Vol. XV & Issue No. 03 March - 2022
INDUSTRIAL ENGINEERING JOURNAL

DESIGN AND DEVELOPMENT OF PNEUMATIC GUN FOR FITTING OIL SEAL IN THE VTU ASSEMBLY OF TRACTOR

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Abstract:

Mechanization of agriculture equipment is an essential input in modern agriculture to enhances productivity with minimum human energy consumption and cost of cultivation. Increased production will require more use of agricultural inputs and protection of crops from various stresses. Tractors have traditionally been used on farms to mechanize several agricultural tasks. Modern tractors are used for ploughing, tilling and planting fields in addition to routine lawn care, landscape maintenance, moving or spreading fertilizer and clearing bushes. The vary touch unit (VTU) of tractor part which contains hydraulic oil due to which it holds the heavy weight of blades used to plough operation. The paper details the mechanization of fitting the oil seal in the VTU part. The fitting of oil seal in the tractor assembly was done manually due to which time consumption for fitting is more and most of the time the seal is damaged during fitting. Manual operation of fitting the oil seal in the plunger hole is overcome by designing the pneumatic gun to fit the oil seal with the help of adapter to increase the productivity and avoid the frequent damage of the oil seal.

Keywords: Pneumatic, Oil Seal, Assembly, Tractor, Fitting

1. INTRODUCTION

All tractors are equipped with hydraulic control system for operation. The hydraulic pump draws up oil from the oil reservoir and sends it to the control valve under high pressure from the control valve the oil goes to the hydraulic cylinder to operate the piston, which in turn, raises the lifting arms. The hydraulic pump is operated by suitable gears, connected with engine. The vary touch unit of tractor part which contains hydraulic oil due to which it holds the heavy weight of blades used to plough operation. The oil seal is fitted in the plunger hole of the vary touch unit assembly for efficient operation. The oil seal is meant to prevent the leakage of the oil from VTU casing consist of hydraulic system. The vary touch unit is used to lift plough from its furrow and to lower it for the next furrow with the forward movement of tractor. It also helps the rear portion of the tractor by lifting it to prevent from the coming obstruction [1-2]. The work of fitting oil seal was done manually due to which oil seal get damage during fitting with substantial effort on the part of the worker. The hydraulic set up is quite heavy and comparatively expensive [3]. Running and maintenance cost is high due to costly oil and time involvement in the operation. Development of pneumatic gun enhance the productivity and reduce the fitting time with less damage of the oil seal.

2 MECHANIZATION OF MAINTENANCE ACTIVITIES

Many researchers have suggested the recommendations for ergonomically design of pneumatic system involved in the maintenance activities. Some of techniques used for the fitting of oil seal and maintenance work to faced the today's challenges are recommended as follows.

Yang S., (2019) studied the sealing effect of a specific seal structure to formulate mathematical model. CFD model was established for analysis of the seal structure, effect of various parameters such pressure, temperature, clearance are evaluated.

Zhang F., (2019) details the effect of oil seal roughness on sealing performance of oil seals with the surface texture. Paper details the effect of oil film thickness, friction torque and pumping rate on the performance of oil seal.

Kumar C.P., Malavari. G.,(2019) Studied components, weight, volume, power supply, maintenance activity, time travel of the Electric Locomotive WAG-9 the new version of the electric locomotive at Kazipet Junction railway station is located in Warangal Urban district of Telangana.

Gopalan R.S.,Ravibabu. M., Sahu. S, (2020) studied how costing on Indian Railways can be more closely related which reducing reliance on arbitrarily calculated apportionment ratios. Analyses data at a more disaggregate level linking costs to performance of individual accounting units.

Cheng Xiang, (2020) studied the sealing performance of oil seal and micro pores texture in rotary shaft surface. The paper details the improvement in reliability and long life cycle of seal with geometry model of oil seal for fitting oil seal.

3. RECENT DEVELOPMENT IN OIL SEAL FITTING

Over the last decade, development of different methods overcomes the limitation of the manual method of fitting the oil seal which was mostly adopted in the industry [4]. The breaking or damage of the oil seal is the disadvantages of the manual fitting oil seal. The recent techniques overcome the limitation faced by the industrial assembly person [5].

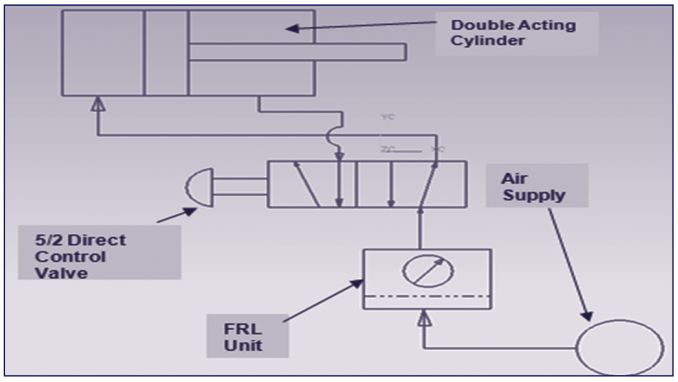
The recent method of fitting the oil seal are listed as follows as.

1. Motorcycle Engine: Method is mostly employed for two wheeler where low pressure is required for fitting oil seal. The oil seal is fitted with the screw type mechanism in which oil seal is pressed with the pressure of screw operated with hand.
2. Heavy duty Engine: Method is used for fitting oil seal in the heavy machinery or heavy duty trucks in which oil seal is fitted with the tools like spanners through which large pressure can be implemented.
3. Production Level: Method is used in the industry on production line during assembly of different components with the actuators by generating sufficient torque. The used of actuators make the method fast and precise.
4. Rack and Pinion Press: It consist of linear actuator attached to the ram through gear pair to convert rotary motion into linear motion. Presses (RAM) are operated with rack and pinion arrangement and applied manual force to apply to fit.
5. Pneumatic Press: Compressed air is used to force in linear direction to develop power to fit the oil seal.
6. Hydraulic Press: Pumps and valves are used to transfer fluid pressure in a particular chamber to apply the powerful presses to fit the oil seal.

4. PNEUMATIC SYSTEM

The technology of pneumatics deals with the study of the behavior and application of the compressed air.

Figure 1: Circuit of pneumatic gun assembly



The figure 1 shows the basic circuit to enlighten the working of the pneumatic gun. It consist of compressor through which the compressed air is passed to the FRL unit for filtration, regulation and lubrication [6]. Regulation of air is then passed through the 5/2 direct control valve to control the flow of air in the double acting cylinder. During off condition button is not pressed. The air is passed through the valve after pressing the trigger accordingly activate the back end of the cylinder as result the piston is in the forward direction. When left valve is actuated the air is directed in the other side of the cylinder results the piston gives a backward stroke [7].

5. DESIGN OF PNEUMATIC GUN

Pneumatic system is used for fitting the oil seal in the plunger hole of the vary touch unit. The development of the pneumatic gun is done by designing the each component involved in the assembling of pneumatic gun.

5.1 Selection of Pneumatic cylinder: The selection of the pneumatic cylinder is done using the force requirement for fitting the oil seal with the help of adapter in the plunger hole. Force calculation is done with reference to the recent force applied by the assembly operator by hammer and stroke applied to fir the oil seal. The hammer used to fit the oil seal is of 2 Kg with some amount of efforts for fitting.

R_1=Inside radius of oil seal

R_1= 14.0125 mm

R_3= Minimum radius of the plunger hole

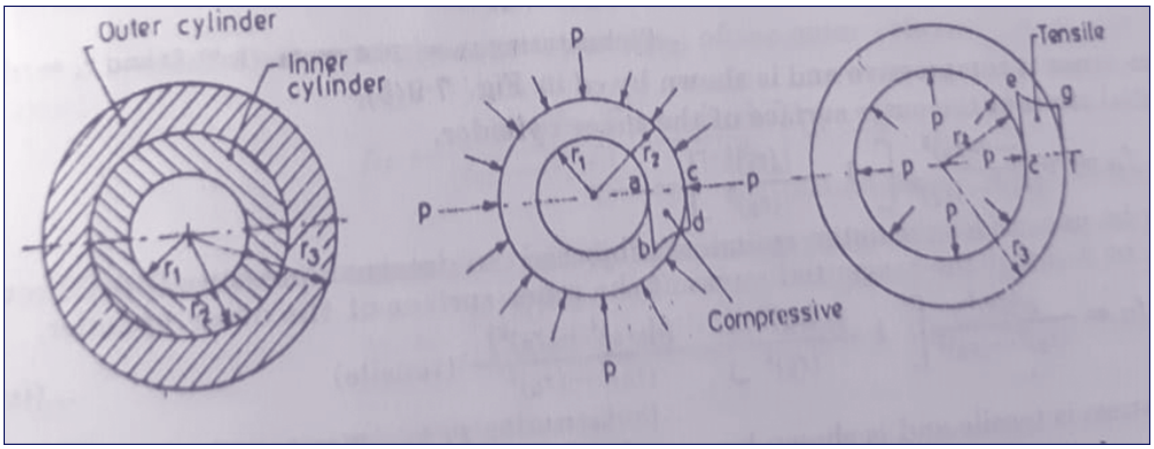
R_3 =14.3058 mm

R_2= Maximum radius of oil seal

R_2 = 14.3835 mm

Contact pressure is developed at the junction of the plunger hole and oil seal, which induced compressive tangential stress of the oil seal and tensile tangential stress in the plunger hole, considering the theory of thick cylinder shell used to fit the oil seal. Calculation of contact pressure is design with great care because of damage of oil seal such as breaking of oil seal, cutting of inner shell [8-9]. The analysis of deformation induced during fitting of oil seal in term of contact pressure as shown in figure 2.

Figure 2: Cross section of plunger hole and oil seal

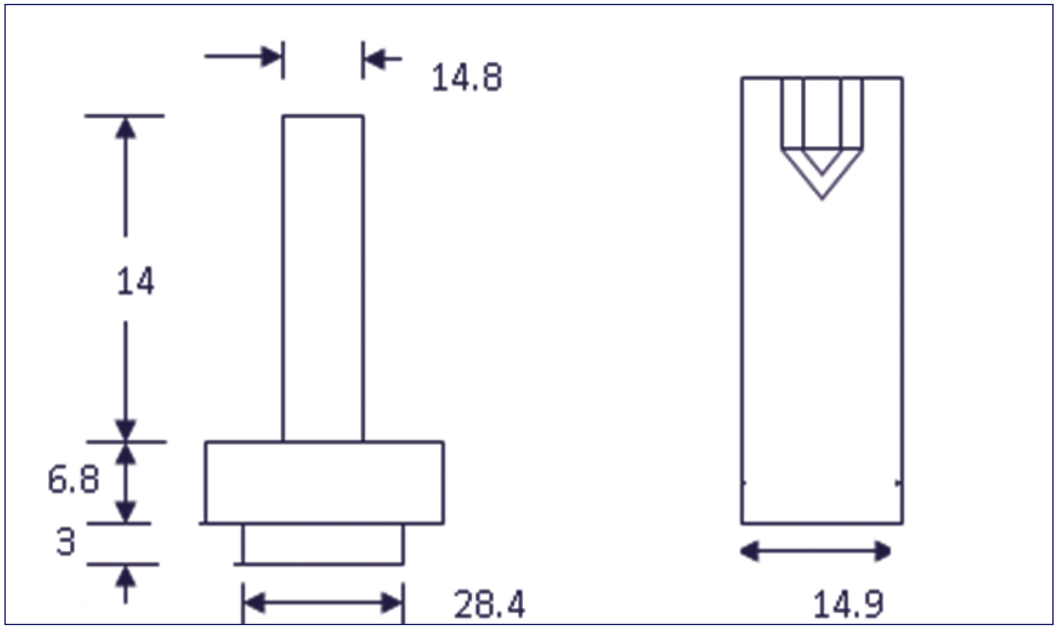


$$\delta = \frac{(R_2 \times Pc \times R_3^2) + R_2^2}{(E_0 \times R_3^2) + R_2^2} + \mu_0 + \frac{R_2 \times Pc \times R_2^2 + R_1^2}{E_i \times R_2^2 - R_1^2} - \mu_i$$

Young's modulus For the plunger hole, E=100x103 N/mm2
Young's modulus for the plunger hole, E=100x10^3 N/mm^2
Poisson ratio of the oil seal, μ_i = 0.292
Young's modulus for the oil seal,E_i = 200x10^3 N/mm^2
Deflection δ = Maximum Radius of oil seal-minimum radius of plunger hole
= 0.0792mm
Contact pressure between plunger hole and oil seal, Pc =0.6837 N/mm^2
Pressure = Force / Area
Surface area of cylinder = P x D x *l*
Therefore, Force required for fitting the oil seal
F= P_c x Π x D x *l* x μ
Where μ = 0.2 (Friction Factor)
F = 99.90N
To be on the safer side, we doubled the force therefore the required force is F=200N
With the help of force calculated diameter of cylinder,
F= A X P,
D = 25 mm.

The minimum available stroke of the cylinder is 25mm, 25 x 25 size cylinder and 5/2 directional valve.

Figure 3: Adapter required for fitting the oil seal (Dimensions are in mm)



5.2 Deign of Adapter: Adapter is a part on which oil seal is placed for fitting it into the plunger hole as shown in Figure 3. While designing the adapter the two things are

1. Inner diameter and length of plunger hole.
2. Inner diameter of oil seal

5.3 Design of Pin: Pin is the most important element of pneumatic gun. It is that part which is going to give reaction to cylinder during the backward motion of piston. Failure of pin can occur either by bending or by shear [10-11]. Bending is avoided by keeping vary less clearance between the outer diameter of adapter and inner diameter of plunger hole. Shear on the pin is not the single shear, it the double shear.
Shear Stress for M.S. = 15 Kg / mm^2.
Assuming the diameter of pin to be 3 mm

$$\text{Area} = \frac{\Pi}{4 \times d^2} = \frac{\Pi}{4 \times (3)^2} = 7.065 mm^2$$

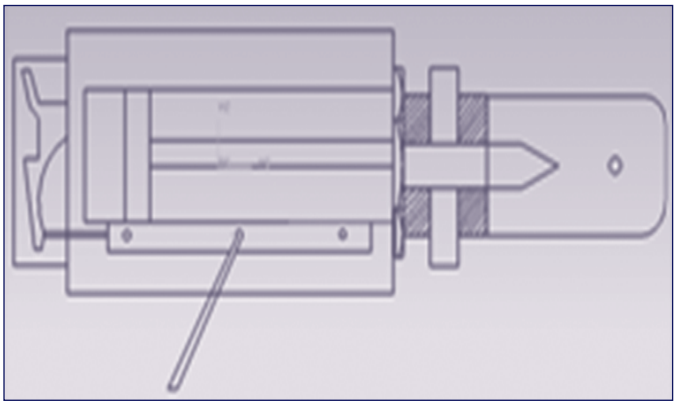
Maximum shear force =P x A
=105.98 kg

As actual force<Maximum shear force
Since design is safe, diameter of pin finalized to be 3 mm.

6. TESTING

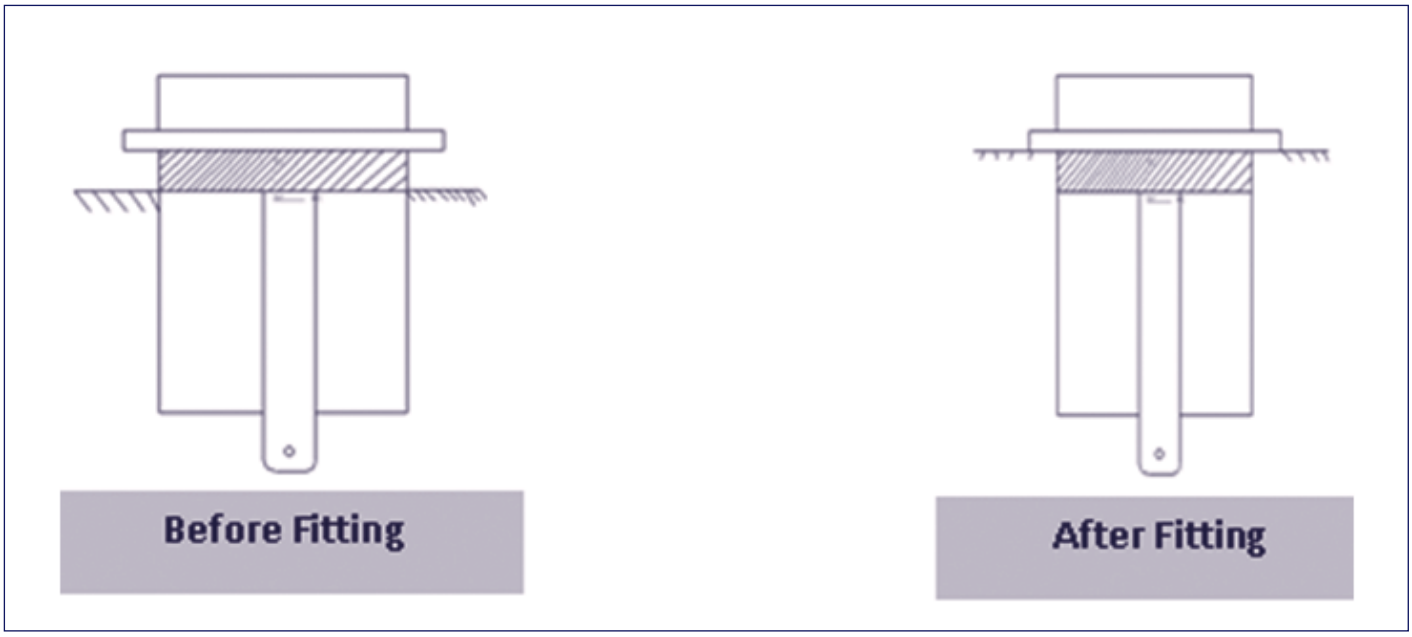
Back thrust was experienced while operating, when the piston is in the forward stroke as shown in figure 4 of Pneumatic Gun Assembly.

Figure 4: Line diagram of pneumatic gun assembly



Back thrust is prevented by pin arrangement. Pin overcome the back thrust and restrict the motion of the piston while operating the cylinder in the forward stroke. The system is placed over the plunger hole of the VTU for fitting the oil seal. The extension of piston rod is passed through the hole and the pin inserted into it through a small hole present at the other end of the plunger hole. The pin has a small clearance with respect to the hole size which is prevent the failure of the pin. The adapter on the cylinder help to fixed the oil seal in the hole and maintains the alignment with the hole. The hole is of size 28.61 mm and the seal is of size28.68 mm which shows the interference fit. Figure 5 shows the assembly of oil seal during operation of fitting.

Figure 5: Adapter with oil seal before fitting and after fitting



RESULT AND DISCUSSION

The efforts required for fitting the oil seal in the VTU part of assembly of tractor is almost reduce with the design of the pneumatic gun. The pneumatic gun is used for the fitting the other oil seal in the tractor assembly. The time requirement and human energy consumption are almost reduced. The compressed air is passed into pneumatic cylinder by pressing the trigger piston operate in the forward direction which move the adapter and oil seal is fitted into the plunger hole. This movement of the cylinder gives the pressing action and the seal gets fitted into the hole. The back thrust is almost zero and minimum effort is required on part of the worker. On releasing the trigger the air enters the second size of the cylinder and piston moves forward stroke of the piston .The pin is removed from the adapter and the system is removed.

CONCLUSION

The back thrust is almost zero and minimum effort is required on the part of the worker. On releasing the trigger the air enters the second size of the cylinder and piston moves forward stroke of the piston .The pin is removed from the adapter and the system is removed. The method employed for fitting the oil seal in the VTU part of tractor assembly prevents the frequent damage of the oil seal. Assembly time is improved as the process is mechanized. The method is efficient for multiple activities with minor modification in the pneumatic gun. The recent method is beneficial due to utilization of a pneumatic gun in multipurpose with no back thrust, easy for assembly and disassembly and aesthetic in appearance.

BIBLIOGRAPHY

[1] Ayoub, M.M., Smith, J.L., Selan, J.L., Chen, H.C., Lee, Y.H., Kim, H.K., and Fernandez, J.E.,"Manual materials handling in unusual postures. Technical Report", Department of Industrial Engineering, Texas Tech University, Lubbock, TX, 1987.

[2] Barnes, R.M., "Motion and Time study Design and Measurement of work John wiley & Sons,"1980.

[3] Belkhode, P.N.,"Mathematical Modelling Maintenance Activity to Minimize Overhauling Time and Human Energy Consumption", Series C Springer Publication: 2017,1-9.

[4] Mittal, A., Nicholson, and M. M. Ayoub.."A guide to Manual Material Handling", 2nd Edition: Taylor and Francis,1997.

[5] Belkhode P.N., Borkar K., "Optimization of Models of Liner Piston Maintenance Activity of Loco Shed", International Journal of Applied Engineering and Technology Vol. 6 (1), 2016.

[6] Yang., "Numerical and Experimental Investigation of the Sealing Effect of a specific seal structure", Mathematical Problems in Engineering" Hindawi, 2019.

[7] Lohkane M, "Oil Seal : Installation Techniques and Preventive Measures to avoid Leakage", IJIRT, 3(9), 2017, 101-104.

[8] Muzakkir S. M., "Design of Mechanical Oil Seals and Gasket", International Journal of Applied Engineering Research, 10(12), 2015.

[9] Zhang Fuying, "Effect of Roughness on Sealing Performance of Oil Seals with Surface texture , Industrial Lubrication and Tribology, 2019.

[10] Belkhode P. N., Sakhale C., Bejalwar A., "Evaluation of the experimental data to determine the performance of a solar chimney power plant", Materials Today: Proceedings 27, 102-106

[11] Cheng Xiang, "Studied the sealing performance of oil seal and micro pores texture in rotary shaft surface", MATEC Web of Conference, 2020.

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