

69875.7764 psi.<92100 psi

Since the installation stress is less than 80% of the minimum tensile strength, permanent set is not expected.

Results

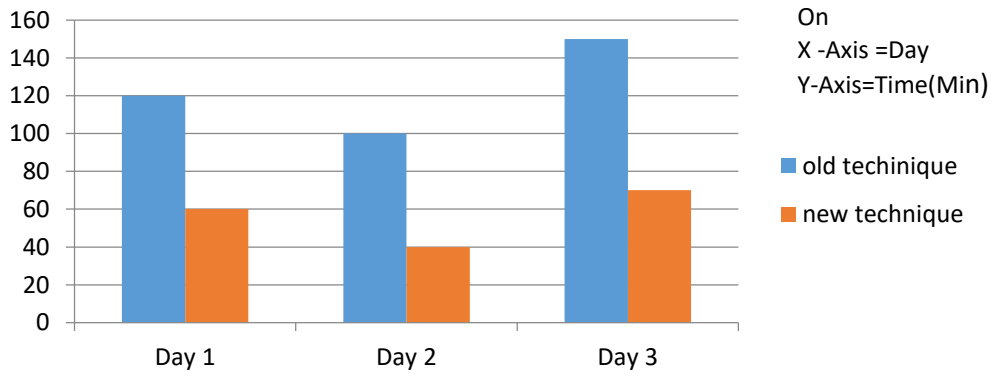


Fig.11 Result Comparison

The above chart shows the Time--Day. So time required for the new technique is very low so as par result there will be the 60% time saved by using new technique

Future Scope

This machine can be improved in future by using different housing structures which can beAccommodated on the machine bed, making setup changes as per requirement of the component with certain adjustments. This machine can also be used for other components of similar types provided the bush Diameter remains same. In future to cover all components of the part family flexibility can be achieved by replacing the fixture. So by this arrangement the Semi-Automated machine can be used for variety of components of same kind.

Conclusion

In this paper, an attempt has been made to present the implementation process of productivity improvement strategies in a small company. To conclude for such a work which is responsible to teach and allow exploring the understanding of engineering hands on, is an altogether a different experience. The project of making a SPM for a component with dimensions that were not a part of routine manufacturing was no less than a challenge. Some of the points, which can be summarized as a conclusion, are:

- The operator fatigue is drastically reduced
- The cost rejection was reduced
- Cycle Time saved with respect to Conventional set up by 60%
- Component accuracy maintained with quality
- Customer satisfaction and target achieved

Acknowledgement

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