Automated mechanical system for loading and feeding two machined plates for assembly and rotating by 90˚ in Automobile Industry

Adhish Umranikar (Author), Ajinkya Shah (Co-author),
Anantha Priya Nettem (Co-author)
Department of Mechanical Engineering
University of Bridgeport

Purpose of this research paper is to introduce a design of a fully automated, cost effective, high-speed mechanical system. This system will assemble two plates of a batch or lot production and deliver them for inspection. For example, in the automobile industry, this system can be used to carry out an assembly of a clutch release bearing and its hub. Automated tools like a rod less pneumatic cylinder and gripper unit, a mechanical flipper wheel, precision indexing conveyors and proximity laser sensors have been used to complete the required tasks at high-speed and with high accuracy. This system is designed and modeled using the Creo Parametric 2.0 software and its computer-aided structural analysis is carried out with the assistance of the ANSYS Workbench 16.0 software.

Keywords: *Automated high-speed mechanical system; assembly; automated tools; Creo Parametric 2.0; structural analysis; ANSYS Workbench 16.0*

Introduction

The word "Automation" is derived from the word "automatic" and is the most commonly used word in every industry all over the world. It was still unknown until the mid-19th century when General Motors introduced the first automation department, which is considered as one of the milestones in the history of industrial revolution [1]. Today, every industry worldwide is trying to be technologically advanced to deliver high quality products which will also be cost effective. Automation saves in labor, materials and energy due to high accuracy and precision.

An automated and high-speed mechanical system plays an important role in engineering that deals with different machine tool development integration of machinery systems and production equipment. The computer-aided design and modeling technology allows mechanical design engineers to quickly and cost-effectively iterate the design process with better quality and reliable function. Through this technology, multiple design concepts can be reviewed and evaluated that requires no real prototype until the product design is completed [2].

Currently, the clutch release bearing assembly is still done manually which causes increased labor costs, reduced production rates and unexpected assembly errors like damaging the edges of components or loss of desired surface roughness due to improper handling of components. A conventional clutch release bearing assembly rides over the inner collar. The internal bearing keeps the conventional bearing assembly centered on the transmission shaft and provides free movement with only minimal clearance difference [3].

This paper introduces a new, fully automated, high-speed mechanical system based on computer aided design, analytical calculations and structural analysis which ensures improved assembly procedure without compromising product quality and with more controlled positioning.

New Clutch Release Bearing Assembling System

This automated system is designed to assemble clutch release bearing and bearing hub. Fig. 1 shows schema of clutch release bearing and hub.

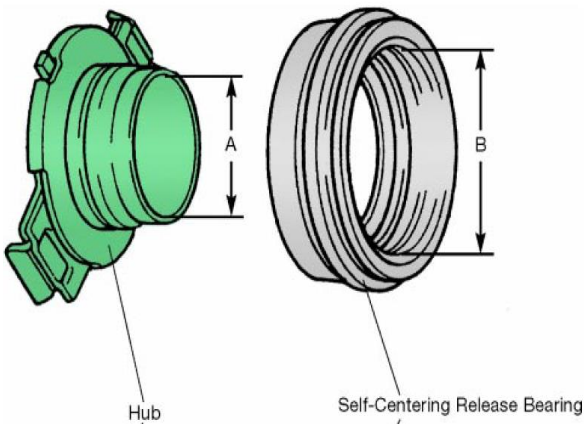

Fig.1- Clutch release bearing components

This system performs following operations-

1. Loading clutch release bearing and a hub on separate conveyors from previous work stations.
2. Flipping bearing hub with the help of mechanical flipper wheel.
3. Feeding bearing hub and bearing to the assembly station.
4. Matching centers of both components with the help of center matching grippers.
5. Assembly of a hub and bearing.
6. Feeding the assembly to the inspection station.
7. Rotating the assembly by 90˚ before the inspection station.

This paper predominantly focuses on 1st, 2nd, 3rd and 7th operations. Fig.2 shows 3D model of complete system to explain all these operations.

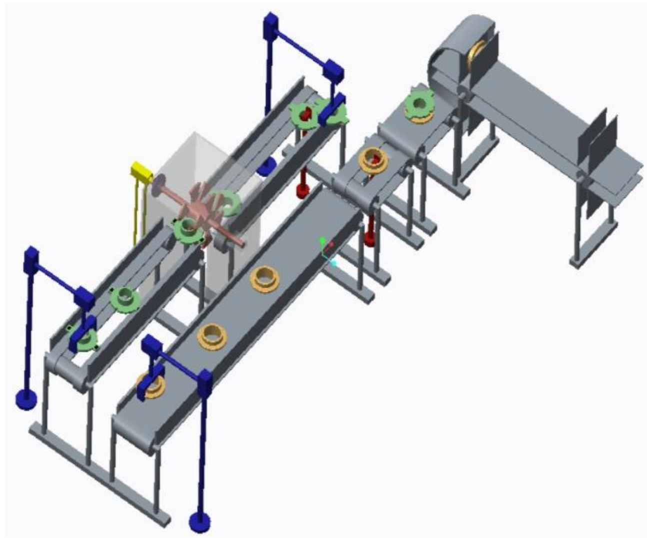

Fig.2- 3D model of a complete assembly

- Loading of Clutch release bearing components:

A rod-less pneumatic cylinder-gripper unit is used to pick and place hub and bearing from previous work station on the conveyor. Advantages like cost effectiveness and easy to use than that of robotic arms make rod less pneumatic cylinder and gripper unit more popular in the automation industry. Fig.3- explains this operation.

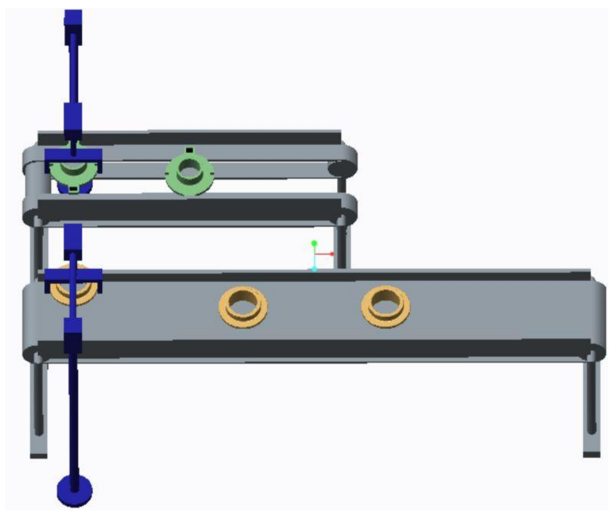

Fig.3- Loading of Clutch release bearing components

- Flipping of bearing hub:

A mechanical flipper wheel is used to flip the bearing hub upside down before it goes to the assembly station. The purpose of using this wheel is to ease the assembling function without investing any labor or additional tool cost. This wheel is driven by a brushless DC motor and is also protected by a cage to restrict lateral movement of bearing hub. This DC motor is directly connected to the shaft of mechanical flipper wheel with the help of a pin bush type flexible coupling. Fig.4 explains this flipping operation.

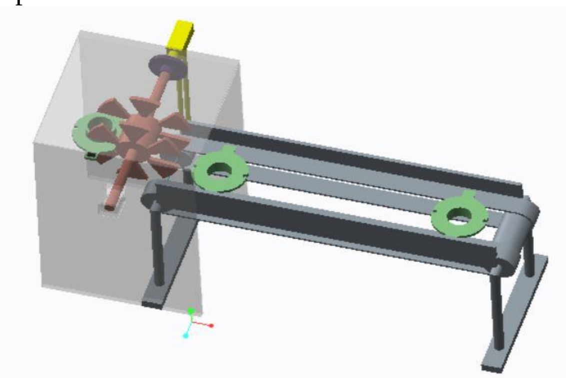

Fig.4- Mechanical flipper wheel

- Rotation of assembly:

After the assembly of clutch release bearing and a hub is completed, it is then rotated by 90˚ before feeding it to the inspection station. Assembly rotation is required for CMM to check dimensions accurately. This operation is performed using precision indexing conveyor and proximity laser sensor. Precision indexing conveyors are particularly well suited to high-speed assembly of small components where high part count or assembly process complexity is involved [4].

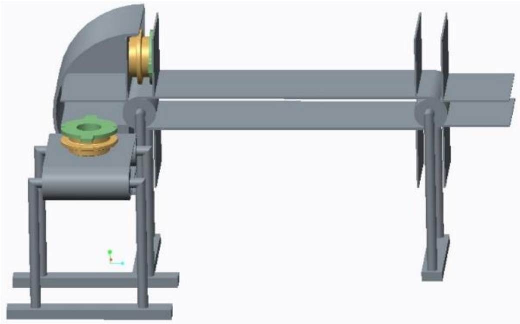

Fig.5- Assembly rotation by 90˚

Analytical Calculations

Some analytical calculations have been done to verify computer-aided structural analysis results.

- Deformation and stress induced in rod less pneumatic cylinder and gripper unit which is used to feed bearing are calculated using following formulae respectively [5]-

$$y = \frac{W \times L^3}{3 \times E \times I}$$

And

$$\sigma = \frac{W}{A}$$

Where,
y is maximum deflection of pneumatic cylinder –gripper unit
W is point load at free end
L is overhanging length of pneumatic cylinder –gripper unit
E is Young’s modulus
I is moment of inertia
σ is stress
A is surface area

- Secondly, torque generated by mechanical flipper wheel is calculated to determine shaft diameter and to select appropriate motor by using following formula [5]-

$$T = F \times r \times \sin\theta$$

And

$$\tau = \frac{16 \times T}{\Pi \times d^3}$$

Where,
T is torque
F is load applied on shaft
r is radius of shaft
Θ is angle between force vector and radius
Ʈ is maximum shear stress induced in shaft

- In both the cases, factor of safety is calculated based on yield strength of material. Its formula is given as [5]-

$$FS = \frac{Yield\ Strength}{Maximum\ Stress}$$

Computer Aided Analysis

A computer aided structural analysis of a rod-less pneumatic cylinder and gripper unit and a flipper wheel shaft is performed to verify their design safety as these automated tools may damage bearing components while carrying out assembly.

A static structural analysis of rod less pneumatic cylinder and gripper is carried out by applying a force on it with the help of ANSYS Workbench 16.0 to observe stress and displacement profile. The material used for this pneumatic cylinder and gripper unit is A36 structural steel.

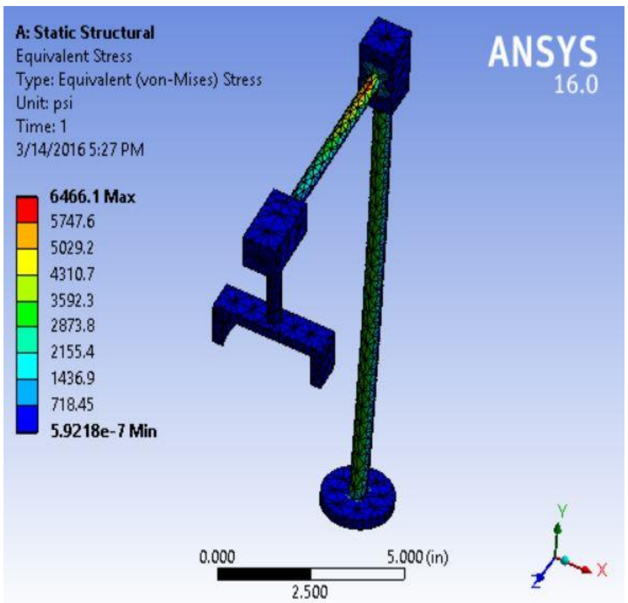

Fig.6- Stress profile of rod less pneumatic cylinder-gripper unit

Fig. 6 shows maximum stress induced as 6466.1 psi. Since the yield strength of A36 steel is 36000 psi [6], we get a 5.56 of safety factor which is well above the required value of 2. Fig. 7 shows displacement profile which is also well within the limit.

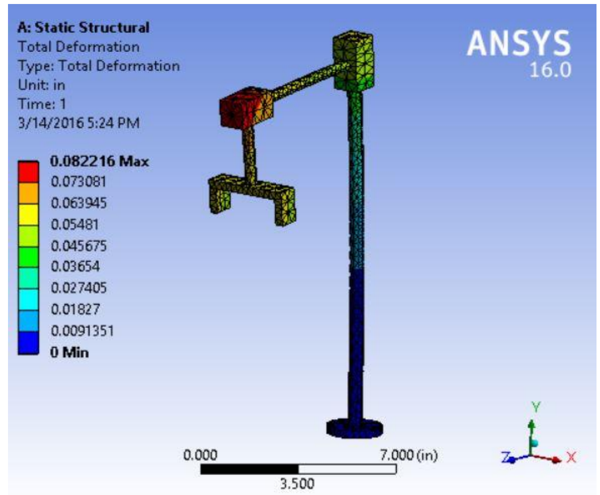

Fig.7- Displacement profile of rod less pneumatic cylinder-gripper unit

Similarly, a static structural analysis of shaft of mechanical flipper wheel is performed by applying torque with the help of ANSYS Workbench 16.0 to observe maximum shear stress and displacement profile. The material used for the shaft is also A36 structural steel.

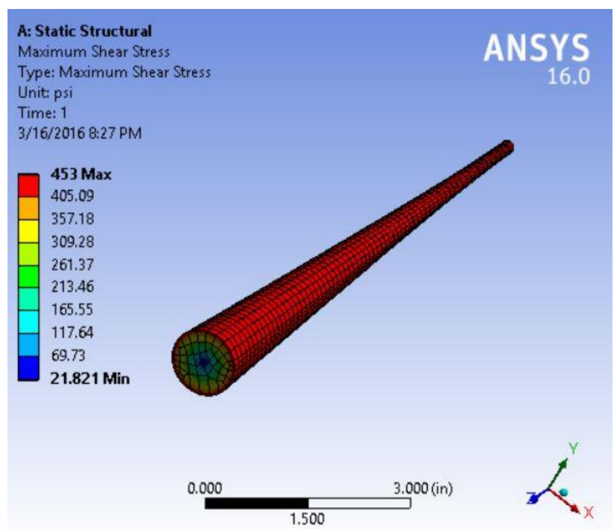

Fig.8- Max. Shear Stress profile of shaft of mechanical flipper wheel

Fig.8 shows maximum shear stress induced in the shaft as 453 psi. Allowable shear stress is considered as 30% of yield strength. Since the yield strength of A36 steel is 36000 psi [6], the allowable shear stress is 10800 psi and thus, we comfortably get a safety factor of more than 2. Fig. 9 shows displacement profile of shaft which is highly negligible.

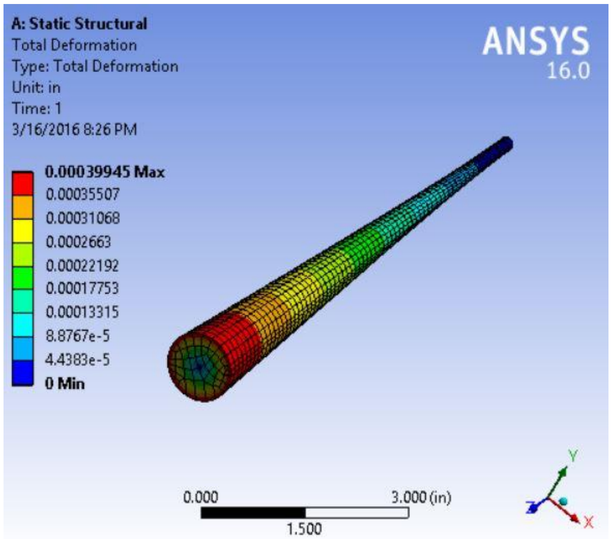

Fig.9- Displacement profile of shaft of mechanical flipper wheel

The results obtained from computer aided structural analysis confirms that design of these automated tools is safe and thus proves the credibility and feasibility of this new system.

Conclusion

This system is designed to improve product quality, productivity and also provide more cost-effective production technique. The result obtained from computer-aided structural analysis is verified with analytical calculations and it proves that this newly developed automated high-speed clutch release bearing assembling system works satisfactorily. However, there is still some scope to make it more cost effective by reducing the size of rod less pneumatic cylinder-gripper unit and mechanical flipper wheel shaft as well as by changing their material from A36 structural steel to low yield point steel (like LYP100 or LYP235) as we are getting more than required value of factor of safety [7].

References

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