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Concept Design and Analysis of Low Cost O-Ring Assembly Machine for Adjustable Ball Race Assembly

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Abstract*- This paper deals with the design of low cost O-ring assembly machine for adjustable ball race assembly. The O-ring sub-assembly is used in TAFE (Tractor and Forming Equipment) steering assembly unit. The adjustable ball race contains the O-ring which avoids the leakage of grease applied on the ball race. The main problem was absence of O-ring in the ABR assembly. This is because of the human errors in assembling the O-ring and adjustable ball race. There was no mechanism or the sensors to ensure the presence of O-ring in the assembly. To eliminate the manual error of workers O-ring assembly machine was designed. This paper consists of design, analysis of the O-ring assembly machine.

***Keywords*- ABR (Adjustable ball race), O-ring assembly machine**

I. INRODUCTION

In a tractor steering gear box assembly the ABR plays a major role, it acts as bearing support member. This supports the roller balls and acts as a supporting roller to the rocker shaft. The ABR helps transfer the torque from the steering wheel to the rocker shaft and worm and nut. This assembly connects to the drop arms and the tie rod assembly. The ABR assembly consists of an O ring, these acts as a leak proof agent which avoids the grease leaking in the roller balls. To avoid the grease coming out of the assembly the o-ring is provided with the adjustable ball race.

II. OBJECTIVE OF O-RING ASSEMBLY MACHINE

The prime purpose of the project is to design and analyze the O ring assembly machine, for the purpose of TAFE steering assembly operations to increase productivity and to decrease the manual error in final assembly process.

The design requirement is to perform the adjustable ball race assembly operations automatically & simultaneously to reduce human error in assembly process.

A. *Problem statement:*
Grease leakage through Adjustable Ball Race, which cause the grease leakage due to O ring absence. This is because of Manual error of the worker and there is no mechanism or the system to ensure the O-ring presence in the assembly.

B. *Developing the ABR O-ring assembly machine as a Permanent solution :*
If a ABR joint fails to perform its work correctly, the results can be dangerous as the wheel's angle will be at unconstrained/uncontrolled position and torque will not transfer correctly to the tyre and it will be at an unintended angle. To avoid these problems we designed the O ring assembly machine which helps to avoid the human errors.

III. CONCEPT DEVELOPMENT

A. *Concept Generation*

Concept 1*: Power transfer through the rack, pinion and pawl mechanism:*

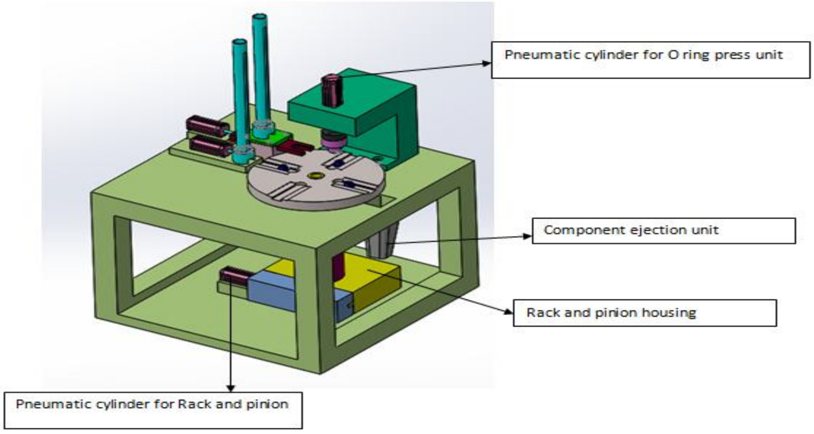

Fig. 1 Rack and pinion with pawl mechanism (concept 1)

The first concept developed for O-ring assembly machine is shown in fig 1, and the dispenser unit consists of component stock bar, O ring stock rack and dispenser supporting unit. Each unit consists of separate pneumatic cylinders. This component dispenser unit pushes the component into the slot of the rotary table.

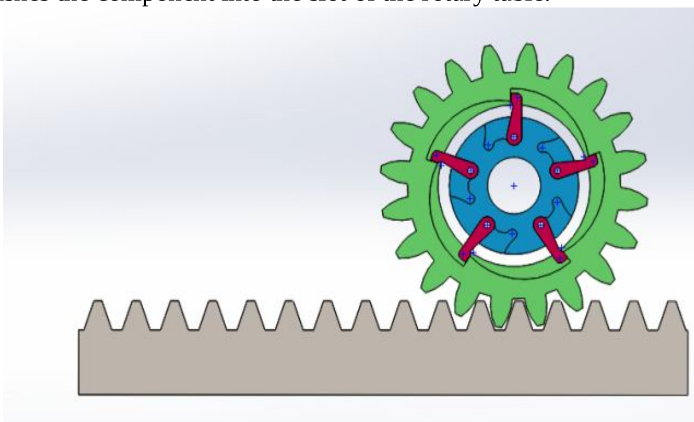

Fig. 2 Power transfer unit (concept 1)

The power transfer unit (fig 2) is constructed with the rack, pinion and pawl mechanism used to give the motion to the rotary table. The pawl mechanism used to provide the stop at 90 degrees of interval. The leaf springs are provided opposite to the pawl pin, these springs will help the pawl to get back into the original position.

CONCEPT 2*: Free hub type power transfer unit:*

In this concept power transfer is made to the shaft through the rack and pawl mechanism. In this type of mechanism the pawl is directly in contact with the rack. This direct contact with the rack cannot provide the required accuracy to the table position, and the repeatability of the table will not be good as compared to the concept 1.

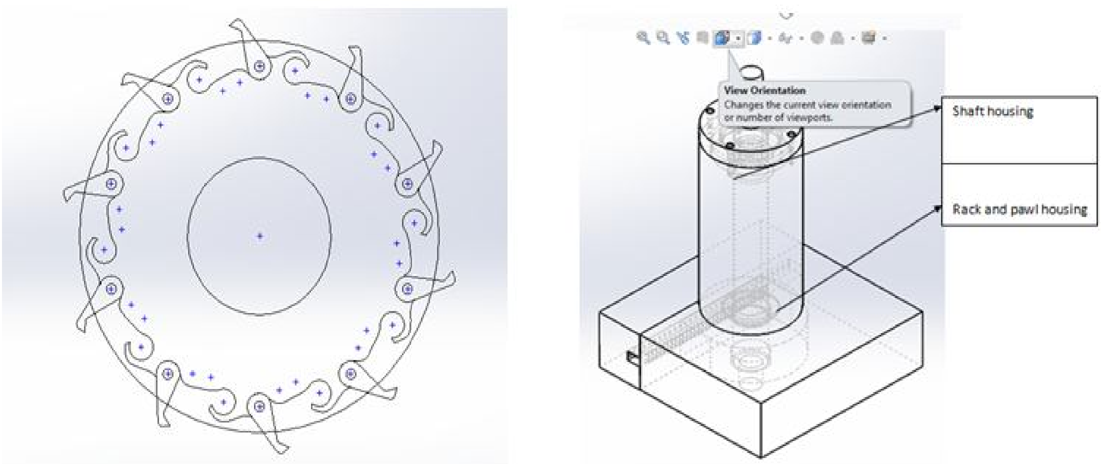

Fig. 3 Rack with pawl mechanism and shaft housing (concept 2)

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CONCEPT 3: *O- ring dispenser through the stepper motor:*

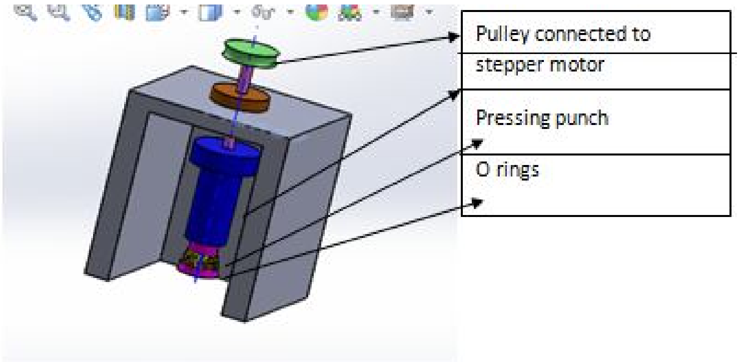


Fig. 4 O- ring dispenser unit through the stepper motor: (concept 3)

The concept 3 is designed with the O- ring dispenser in the press unit itself. In concept one and concept 2, the O ring dispenser is made with the extra unit to dispense the O ring. Here the O rings are inserted in between the component locator and the press punches.

CONCEPT 4*: O- ring dispenser through the gear controller:*

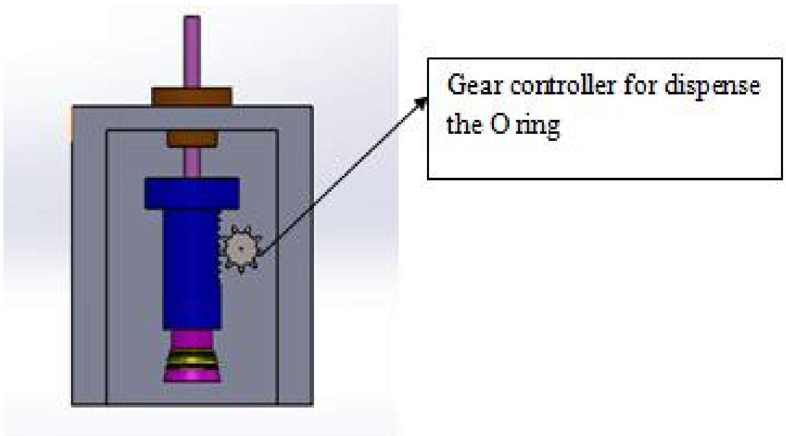


Fig. 5 O- ring dispenser unit through the gear control: (concept 4)

In concept 4, the gear controller is used to give the motion to the press punch. As the press punch moves downwards, it pushes the O ring down and the component locator comes in contact with the component and locates the component, then the press punch punches the O ring into the component grooved area.

B. Concept selection:

Table 1 – PUGH matrix selection criteria for the O ring assembly machine.

S.NO	SELECTION CRITERIA	CONCEPT 1	CONCEPT 2	CONCEPT 3	CONCEPT 4
1	Ease of manufacturing	**0**	+	-	-
2	Ease of operation	+	+	**0**	-
3	Power supply constraint	+	-	-	-
4	Cost	+	**0**	**0**	-
5	Time	**0**	**0**	+	**0**
6	Accuracy of table movement	+	-	+	+
7	Repeatability of table movement	+	-	+	+
8	Ease of handling/ human interference	+	+	-	**0**
9	Safety	+	+	-	+
10	Ease of maintenance	+	**0**	-	+
11	Mechanical efficiency	+	+	+	+
	Sum +‟s	**9**	**6**	**4**	**5**
	Sum 0‟s	**3**	**3**	**2**	**2**

Sum –"s	**0**	**3**	**6**	**5**
Net score	**9**	**3**	**-2**	**0**
Rank	**1**	**2**	**4**	**3**

Due to the accuracy, repeatability in the table movement and design simplicity, concept 1 is selected

IV. DESIGN OF O- RING ASSEMBLY MACHINE ELEMENTS:

A. Check for stress on rack and pinion:

Pinion material, Cast steel, 0.2% c, heat treated

σ_0=193.2 MN/M^2 , BHN =250..(Reference 10, T 12.7, Pg no 186)

σ_0=Allowable static stress

$\sigma_{perm\,=}$ permissible stress

Cv = velocity factor

$\sigma_{perm}= \sigma_0*C_v$

For ordinary gear running with pitch line velocity (v)< 8m/s

$Cv = \frac{3.05}{3.05+v}$..............................(Reference 10, EQ 12.19a, Pg no 164)

C_v =.086

$\sigma_{perm}= (\sigma_0*C_v)_{perm}$

= (193.2*0.86)

σ_{perm}= 166.152 N/mm^2

$\sigma_{induced}= (\sigma_0*C_v)_{induced}$

where, $\sigma_{induced}$= induced stress

b= face width of the gear

Y= form factor

P= pitch circle diameter

b= 9.5m≤ b≤12.5..(Reference 10,EQ 12.18, Pg no 164)

Therefore b= 9.5m

=9.5*8

= 76 mm

$Y = 0.154 – \frac{0.192}{Z}$...(Reference 10,EQ 12.17b, Pg no 163)

$= 0.154 - \frac{0.192}{20}$

Y = 0.15

p = circular pitch $= \frac{\pi d}{Z}$..(Reference 10,EQ 12.1, Pg no162)

$= \frac{\pi*160}{20}$

= 25.13 mm

$\sigma_{induced} = \frac{Ft}{bYp}$ ....(Reference 10,Eq no 12.15, Pg no 163)

$\sigma_{induced} = \frac{377}{(76*0.15*25.13)}$

$\sigma_{induced} = 1.31\ N/mm2$

Because of $(\sigma_0*C_v)_{induced} \leq (\sigma_0*C_v)_{allowable}$.................*The design is safe.*

B. Pawl pin:

All formulae below are taken from [Design data – PSG.................(Reference11, Pg no 785)

P= peripheral force

$Mb_{1=}$ bending moment of the pawl pin.

b= width of the pawl pin

x= thickness of the pawl pin

$Mb_1=P*e_1$

Where, P = 502.67 N, e_1 = 6.5 mm

Mb_1 = 502.67*6.5

= 3267.3 N-mm

$$\sigma = \frac{6*Mb1}{b*X^2} + \frac{P}{X*b}$$

$$= \frac{6*3267.3}{42*12.5^2} + \frac{502.67}{12.5*42}$$

$$=3.92 \text{ N/mm}^2$$

V. STATIC ANALYSIS OF RACK, PINION AND PAWL PIN:

A. Analysis of rack and pinion:

In the analysis of rack and pinion the force applied on the left side of the rack of 377N which is applied through the pneumatic cylinder.

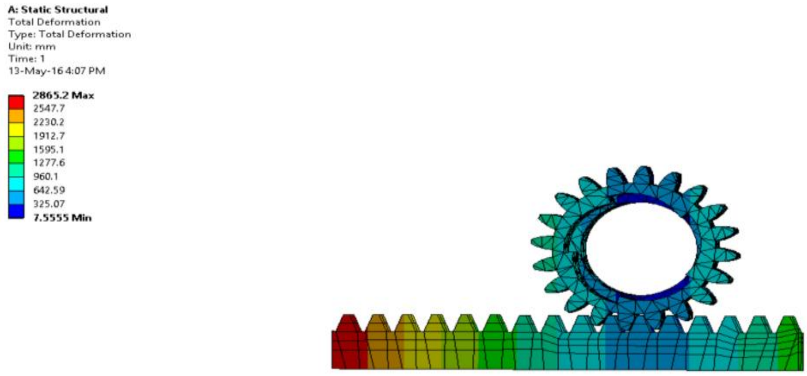


Fig. 6 Equivalent(Von-mises) stress rack and pinion.

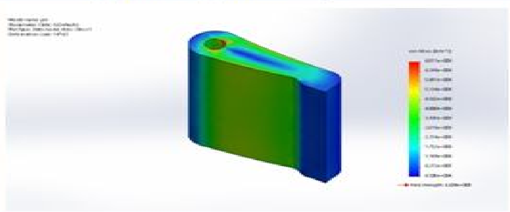
Table 2-Solution > Total Deformation

TIME [S]	MINIMUM [MM]	MAXIMUM [MM]
1.	0	0.000561436

By observing the solution table we can conclude that the deformation is within the permissible limit and hence the design is safe.

B. Analysis of pawl pin:

Name	Type	Min	Max
Stress1	VON: von Mises Stress	65078.2 N/m^2 Node: 9895	6.81086e+006 N/m^2 Node: 783



Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 1	0.0022016 mm Node: 182

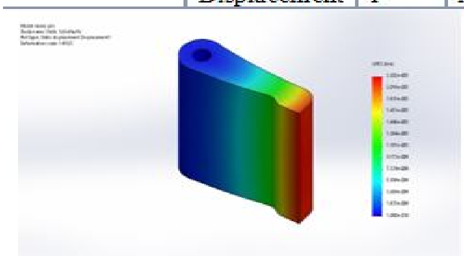


Fig. 7 Equivalent (Von-mises) stress and deformation for pawl pin.

The maximum Displacement at the extreme end of the pawl pin is within the permissible limit and hence the design is safe.

VI. CONCLUSION:

Human errors cannot be eliminated completely but it can be minimized by developing or implementing innovative ideas. The O ring machine is developed to reduce the human errors and to improve the productivity of the product. Thus we can conclude that O ring assembly machine will have the tendency to reduce the grease leakage and also improve the productivity. The O ring and the adjustable ball race was assembled in one separate stage. This will help to avoid the human error in the assembly. Assembly of the O ring and the component are then assembled in the main steering assembly. Therefore, there will be no tendency of the error in the steering assembly process. The mechanism is well suited to transfer the load to the rotary table through the shaft.

This mechanism gives greater repeatability due to the controlled motion of the rack and pinion and greater positional accuracy to the component. Low cost assembly machine also helps to increase the production rate because the machine is installed in the assembly line itself. Therefore no need for extra transportation for the O ring and component sub assembly.

REFERENCES

[1] V.T. Portmana, V.S. Chapskya, Y. Shneora, b, E. Ayalona, *"Machine stiffness rating: Characterization and evaluation in design stage"* CIRP 36, pp. 111 – 116, 2015.

[2] Christer W. Elveruma, Torgeir Weloa, *"The role of early prototypes in concept development: insights from the automotive industry"*, Procedia CIRP 2, pp. 491 – 496, 2014.

[3] Zhuang, Yan, Goldberg, Ken and Wongs, Yiu-Chung. *"On the Existence of Modular Fixtures"*. San Diego, CA, *USA : IEEE International Conference on Robotics and Automation.*

[4] Wu, Yuguang, Gao, Shuming and Chen, Zichen. s.l. *"Automated Modular Fixture Planning Based on Linkage Mechanism Theory. Elsevier Ltd., 2008, Robotics and Computer-Integrated Manufacturing,*Vol. 24, pp. 38–49,2015.

[5] Jian Zhanga,b, Deyi Xuea, Peihua Gub, *"An Integrated Framework to Design Architecture, Configurations and Parameters of Adaptable Product with Robust Performance"*, Procedia CIRP 36, pp. 147 – 152, 2015 .

[6] Reuven Katza *,"Integrating Analysis and Design in Mechanical Engineering Education"*, Procedia CIRP 36, pp. 23 – 28, 2015.

[7] D. Mourtzisa, M. Doukasa, T. Skrepetosa, *"A Knowledge-Enriched Problem Solving Methodology for the Design Phase of Manufacturing Equipment"*, Procedia *CIRP*, pp. 95-100, 2015.

[8] C.A.Arjun ,Wahid Hussain ,S.K Vishal, *"Design and Fabrication of Welding Fixture for a Single Doorframe"*, Volume : 3, Issue : 11, ISSN No 2277 – 8179, November 2014**.**

[9] Wang, Michael Yu. Hawaii, *"A Full-Kinematic Model of Fixtures for Precision Locating Applications". USA: IEEE, 2001. Intenational Conference on Intelligent Robot and Systems.*

[10] K.Mahadevan & K.Balaveera reddy *"Design Data Hand Book"*, CBS publishers, 2008.

[11] *Design data, data book of engineers,* PSG College of technology, Kalaikar Achchagam, 2008.