DESIGN AND ANALYSIS OF UNIVERSAL PICK AND PLACE FOR RING GEAR

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Abstract:

Today's the modern day world, the need for a more economical and safer means of increasing production in the manufacturing industry is vital. Now days replacing the 'human-being' by a simple machine. In Automation with the use of control systems and information-technologies reduce direct interaction between man and machine. Automation brings accuracy, precision, and efficiency. Since automation replaces the human-being. The automation is playing an important role to save human efforts in most of the regular and frequently carried works. In industry picking jobs from one place and placing it to the destination is most commonly performed work. The pick and place mechanism is a controller based mechatronic system that detects the object, picks that object from the source location and places at the desired location. Heavy materials sorting can be done by pick and place robot. Usually, the transfer process of the heavy materials is being carried out using manpower and if the transfer process is repeated for a period of time, the efficiency of an operator decreases and may causes injuries. The Operator will make mistakes whether small or big everyone in a while. Today industrial world, the industry cannot afford to take kind of mistakes. Every mistake is costly whether in money, material and time. Unlike the human, robots also have the ability to work for an extended time. Assembly of ring gear with diff-case at cold condition is not possible, so required to heat ring gear of differential up to 200°C then it assembles with diff-case. Manual assembly requires 3-Labour and less production per shift. The Company wants 300 Assembles of differential per shift, so it is required to develop an automatic pick and place universal gripper that picks ring gear and place it on induction heater. After heating again pick it from the induction heater and finally assemble with diff-case.

1. Introduction:

A literature review of available literature is done to put forward the background information on the issues to be considered in this thesis and to highlight the importance of the present study. The review is focused on the various aspects of different grippers. Taylan Atakuru [13] first of all, the design details of the gripper are presented. Then, preliminary analyses are performed using three-axes Delta-type manipulator for a typical pick-and-place task. Lastly, the developed gripper is integrated into the same manipulator and tested for certain performance criteria. S. D Rajgure [11] Studied design and load carried by a robotic arm with the use of a pneumatic cylinder. In that different loading conditions are taken to analyze the system. According to the different loading condition, the result of the graph is plotted. Carlos Blanes [3] Study the phases of the action of grasping and the influence of the relative position between the gripper and the cylinders. Victoria Cortes [4] the design of the gripper fingers and its mechanical configuration can adapt to a wide range of varied shapes during handling and provides a good performance. M. Demetgul [9] in this study, performances of multiple generic methods was studied for the diagnostic of the pneumatic systems of the material handling systems. Tian Huang [14] studied conceptual design and optimal dimensional synthesis of a novel 2-DOF translational parallel robot for pick-and-place operations. Gareth J [7] explained different types of the gripper and analytical calculation of different working condition. B. O. Omijeh [2] a prototype of the Remote Controlled "Pick and Place" Robotic vehicle was built to validate design specifications. The results obtained were very satisfactory. The use of Robots is highly recommended for Industries increasing productivity, safety and low production time. Mohammed. [10] the designed gripper has two jaw actuated gripper which is different from the cam and follower gripper in the way that controlled the movement of the gripper jaws is done with the help of pneumatic pressure. The force is developed in the cylinder is directly given to the gripper jaws. Tian Huang [14]. This paper deals with the design and dimensional optimisation synthesis of a novel 2 DOF translational parallel robot for pick-and-place operations. A different variant of pick and place grippers were designed with the use of pneumatic, Hydraulic and electric system but with the use of a pneumatic system have more advantages as compared with another system. Many pick and place were designed but no one worked on pick and place gripper for gear which grips gear from a periphery of the gear tooth.

2. Design approach

Assembly of ring gear with diff-case at cold condition is not possible, so required to heat ring gear of differential up to 200°C (also not affect the material property of ring gear) then it assembles with diff-case. Manual assembly requires 3-Labour and less production per shift. The Company wants 300 Assembles of differential per shift, so it is required to develop an automatic pick and place universal gripper that picks ring gear and place it on the induction heater. After heating again pick it from the induction heater and finally assemble with diff-case. The main aim of this research work is designed Automatic pick and place that assembles 300 ring gears with diff-case per shift.

3. The geometry of proposed grippers:

The proposed geometry of pick and place of the universal gripper is shown in fig in that two jaws of the gripper are connected with a belt and one is connected with the pneumatic cylinder at the same time. With the use of only one pneumatic cylinder gripping of ring gear can be possible. For the longitudinal motion of the gripper, there is required another one pneumatic cylinder.

The proposed designs of gripper were chosen because similar existing grippers are capable of handling semi-cylindrical parts with different diameters. The gripper dimensions chosen were based on observed ring gear dimensions. The proposed gripping device designated the basket gripper and consists of two curved arms which come together to enclose the ring gear. The pressure required holding of ring gear for the curved beam is less as compared to the straight beam.

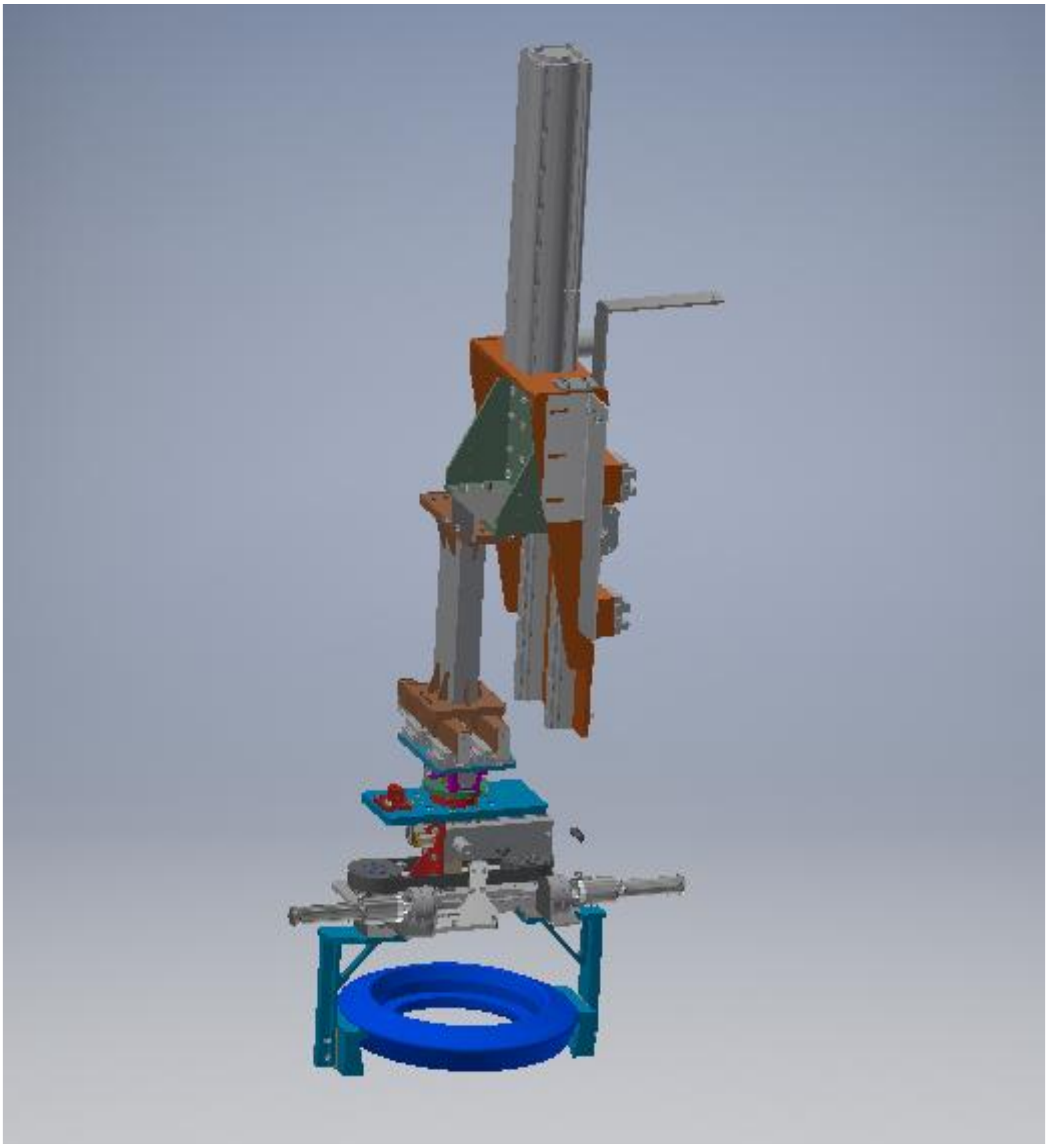

Fig.1 Model of pick and place gripper

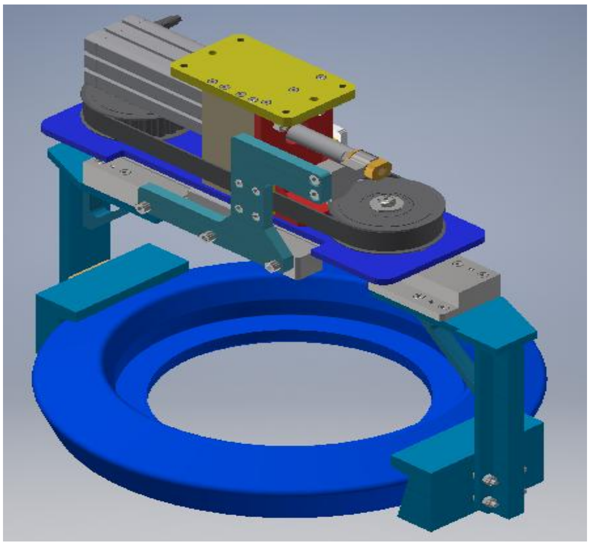

Fig.2 Gripper for ring gear from LHS

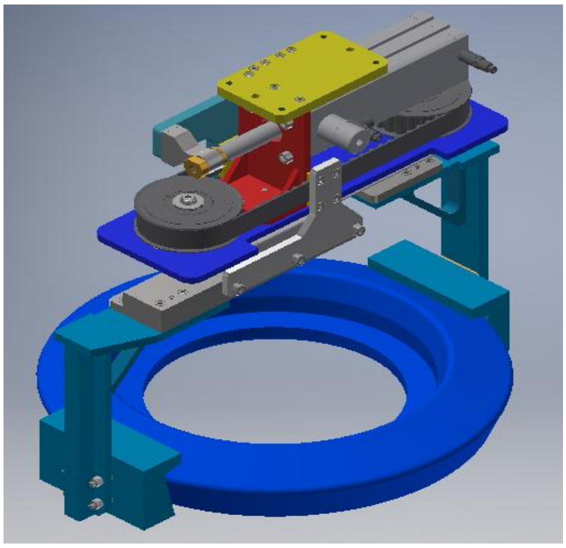

Fig.3 Gripper for ring gear from RHS

4. Working principle:

The gripper is at home position. When the operator press the button to start the cycle, the gripper will come down using the longitudinal cylinder and with use of transverse cylinder gripping of ring gear can be done. An operator presses the button to run the machine in auto-mode. The gripper lifts the gear to the home position, then it travels towards the induction heater and places the gear on the heater. The gripper moves up and waits until the gear heated properly. The pyrometer sensor (mounted near to the induction heater), will give confirmation of gear heating and heat up to 200˚C (at the temperature property of the material is not get changes). After pyrometer signal gripper will come down, pick the gear and go up and travel towards home position. The operator now makes this gripper from auto to manual mode and operator take gripper down to engage gear with diff-case. Gripper will go to home position and wait for the next cycle.

5. Force calculation:

5.1 Gripper force

Impactive grippers of the form shown in Fig. retain object solely by frictional forces F_R. The gripping force F_G applied to the workpiece is given for a slow vertical motion by,

$$G = F_G \times \mu \times n$$

$$F_G = \frac{mg}{\mu n}$$

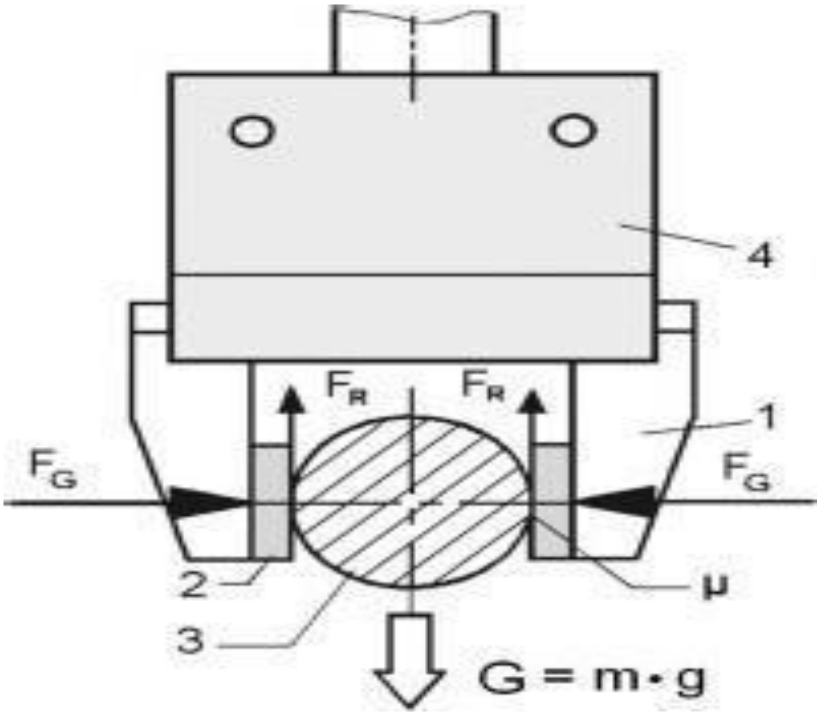

Fig.4 Forces acting on an object held at rest and during motion

$$\alpha = \frac{v_f - v_f}{t}$$

$$\alpha = \frac{150-0}{4}$$

$$\alpha = 37.4mm/\sec^2$$

$$F_G = \frac{m(g+\alpha)\times s}{2\mu} \quad \text{..[1]}$$

$$F_G = \frac{40(9.81+0.038)\times 1.5}{2\times 0.35}$$

F_G=844.1 N

5.2 Contact force

$$F_G = \frac{45\times(9.81+0.0374)\times 2}{(2\times 0.35)}$$

$$F_G = 1266.1N$$

The sum of the four frictional forces must be at least equal to the gravitational force G. In case of handling of delicate objects, the surface contact forces must also be considered.

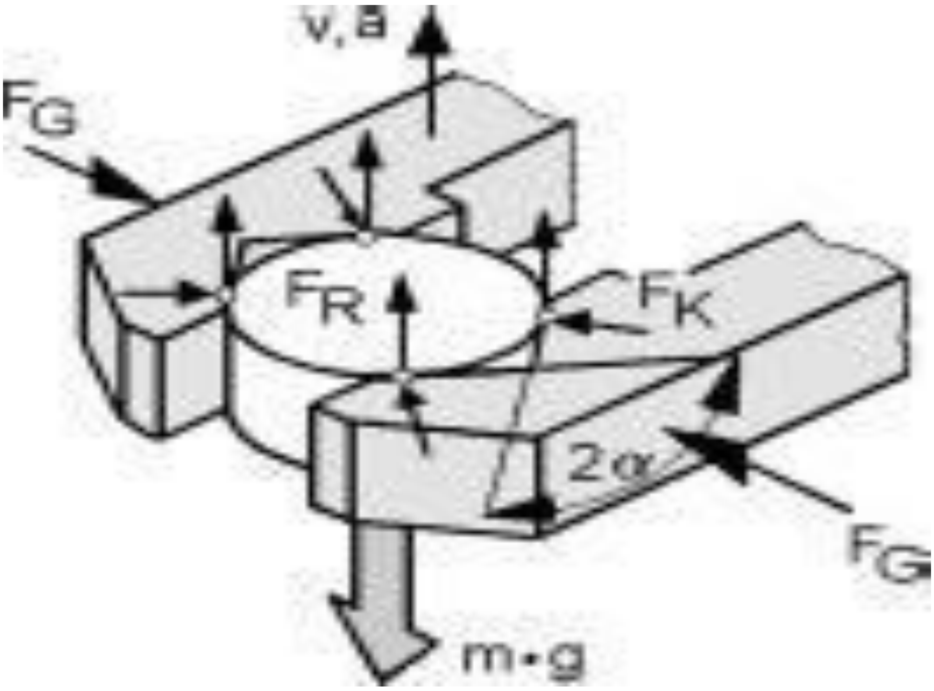

Fig.5 calculation of contact forces in the case of a gripper

$$G = \sum F_{Ki} \times \mu$$

$$F_K = \frac{m(g+\alpha)}{4\mu} \quad \text{..}[2]$$

$$F_K = \frac{45(9.81+0.0374)}{(4\times 0.35)}$$

$$F_K = 316.52N$$

Nomenclature

F_G=Frictional force (N)

n= Number of fingers and jaws

v_f =Final velocity (mm/sec)

v_i = Initial velocity (mm/sec)

F_R=Frictional force (N)

G=gravitational force (N)

F_k=Contact force (N)

α= Acceleration (mm/ sec^2)

m= Mass of Gripper and Gear (Kg)

t= Time (sec)

M= Bending moment (Nmm)

y= Distance of the layer at which the bending stress is consider (mm)

A= Area of cross-section (mm^2)

r_n= Radius of neutral axis (mm)

e= distance from centroidal axis to neutral axis (mm)

6. Material properties:

Table No.1 Material properties of gripper and ring Gear

	Gripper	Ring Gear
Poisson's ratio	0.29	0.27
Elastic modulus (GPa)	205	200
Elastic shear modulus (GPa)	80	80
Density (kg/m3)	7870	7850
Hardness, Brinell	126	96

7. Stress analysis

The basic problem in the strength of materials is to determine the relationship between the stresses and deformations for the applied loads. These stresses and deformations depend on geometric configuration, material properties (i.e., elastic modulus, Poisson's ratio, and elastic shear modulus), and on the magnitude and distribution of the applied forces. In a three dimensional problem, the state of stress at a point is defined by six independent stress components as follows:

$$[\sigma]^T = [\sigma_{XX} \quad \sigma_{YY} \quad \sigma_{ZZ} \quad \sigma_{XY} \quad \sigma_{XZ} \quad \sigma_{YZ}] \qquad \text{[3]}$$

The maximum, intermediate, and minimum normal stresses are called the principal stresses and are defined by σ_1, σ_2, σ_3. The equivalent or von Mises stress (σ), which is typically used in design procedures, is defined as:

$$2\sigma_e^2 = (\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 \qquad \text{[4]}$$

An initial analysis of the gripper was performed using the theory for curved beams. For a curved beam the stress distribution can be derived from the following equation.

$$\sigma = \frac{My}{Ae(r_n - y)} \quad \text{[5]}$$

It was assumed that the melon exerted pressure on the gripper in the manner predicted by Hertz contact stress theory. Thus, the pressure on the gripper had a semielliptical distribution with maximum pressure occurring at the center of the contact area.

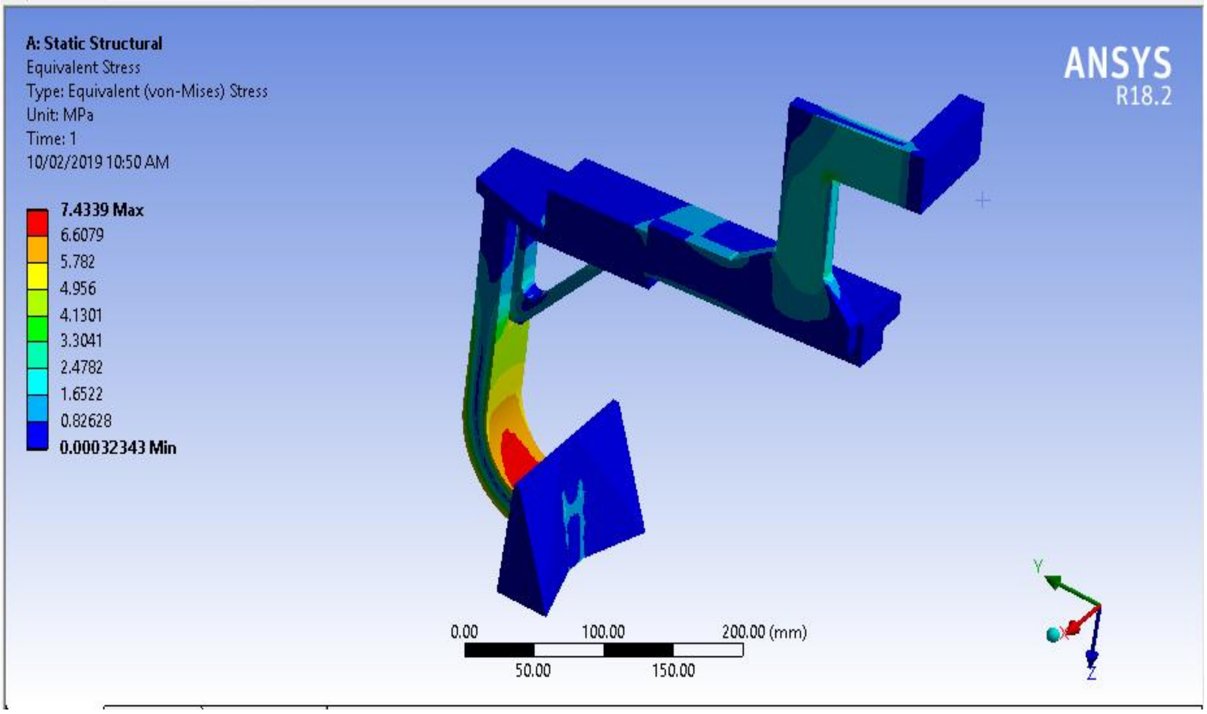

Fig.6 Stress calculation with help of FEA

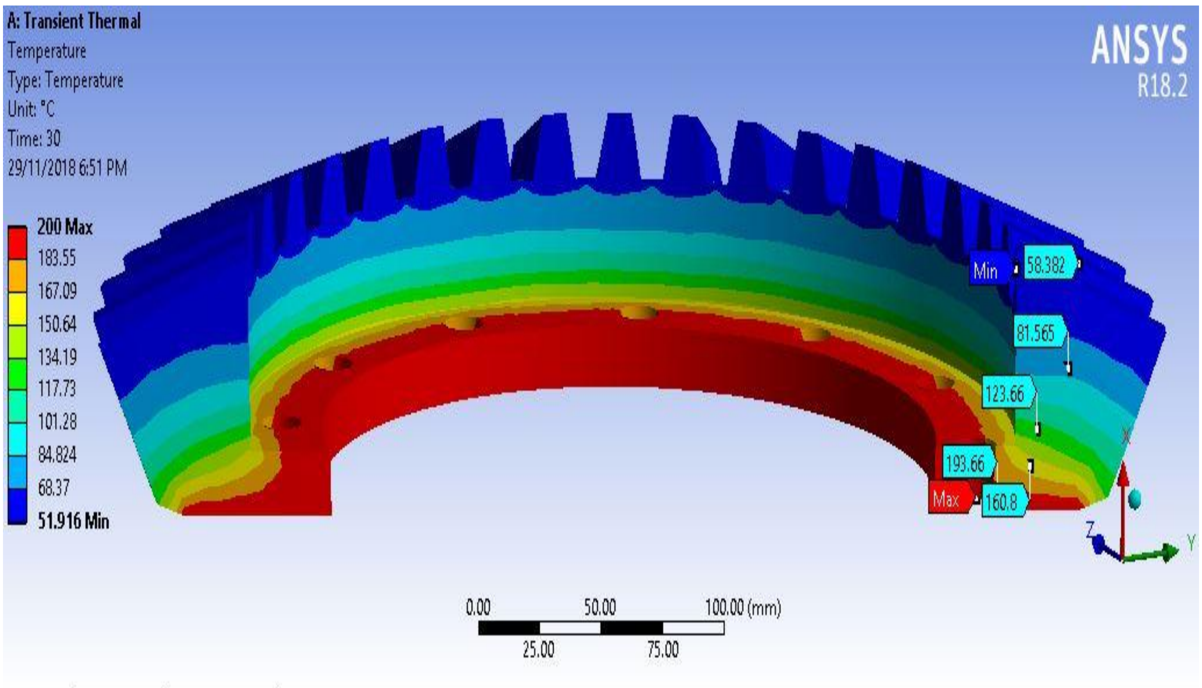

Fig.7 Thermal analysis of Ring the gear

8. Thermal Analysis of ring gear

The internal diameter of a ring gear is less than the outer diameter of plain half, so ring gear will not easily assemble with plain half. There is required to head ring gear with 200° then the internal diameter of gear get to expand and easily get assemble. Fig.7 shows the heat flow from the internal diameter to the outer tooth of the ring gear. Initially, if heat ring gear at 200° at time internal gear temperature is 200° (max) and outer tooth diameter is 58.382°. It shows the outer diameter is very less as compared with an internal diameter so, designing of any gripper with the application of 58.382° and also there is not required to take any special material for the gripper.

9. Pneumatic circuit and cylinder analysis:

Designing of pick and place there are mainly two pneumatic cylinders are required, one for horizontal application and other for vertical application. The schematic circuit diagram for horizontal cylinder (transverse direction) and for vertical cylinder (longitudinal direction) with help of Amesim software shown in Fig (8) and Fig (10). In this circuit diagram filter regulator, check valve, direction control valve and pneumatic cylinder are used. To grip ring gear from table and smoothly placed over diff-case can be done with help of horizontal cylinder. For vertical motion of gripper and whole assembly can be done with help of vertical cylinder. There are mainly 96 variant of ring gear, these are converted into 13 family with help of outer diameter of ring gear. Now required to grip 13 variant of ring gear with help of one gripper, so selection of right type of pneumatic cylinder can done with help of graph shown in fig.12 In graph rod displacement of smallest and largest gear varies, so selecting largest rod displacement in consideration. There are required to assemble 300 differentials in 8 Hours so for gripping of ring gear with help of gripper can do within 2 sec. Also velocity for horizontal and vertical application is calculated with help of Amesim

Heated ring gear up to 200°C then expands the internal diameter of ring gear was 0.238mm. After Heating Tolerance between the internal diameter of the ring gear and the outer diameter of plain half was 0.1215mm. (This gap can be controlled with help of pneumatic press). From Fig.12 there use 13 variant of ring gears for the gripping purpose, from that selected largest displacement of a piston rod of a pneumatic cylinder and on the basis of largest displacement velocity of the pneumatic cylinder for 2sec calculated with help of Amesim software. Also, for vertical application selection of write type of pneumatic cylinder on the basis of rod displacement and velocity of piston rod was done with help of Amesim software. Static analysis of the curved beam was calculated with help of analytical and also with help of FEA software ANSYS (Shown in fig.6). The stress value obtained from theoretical and FEA were nearly the same and gripper was also safe condition under the application of load.

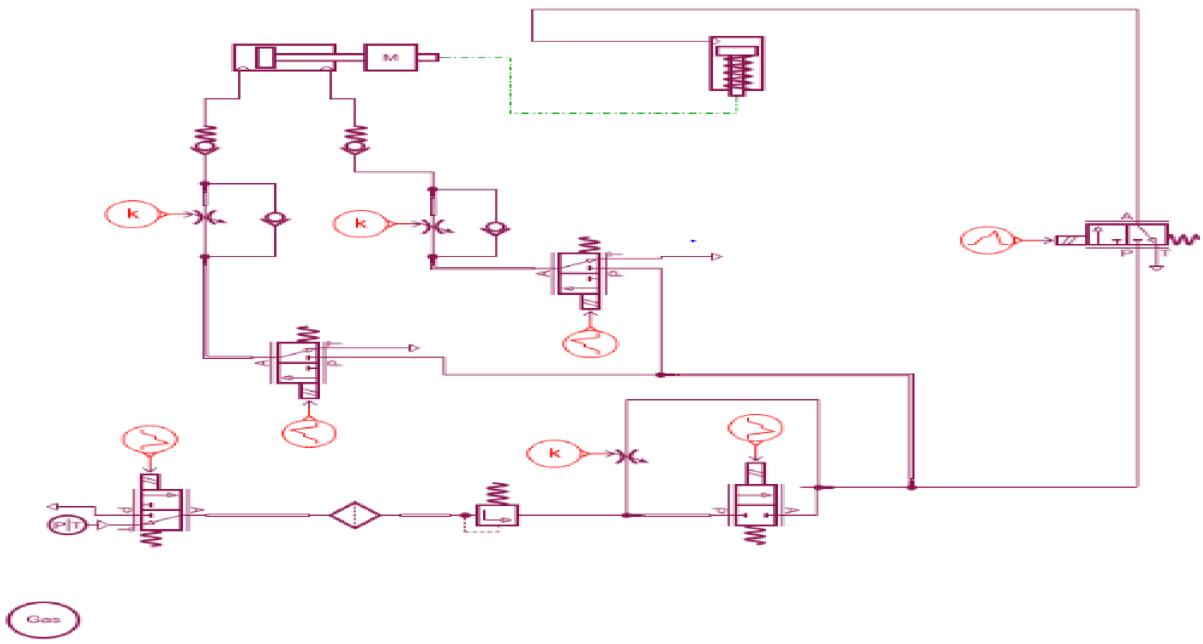

Fig.8 pneumatic cylinder circuit diagram for transverse direction

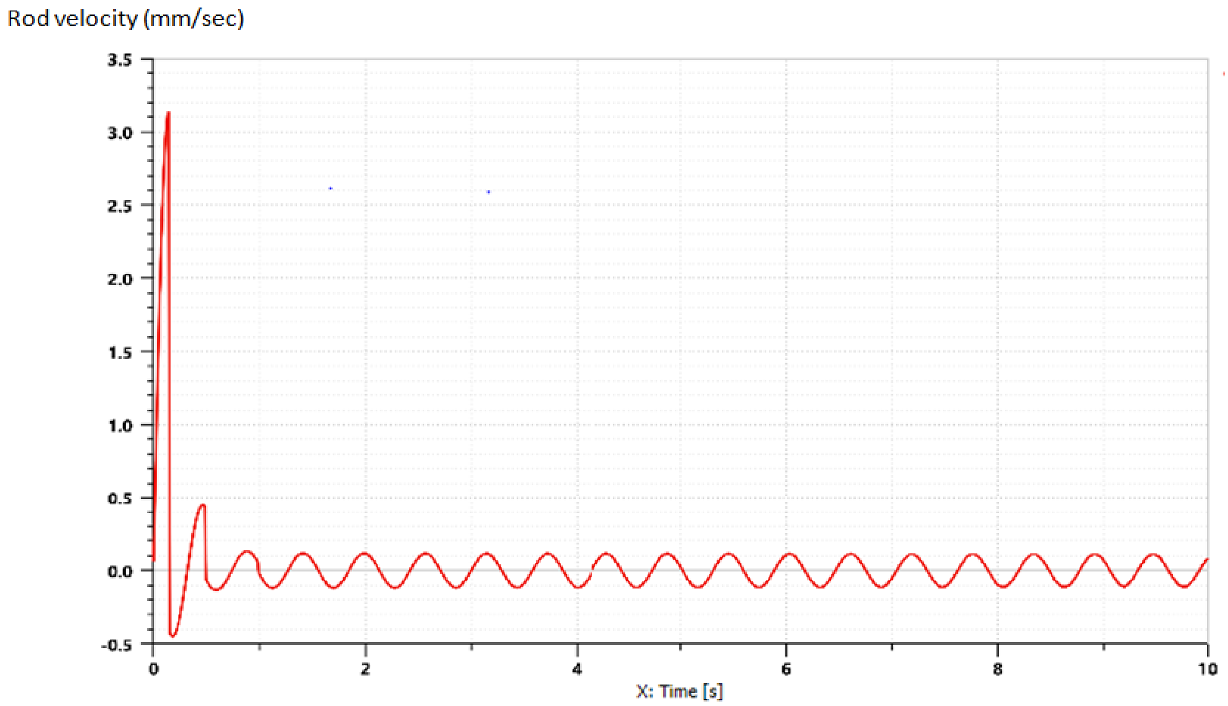

Fig.9 Velocity of rod in longitudinal direction

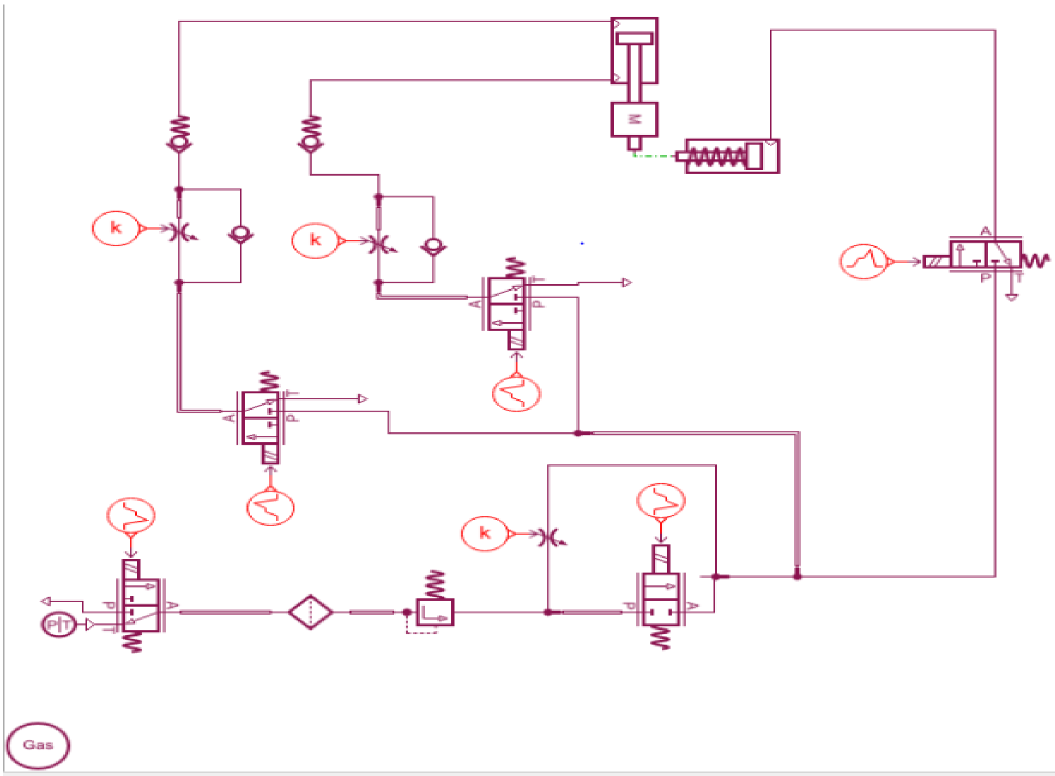

Fig.10 pneumatic cylinder circuit diagram for longitudinal direction

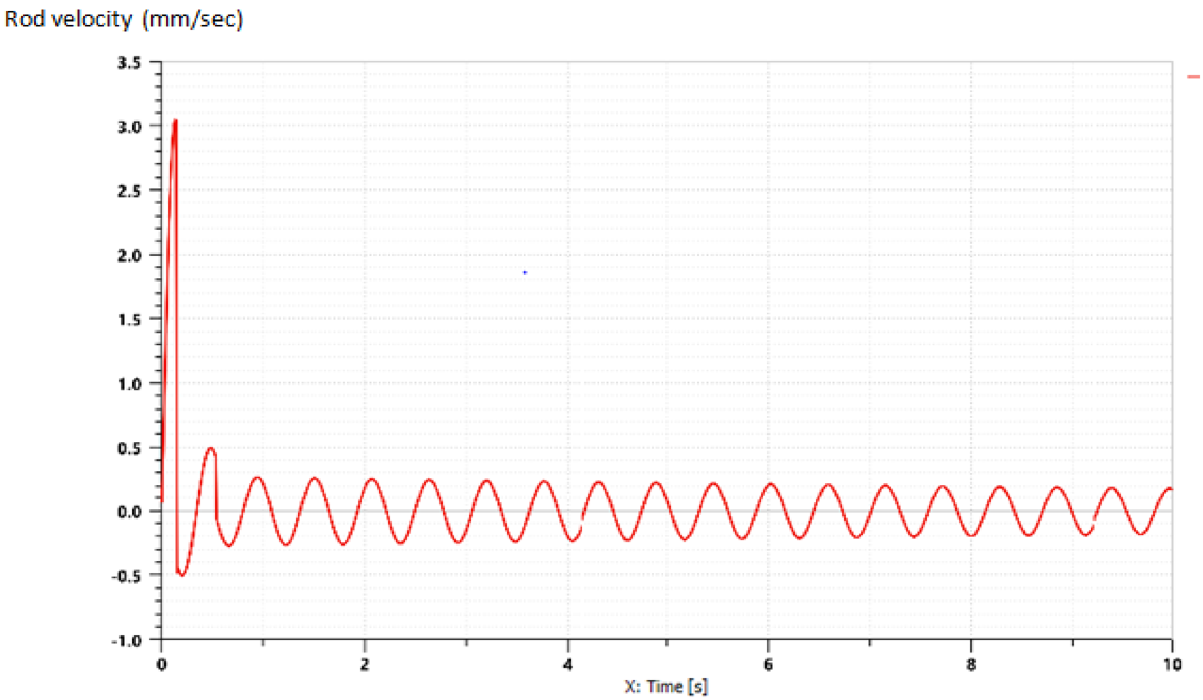

Fig.11 Velocity of rod in longitudinal direction

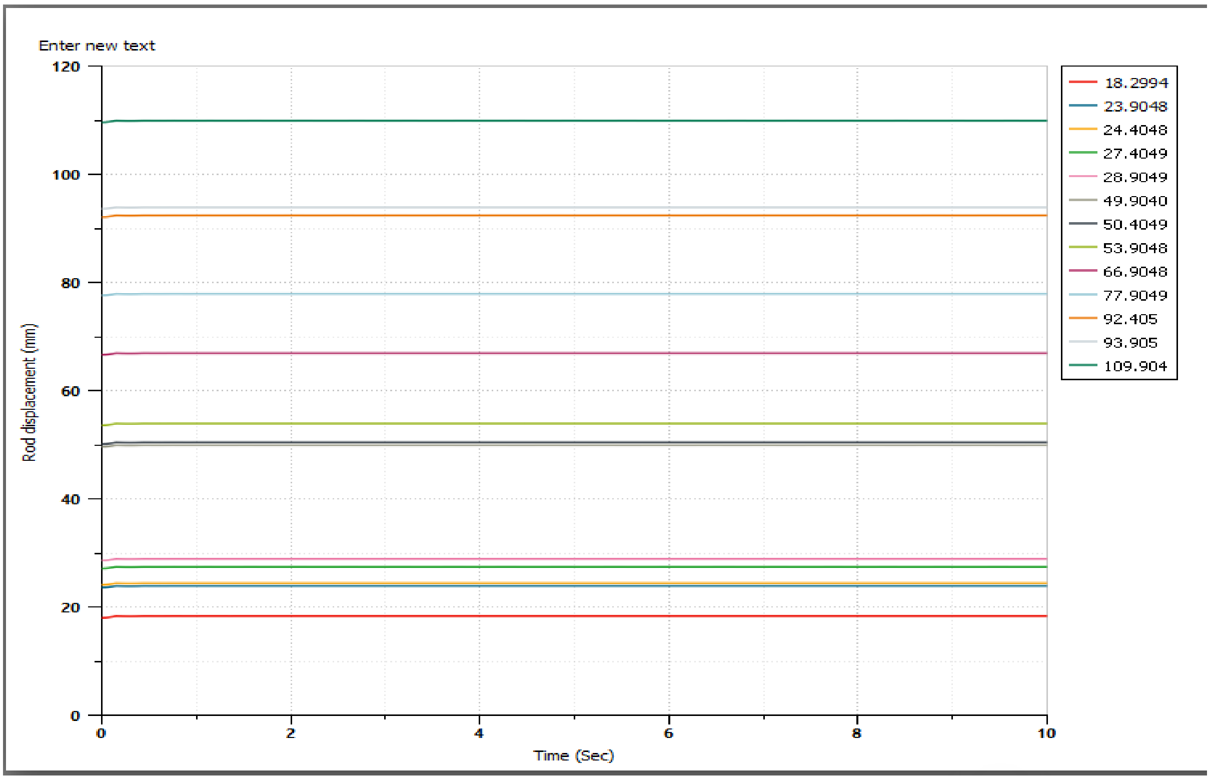

Fig.12 Displacement of rod for thirteen variant

Table No.2 Comparison of maximum theoretical and finite element stresses (MPa) for the applied force for the gripper model

Force (N)	Theoretical	FEA
422.05	42.40	44.343

10. Conclusion

Assembly of diff-case with ring gear at cold condition is not possible so heating the ring gear to some extent so ring gear gets easily assemble with diff-case. With help of experiment and FEA software calculated temperature variation on ring gear for 60sec. Both Experimental and the FEA gives nearly the same temperature variation. From this, conclude that assemble of diff-case with ring gear can be done with help of pneumatic gripper at the heated condition. Pneumatic pressure force applied on one side of the gripper that given safe stress value, also selected pneumatic cylinder works properly with same rod displacement and velocity. Now with the use of pick and place gripper assembly of the ring gear with diff-case is done very smoothly and 300 assembly of the ring gear is possible to assemble within 8 Hours

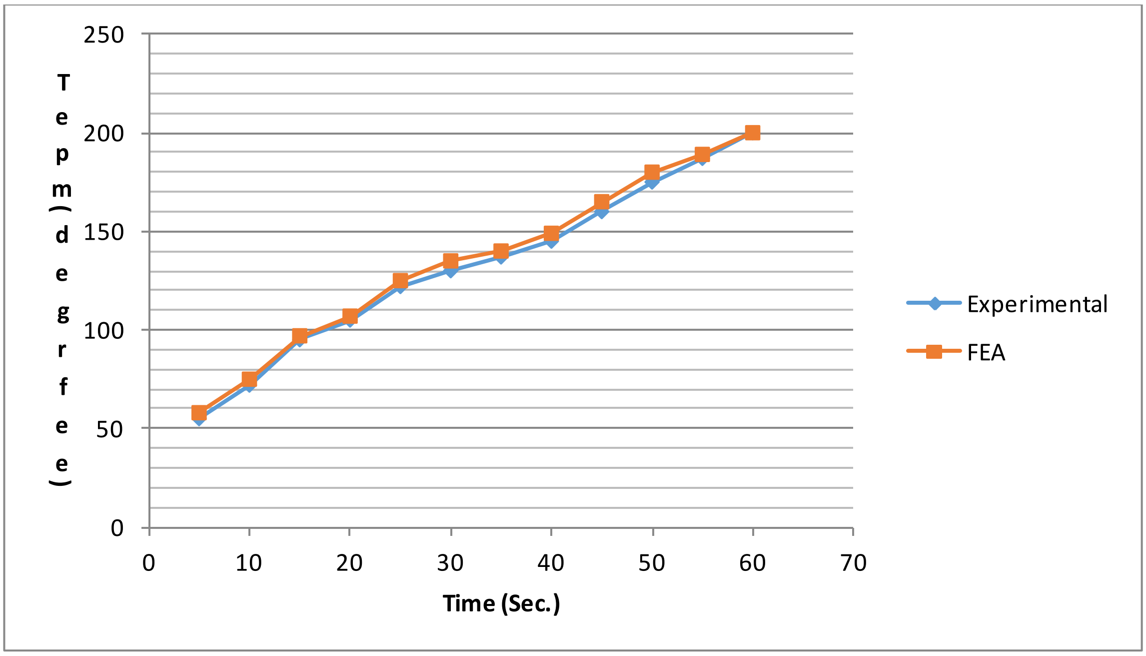

Fig.13 Temperature variation on gear Experimental and FEA method

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