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Rolling of Hose-Clamp Strip

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ABSTRACT:

In this modern age of competition, manufacturing sector is no exemption. With increasing customer demands the precision and accuracy required in the manufacturing of component is very high. In order to have mass production and high productivity of any component the availability of an SPM (Special Purpose Machine) is a must. The hose-clamp finds various applications in moderate pressure devices like the automotive pipes, LPG pipes etc. This paper deals with bringing in simple but effective machine to roll the hose clamp into its circular form and to enhance the quality and quantity of production.

Keywords — SPM, Hose-Clamp, Productivity.

I. INTRODUCTION

First invented by ex-Royal Commander, Lumley Robinson in 1921, the hose-clamp is an important fitting device. The basic manufacturing process of the hose-clamp consists of three parts :

1. Thread-cutting
2. Rolling
3. Assembly

This paper deals with the rolling operation of the manufacturing process.

II. SCREW/WORM CLAMPS

Screw clamps consist of a galvanized or stainless steel band into which a screw thread pattern has been cut or pressed. One end of the band contains a captive screw. The clamp is put around the hose or tube to be connected, with the loose end being fed into a narrow space between the band and the captive screw. When the screw is turned, it acts as a worm drive pulling the threads of the band, causing the band to tighten around the hose (or when screwed the opposite direction, to loosen).

III. USES AND APPLICATIONS

Hose clamps are typically limited to moderate pressures, such as those found in automotive and

home applications. At high pressures, especially with large hose sizes, the clamp would have to be

unwieldy to be able to withstand the forces expanding it without allowing the hose to slide off the barb or a leak to form. Hose clamps are frequently used for things other than their intended use, and are often used as a more permanent version of duct tape wherever a tightening band around something would be useful. The screw band type in particular is very strong, and is used for non-plumbing purposes far more than the other types. These clamps can be found doing everything from mounting signs to holding together emergency (or otherwise) home repairs. Some things seen assembled with hose clamps include the tail boom on a GMP Cricket model helicopter, a homemade gas scooter, makeshift pipe hangers, mounts for rooftop TV and shortwave antennas, and virtually every imaginable automobile body component.

IV. MANUFACTURING PROCESS

The process consists of three parts :

a. Thread-cutting
b. Rolling
c. Assembly

a. Thread-Cutting:

Threads are pressed on the clamp strip by making it pass through two rolls. This operation is similar to coining operation but the major difference is that coining is performed on a press whereas this thread cutting is done by using rollers.

b. Rolling:

The hose-clamp strip now has threads pressed on it and a head is mounted on one side. This strip needs to be rolled into its circular form. This is done by using an SPM in which the strip is clamped between two rollers and another third roller bends it to the required diameter.

c. Final Assembly:

In this step the components of the hose clamp, viz. strip, screw and covering, are hand assembled and kept on the cover plate for the permanent assembly. The head position is finalised by the worker. Then the Electro pneumatic circuit is actuated which punches dimples on the screw cover and holds it in a firm position. Then electric motor fastens the screw for certain revolutions and unfastens it for a few revolutions in order to remove the work piece. In this way the hose-clamp is assembled.

This gives a completely assembled hose-clamp.

In this paper we will focus on the second step of the manufacturing i.e. Rolling of the strip

V. CONSTRUCTION AND WORKING

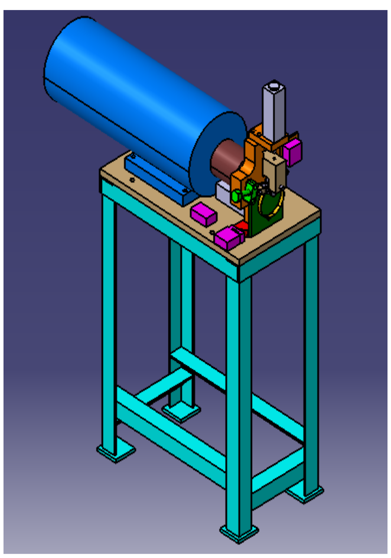


Fig. 1 Assembly of the machine

a. Construction:

1. It consists of three rollers, two of which help in holding the strip in place and the third is used for adjusting the clip diameter.
2. A pneumatic cylinder is used to clamp the strip.
3. A motor coupled with a gearbox i.e. a geared motor is used to drive the main shaft.
4. The geared motor is coupled to the shaft by using a chain coupling.
5. The position of the third roller is adjustable and can be adjusted by using a bolt and plate arrangement.
6. The motor used in the machine is powered electrically.
7. One pneumatic cylinder helps in clamping and the other in ejection of the part.
8. There are limit switches and triggers which help in automatic actuation of the cylinders.

This whole arrangement is placed on a robust and ergonomically designed stand.

b. Working:

1. The drive i.e. geared motor is switched on.
2. Then the strip is inserted between the two rollers such that the free end i.e. the end without the head is between the rollers.
3. The Electro-pneumatic circuit is then actuated and the clamping cylinder will hold the clip in position between the two rollers.
4. The drive shaft will then roll the strip into its circular form.
5. Then the head end of the strip will actuate a trigger which in turn will de-clamp the job.
6. Another pneumatic cylinder will also be actuated by the same trigger which will eject the job.

Thus, we will get a rolled hose clamp ready to be assembled.

VI. DESIGN

a. Diameter of Roller 1:

The diameter of roller 1 should be high so that the contact area increases but it should be less than the minimum diameter of the clip to be rolled. Minimum diameter of clip is 22mm which the size of clip when it is clamped. The open size of the clip will approximately be equal to 27 to 28 mm. Therefore diameter of roller 1 is 25mm.

b. Selection of position for Adjustable Bolt:

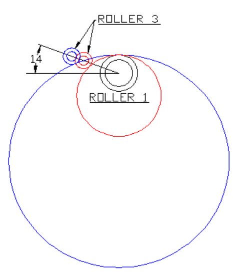


Fig 2. Basic Positioning of adjustable bolt

The position of the adjustable bolt is decided as follows:

1. First the position of the clip of minimum diameter and maximum diameter with respect to the roller 1 is decided.
2. Roller 3 is placed at both positions of clip such that it is tangential to the clip.
3. A line passing through the centres of roller 1 and roller 3 at both positions is drawn.
4. The angle of this line with horizontal is approximated to 14 deg.

c. Calculation of bending force:

The present requirement of the machine is to roll a clip of thickness 0.96mm made of AISI 1028. But it is required that the machine should be able to roll clips of thickness 1.5mm made of SS316.

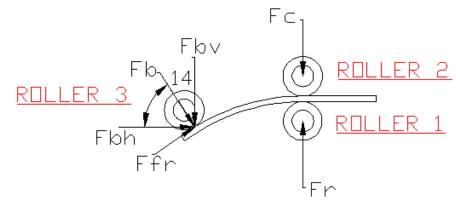


Fig 3. Force diagram for calculating bending force

By flexural formula,

$$\frac{M}{I} = \frac{\sigma_b}{y}$$

Now we want the component to bend i.e. we want yielding,
Therefore, considering $\sigma_b = S_{yt}$ (strip).
Material of clip = SS316
Maximum width, b = 12.8mm
Maximum thickness, d = 1.5mm
$\sigma_b = S_{yt}$=310 N/mm^2
Now,

$M = F_{bv} \times 24$

$I = \frac{bd^3}{12} = 3.6mm^4$

$\frac{M}{I} = \frac{\sigma_b}{y}$

$F_{bv} = 62\ N$

$F_b = \frac{F_{bv}}{\sin 14} = 256.28\ N$

$F_{bh} = F_b \times \cos 14 = 248.66\ N$

d. Calculation of clamping force:

Friction force, $F_{fr} = \mu_s \times F_b$
= 102.512 N

Where $\mu_s = static\ co-efficient\ of\ friction =$ 0.4

Now, the horizontal component of the friction force

$F_{frh} = F_{fr} \times \cos 76$

$F_{frh} = 24.799\ N$

Total horizontal resistance to overcome,

$F_h = F_{bh} + F_{frh}$
= 273.459 N

This force will be overcome by friction force (F_f) between the clip and roller 2.

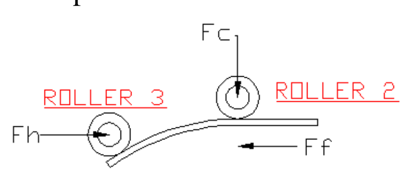


Fig 4. Force Diagram for Calculating Clamping Force

Now, $F_h = F_f$
Therefore, $F_f = 273.459N$
Also, $F_f = \mu_d \times F_c$
$F_c = 1093.839$ N
Clamping force = 1093.839 N

e. *Selection of Geared Motor:*

For calculation of speed required at roller 1:

Considering that 2000 parts are manufactured in 8 hrs.
Therefore,
1 part requires 14.4 seconds.

The circumference of the clip of maximum diameter clip is 267.0353 mm.

So, the velocity is 18.54 mm/s

$$v = \frac{\pi \times d \times N}{60}$$

N = 14.16 rpm ~ 20 rpm

Frictional torque, $T_1 = F_f \times r1$
Where r1 = radius or roller 1 = 12.5mm
T_1 = 3.418 Nm = 5 Nm

Now considering the shaft of roller 1,

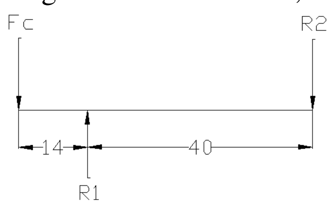


Fig 5. Loading diagram for shaft 1

$$R_1 - R_2 = F_c$$
$$R_1 \times 40 - R_2 \times 54 = 0$$

R_1 = 1476.68 N
R_2 = 382.84 N
For MS, $\mu_d = 0.57$.

$$F_{fr} = 0.57(R_1 + R_2)$$
$$= 1059.9264 \text{ N}$$

Frictional torque T_2 = 14.044 Nm ~ 20 Nm
Now,
Torque requirement at coupling = $T_1 + T_2$

T = 25 Nm

Considering service factor of 1.4,
Therefore T = 35 Nm

Frictional losses in gearbox are about 13 %.

$$P = \frac{1.13 \times 2 \times \pi \times N \times T}{60} = 82.79 \sim 85\ W$$

Motor efficiency = 0.7
Power = 130 W

Also considering an additional FOS of 5.

Power , P = 650 N

Selecting motor with power 0.75 kW at 20 rpm.

Therefore from the following table from the catalogue we selected

Table 1. Motor Specification Chart

MOTOR KW	OUTPUT SPEED RPM	TYPE		
		L = SERVICE FACTOR = 1	**M = SERVICE FACTOR = 1.4**	**H = SERVICE FACTOR = 1.65**
	8-10-12	1603D-D80L4	1803D-D80L4	1803D-D80L4
	15-18-20-25-30-33-40	1123D-D80L4	1323D-D80L4	1323D-D80L4
1	43-48-50-52-60-63-70	1003D-D80L4	1123D-D80L4	1123D-D80L4
	80-90-100-125-150-180-200-250	1002D-D80L4	1002D-D80L4	1002D-D80L4
	300-350-400-520	1002D-D80L2	1002D-D80L2	1002D-D80L2

So the motor selected from the given table is 1323D-D80L4

f. *Design of Pin for Roller 2:*

The load acting on the shaft of roller 2 is the clamping force and the weight of cylinder.

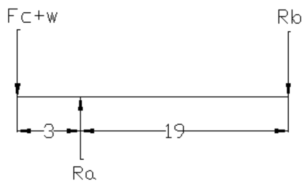


Fig 6. Loading diagram for roller pin 2

Total load acting on shaft = 1093.839 +15.3 = 1109.139 N

Ra and Rb are the reactions at the bearing.

$$R_a - R_b = F_c + w$$

$$(F_c + w) \times 3 = R_b \times 19$$

R_a=175.1272 N and R_b=1284.26N

Maximum bending moment , M = 3.3274 Nm

Also,

Torque, T = 3.418 Nm

For MS,

$S_{yt} = 240N/mm^2$

$S_{ut} = 440N/mm^2$

Considering FOS = 5

$$\tau_{per} = \frac{0.5 \times S_{yt}}{FOS}$$

= 17.1428 N/mm^2

Now, by maximum shear stress theory

$$\tau_{per} = \frac{16}{\pi \times d^3}\sqrt{M^2 + T^2}$$

d = 11.232 mm ~ 12mm

g. Design of shaft for roller 3:

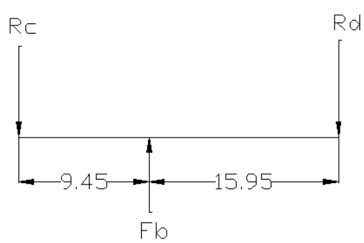


Fig. 7 Loading diagram for roller pin 3

This shaft is a simply supported beam between two supports having reactions Rc and Rd.

Also the only force acting on this shaft is the bending force F_b

$$R_c + R_d = F_b$$

$$F_b \times 9.45 - R_d \times 25.6 = 0$$

R_c = 161.676 N and R_d = 94.603 N

Maximum bending moment, M = 1.5278 Nm

Also,

Torque, T = 3.418 Nm

For MS,

$S_{yt} = 240N/mm^2$

$S_{ut} = 440N/mm^2$

Considering FOS = 5

$$\tau_{per} = \frac{0.5 \times S_{yt}}{FOS}$$

= 17.1428 N/mm^2

Now, by maximum shear stress theory

$$\tau_{per} = \frac{16}{\pi \times d^3}\sqrt{M^2 + T^2}$$

d = 10.36 mm ~ 12mm

h. Design of the Support for pneumatic cylinder:

Material : MS C35

S_{ut} = 440 N/mm^2 and S_{yt}= 280 N/mm^2

Now as per the specifications of the pneumatic cylinder used, the actuating force required is 362 N

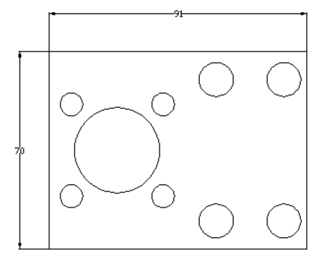


Fig. 8 Outline of the support for pneumatic cylinder

Minimum Area for the given force with FOS 3

$$\sigma_{ind} = \frac{Force}{Area}$$

$$= \frac{1100}{70 \times 91}$$

$$\sigma_{ind} = 0.1726\ N/mm^2$$

$$\sigma_{per} = \frac{280}{3} = 93.33N/mm^2$$

Now considering shear failure,

Shear Area = 70 × 20

= 1400 mm^2

$$\tau_{per} = \frac{Force}{Shear\ Area} = \frac{1100}{1400} = 0.785N/mm^2$$

$$\tau_{per} = \frac{S_{yt}}{2 \times FOS} = \frac{280}{2 \times 3} = 46.7N/mm^2$$

$$\tau_{per} << \tau_{ind}$$

Therefore, design is safe.

5.9 Selection of pneumatic cylinder:

Selecting two double acting cylinders for the operations of clamping and ejection respectively. Cylinders will be operating at a pressure of 4-5 bar. The selected cylinder is A23032050O from the Janatics catalogue.

VII. DESIGN VALIDATION

The critical parts of the machine are to be analysed using software simulation. We have taken help of the ANSYS software for the same.

The most critical part that needs to be analysed is the Drive Shaft. All the major operating forces are acted on this assembly. Therefore, we have simulated this assembly in ANSYS.

There are three loads acting on this assembly,

1. Two reaction forces, F_{r1} and F_{r2}, acting on the Punch end of the lever due to punching operation.
   From the design calculations, $F_{r1} = 1476.7\ N$ and $F_{r2} = 382.84\ N$
2. The Pneumatic force, F_c, exerted by the Pneumatic cylinder on the other end of shaft.
3. From the design calculations, $F_c = 1093.839\ N$.

The shaft is supported at one end.

The following results are plotted from the analysis.

1. The Total Deformation.
2. Induced Von Mises Stresses.

a. Loading:

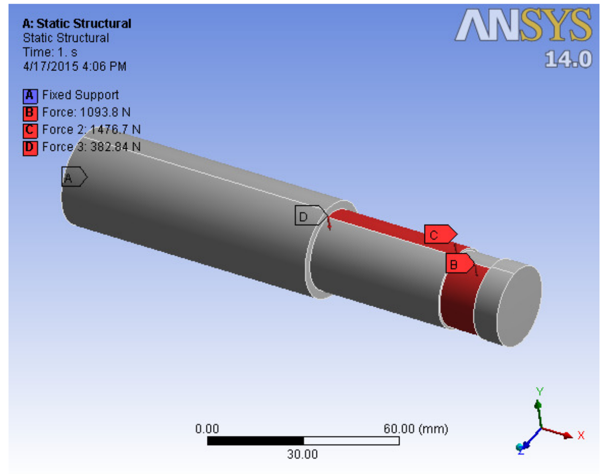


Fig 9. Loading diagram of drive shaft/shaft1

This drive shaft has three forces acting on it. For the analysis purpose from the above given figure point A is fixed in all directions reaction forces acted at point C in upward direction and point B and D in downward direction.

b. Total deformation:

After the simulation and evaluation of results the deformation after the actuation of the levers and the reaction forces we can see that the maximum deformation is at point C and its magnitude is 0.051224mm which is considerably low and can be neglected. And hence the design proves to be safe in deformation.

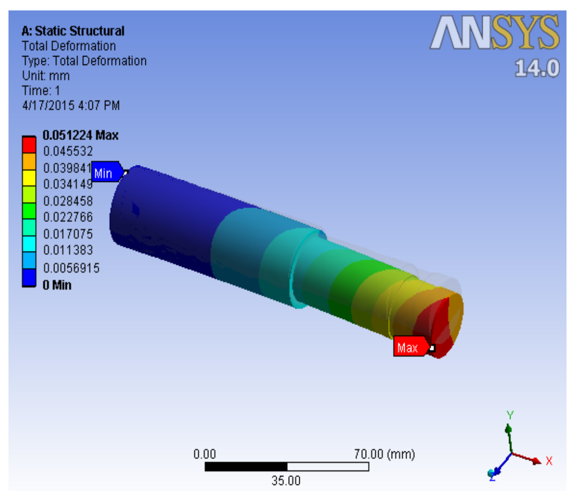


Fig 10. Total Deformation

c. ***Equivalent Stress:***

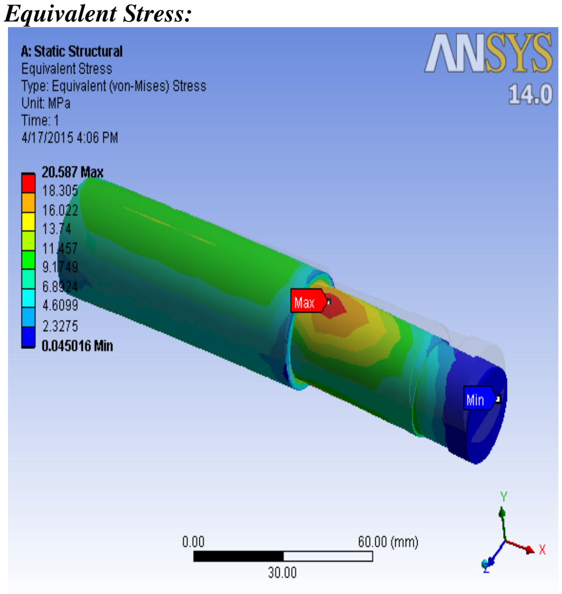


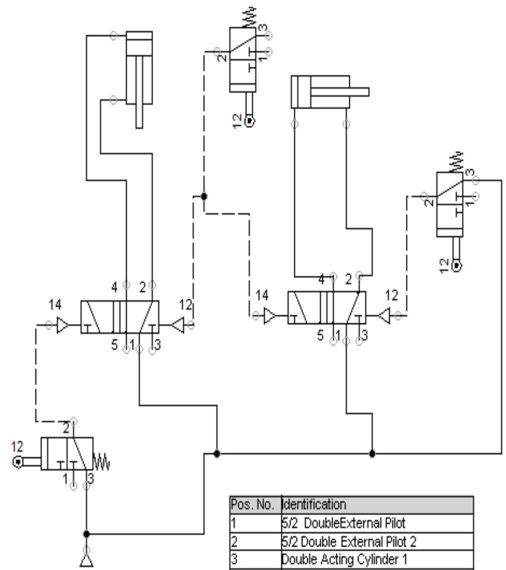
Fig 11. Equivalent Stress

Von-Mises Stresses follow the 'Distortion Energy Theory' of Failure which takes into account stress in all direction for equivalent stress determination. For the simulation we can deduce that the maximum stresses are near point D and have a magnitude of 20.587 N/mm^2 which are low as compared to the permissible stresses in Mild Steel, hence we can come to a conclusion that it is safe for stresses.

VIII. PNEUMATIC CIRCUIT

Pneumatic operations:

i. Start.
ii. Clamping cylinder extends.
iii. Clip head pushes the trigger which actuates 3/2 DCV and thus clamping cylinder retracts and ejection cylinder extends.
iv. The pusher plate touches the limit switch in the front which actuates next 3/2 DCV and the ejection cylinder retracts.
v. Stop.



Pos. No.	Identification
1	5/2 DoubleExternal Pilot
2	5/2 Double External Pilot 2
3	Double Acting Cylinder 1
4	Double Acting Cylinder 2
5	3/2 Roller operated spring return
6	3/2 Roller operated spring return 2
7	3/2 Roller operated spring return 3
8	Pressure point

Fig 12. Pneumatic Circuit Diagram

IX. CONCLUSION

The main aim of our project was to increase the productivity.

a. Earlier the time required to roll one clamp was 16 seconds and now we require 8 sec. Thus the production rates will be doubled.
b. This process saves handling time.
c. This process also gives fool-proofing of the jobs.
d. The previous methods in which clamps were rolled mechanically have been replaced by a better organized and sophisticated alternative.

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