International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Design and Development of Torque Measurement Machine and Automation in Assembly of Steering Control Unit

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Accepted 12 March 2017, Available online 16 March 2017, **Special Issue-7 (March 2017)**

Abstract

The aim of this project is to provide a customized automated solution for the assembly of the Steering Control Unit to reduce the assembly time. It involves the development of an automatedsolution for the assembly of the bolts and washers into the End Cover and also the torque measuring system in the assembly line of a steering control unit to sense the torque produced in tightening of bolts in a steering control unit. It achieves the requirement of decreased cycle time and increased accuracy in the present manual torquing system.

***Keywords**: Steering Control Unit, End Cover, Torque sensing, Automation, Special purpose Machine.*

1. Introduction

Automation or **automatic control**, is the use of various control systems for operating equipment with minimal or reduced human intervention. Torquing is widely done in many industries and is essentially required in varied equipments and machine units. A slight difference between the applied torque and the required torque can render a product useless for its further use. In the present case, a steering control unit consists of 6 standard bolts and a single bolt which needs to be inserted with a necessary torquing arrangement. These units are produced in large quantities which leads to worker fatigue and low accuracy leading to a large number of units being faulty.

Fig.1 The Steering Control Unit

Therefore, there was a need to to change the present mechanism and build an automated mechanism for torque measurement. This is a special purpose machine is built specifically for torque measurement in steering control units.

The mechanism and design for a special purpose machine for the assembly of the End Cover is also finalized and is in the company at an approval stage.

The methodology for this project is determined with the help of guidelines from the experts assigned to us by the company.

2. Literature survey

The aim of the author is to use various methods of torque measurement on the same machine and to compare the obtained results. The methods of measurement could be divided into two groups.

Some methods need either a special intervention to the machine under the test or expensive equipment. Due to this fact these methods are applicable almost exclusively in the laboratory. Nevertheless, they would give important results. As a contrast, some methods need just a speed sensor, current sensors or helping measurement turns. The speed or current sensors can be used for other purposes simultaneously. These methods are very suitable for industry.

Finally, he chooses some suitable transient phenomena (run-up, reversing,) and we will analyze the torque by each different method. For a complete description, this paper contains the short overview of all, well known methods. The attention is paid to the latest case – the proposal of the torque measurement thanks to piezoelectric accelerometers. As part of the research, a torque standard machine of rated capacity

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1 kNm was developed This machine has a variety of features enabling it to perform precise measurements of torque, including the correction of the lever length due to deadweights loading and an aerostatic bearing in order to minimize torque loss caused by friction at the fulcrum. In this paper, the torque standard machine is outlined.

This report introduces the first torque standard machine with a rated capacity of 1 kN×m developed at the NRLM, where a lever/mass system has been utilized. The author investigated the mechanism for bolt and washer assembly machine and method of assembly. Their objective was to construct a device for assembling an element, such as a washer, to the end of a fastener, such as a bolt, in a reliable, high-speed fashion wherein the assembling device includes the washers being supplied in a position to be picked up by an end of the shank of the bolt and slides along a ramp causing the washer to be positioned closer to the head of the bolt. The author realized that the part feeding systems available were incompetent to be employed at processes requiring high accuracy and precise alignment. Therefore, there was a need for devices and methods that promote precise alignment between components which can be quickly and inexpensively incorporated into existing manufacturing systems. They made the use of vibratory or wave energy to increase the accuracy and efficiency of existing systems to achieve such a result.

The torque standard machine consists of the following parts:

(1) Pedestal parts which have high stiffness and which support torque occurring with deadweights and the lever.
(2) Bearing parts for thefulcrum which are mainly equipped with an aerostatic bearing unit in order to keep the friction at the fulcrum to a minimum.
(3) Lever parts which can accommodate the lever for the application of both the right- and left-handed torque, and which have an observation system for inclination level, flexure and length of the lever.
(4) Weight loading parts which consist of l linkage deadweight series, weight loading elevators, turntables to change the weight series, and so on.
(5) Bearing parts for counter torque necessary for reacting to the generated torque and returning the inclined lever by weight loading to the horizontal position.
(6) Installation parts of the torque transducer which include base flanges, diaphragm coupling, friction joints, torque transducer connecting flanges among others. They are used for mounting the torque transducer onto the standard machine with arranging these axes.

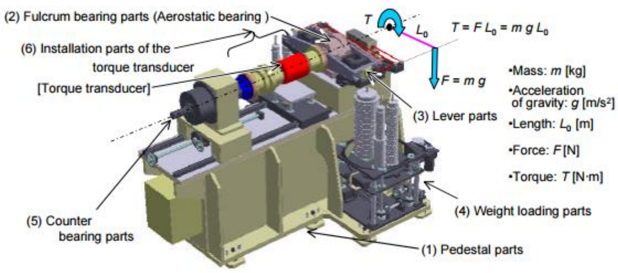

Fig.2 Schematic view of the Torquing machine

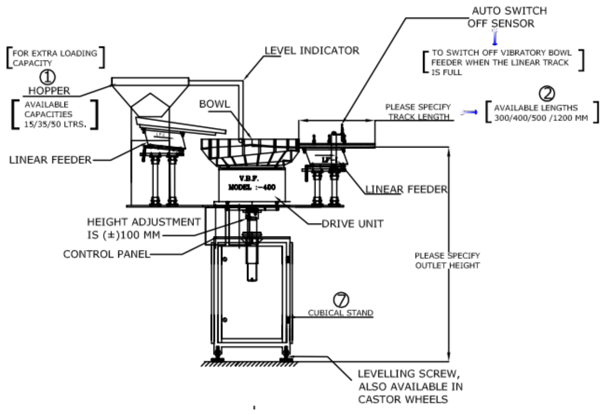

Fig.3 Schematic view of the vibratory bowl feeder

The vibratory bowl feeder is the most common mechanism for feeding industrial parts. The bowl has a helical track climbing the inside wall. By giving the bowl a circular vibratory motion, parts dumped into the bowl will climb the helical track in single file. As parts climb the track, they encounter a sequence of obstacles which either re-orient the parts, or deflect disoriented parts back into the center of the bowl. While surveying the present status at the company following gaps and problems were found out

- Manual Operations
- Possibility of Human Errors
- More assembly time than desired
- Less Productivity
- Higher labor cost

3. Comparison with earlier designs

Earlier, an operator was stationed at the assembly line of the steering control units who would manually collect the piece from the stock and torque it. The daily production rate of these units is about 500 units per day. Each unit has total 7 bolts (6 standard +1 pin). Thus the total torquing is done about 3500 times in a day which is quite large. This large amount of torquing causes problems such as under-torquing or over-torquing in some cases and hence the unit is useless for its further use.

The mechanism provided in this project automates the torque measurement and hence is optimal solution for finding defective units. It also reduces the cycle time considerably.

4. Experimental Setup for Assembly of the End Cover

There are two servo controlled motors used and a single pneumatic cylinder. One servomotor is connected to a gear box which is used to generate required torque of 40Nm. Only the servo motor is incapable of generating this torque. the other servo motor is used for the indexing table. This is controlled with the servo motor as it gives a feedback during operation. The feedback is given in mv but it is amplified to a value between 1 to 10 V. Later this is converted into the torque in Nm and the final value is displayed on the screen. If the obtained torque is lesser than the required torque, the system rejects the steering control unit and it is sent back for torquing. This is done using the inline torque sensor. The pneumatic cylinder is used for the purpose of clamping the unit on the indexing table.

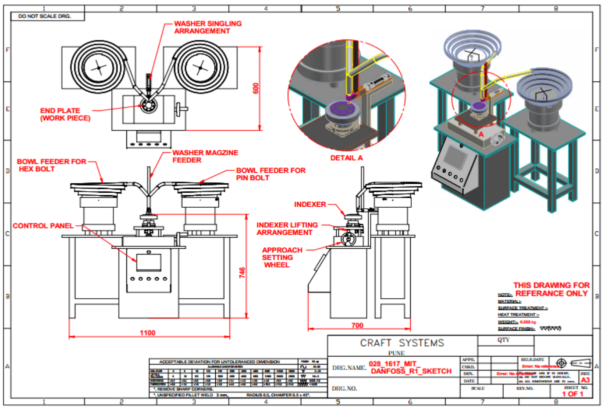

Fig.4 Proposed Assembly Design

The proposed design consists of two Vibratory bowl feeders for the two types of bolts and a feeding mechanism for the washers.

The electromagnetic parts feeder is a two-mass system. Mass one consists of the heavy base and rubber isolator feet, as well as the electromagnet. Mass two consists of the bowl mounting plate (often called the cross arm), the armature, and the bowl. The two masses are connected through four sets of leaf springs. When the magnet receives power, vibration occurs because a pulsating magnetic field is established between the armature and the magnet. The springs permit the armature to move toward and away from the magnet, which imparts the vibration into bowl that ultimately moves the parts. The leaf springs are mounted at an angle, causing the parts to left off the bowl surface as they convey forward (ref. Fig. 4).

5. Experimental Setup for Torque Sensing

Fig.5 Setup of the Torquing machine

Inline torque measurements are made by inserting a torque sensor between torque carrying components, much like inserting an extension between a socket and a socket wrench (ref. Fig. 5)

Fig.6 PLC Display

Mitsubishi PLC with Delta HMI is the hardware used to program the special purpose machine. The output in obtained in mili volts which is further amplified and converted to Nm (ref. Fig. 6).

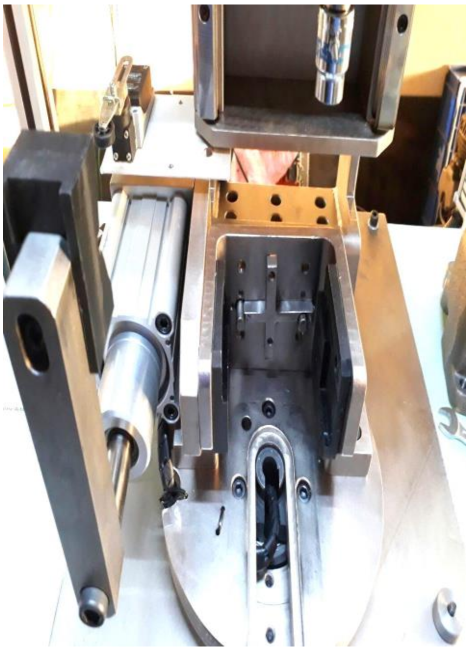

Fig.7 Clamping setup of the torquing machine

A pneumatic rotary cylinder is used for clamping. It consists of an arm which holds the object while indexing. Mild steel guideways are provided for the movement of the control units.(ref. Fig. 7)

6. Observations

A) Assembly of End Cover and Bolts

Table 1 Experimental observations

Sr. No.	Type	Time
1	Total Cycle Time	36.8 sec
2	Total Cycle Time	37.2 sec
3	Total Cycle Time	34.6 sec

Table 2 Experimental observations

Sr. No.	Type	Time
1	Bolts(individual)	14 sec
2	Bolts(individual)	15.5 sec
3	Bolts(individual)	13.9 sec

Table 3 Experimental observations

Sr. No.	Type	Time
1	Washers	8 sec
2	Washers	11 sec
3	Washers	13.3 sec

B) Torquing Time

Table 4 Experimental observations

Unit type	Previous time	Current time
80cc	60 sec	40sec
160cc	58 sec	34 sec

7. Discussion

The assembly line also requires automated mechanism for the insertion of bolts into the unit to reduce cycle time and eliminate the operator. The design for this process is in the stage of approval in the company. The theory regarding it has been finalized and the design will be confirmed as the final part of this procedure. The mechanism and design for a special purpose torqueing machine has been finalized and manufactured.

Conclusion

In this paper, the mechanism and design for a special purpose assembly machine has been finalized. The ergonomically designed torquing machine setup is complete and is manufactured. The 80cc and the 160cc control units were tested and it was found out that the torqueing time is reduced by

- 20 secs for 80cc
- 24 secs for 160cc

Some more tests need to be carried out on the torquing machine before it gets sanctioned on to the actual assembly line.

Acknowledgement

The authors wish to acknowledge **Danfoss Power Solutions India Pvt. Ltd** who has given us the opportunity to work with them and also provided the financial support for performing this experimental work.

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