Journal of Material Science and Mechanical Engineering (JMSME)
p-ISSN: 2393-9095; e-ISSN: 2393-9109; Volume 3, Issue 6; July-September, 2016 pp. 373-377

http://www.krishisanskriti.org/Publication.html

Modeling and Simulation of Automated Special Purpose Machine for Fastening of U-Frame Bi-Metal Subassembly and Screw

Girish M. Patil[1], V.S. Jorapur[2] and Tushar Sharma[3]

[1]*M.E Student, Fr. Conceicao Rodrigues College of Engineering, Bandra, Mumbai, India*
[2]*Fr. Conceicao Rodrigues College of Engineering, Bandra, Mumbai, India*
[3]*M/S Larsen & Toubro, Powai, Mumbai, India*
E-mail: [1]gp2745@gmail.com, [2]jorapur@frcrce.ac.in, [3]tushar.sharma@lntebg.com

Abstract—*This paper presents Design, Modeling and Simulation of screw fastening special purpose machine to fasten screw into bimetal of MCB (Miniature Circuit Breaker). Problems found in current process include intricate shape and size of screw and whole fastening operation is manual intense operation which makes handling difficult for the operator and also the size of screw is M2 and it is headless with cross flat. In partnership with the operator SPM act as a tool to increase the productivity by reducing fatigue of the operator. The system is a convolution of automated material handling system, linear motion, gripping solution, fastening tool, automatic ejecting system, actuation system, sensors and control functionalities etc. The handling of small screw and cycle expectation is the key challenges in the development of special purpose screw fastening system. The Modeling of system and Simulation study is carried out and results are encouraging.*

Keywords*: Modeling, Simulation, MCB, SPM, Fastening tool, Ejecting system.*

1. INTRODUCTION

Today the development of technologies made it possible to introduce industry automation systems into almost all manufacturing fields. Industry automation of production processes enhances labour efficiency and allows cutting net cost and improving product quality. [1] Moreover, it extends the equipment service life, saves consumables and raw materials, and improves production safety as a whole.

Automation or automatic control is the use of various control system for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching on telephone networks, steering and stabilization of ships, aircraft and other applications with minimal or reduced human intervention. [2] Some processes have been completely automated. The biggest benefit of automation is that it saves labour, however, it is also used to save energy and materials and to improve quality, accuracy and precision.

Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronic devices and computers, usually in combination. Complicated systems, such as modern factories, airplanes and ships typically use all these combined techniques.

The main advantages of automation are:

- Increased throughput or productivity.
- Improved quality or increased predictability of quality.
- Improved robustness (consistency), of processes or product.

2. LITERATURE REVIEW

K Feldmann(1), M Steber(1992)- Computer integrated system was developed, which helps to plan and control the screw fastening process. The concept was tested systematically in an assembly cell with a gantry robot, which manipulates a bolting spindle. The developed program can control several bolting processes simultaneously. Furthermore, relevant process data can be recorded and stored. In case of process failures the additional monitoring system supports the supervisor to solve the problems. [3,4]

S.S. Malek, Y.J. Chiang and J.E. Mason (1993)- An Automatic screw fastening process for small screws was successfully setup. Three different sensors were used to measure force curve, torque curve and rotating speed of screwdriver. A programmable horizontal servo slide was taught to do the fastening job. Design of experiments was employed to identify the significant factors that might have an impact on the final torquing process. In addition to the size of screw and work piece material, screw head geometry, rotating speed of the driver, and servo slide speed have significant individual effects on the final torquing process. [5,6]

Nitin Dhayagude, Zhiqiang Gao and Fouad Mrad(1996)- An intelligent control strategy for automated screw fastening was developed. In automated assembly processes, there are often found dedicated stations for various types/sizes of screw fastening. Problems found in current processes include cross-threading, screw jamming, slippage and the need to apply precise torque. The intelligent controller developed here supervises the integrated process of an electric driver mounted on a robotic positioning system to fasten screws. The new scheme controls continuously the motion and driving stages to avoid process-caused failures, to achieve a desired precise torque and to detect bad parts at early stages of the assembly. [7,8]

3. INTRODUCTION TO SPECIAL PURPOSE MACHINES

Increase in production level but speed of person is almost constant. To enable increase in productivity, automation is key enabler. One such problem in a switch gear industry, of fastening a calibration screw in bimetal is a manual intense operation. In addition to the increased demand, the operator is burdened with the limitation of screw size and shape.

To overcome this challenge a automated solution is necessary. A special purpose machine for screw fastening is developed. In partnership with the operator the SPM act as a tool to increase by reducing fatigue of the operator. The system is convolution of automated material handling, linear motion, gripping solution, fastening system, sensor and control functionalities.

Fig. 1 U-Frame Bimetal Assembly

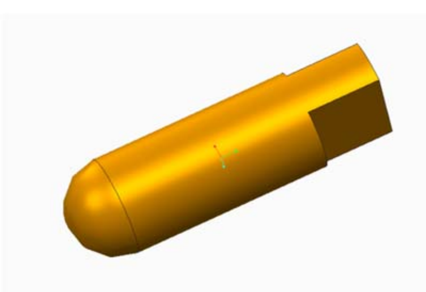

Fig. 2 Screw

The special purpose machine consists of-

- Buffer system
- Linear Bowl feeders
- Clamping device with gripper
- Piston cylinder arrangement with Torsional spring
- Ejecting area
- Stepper motor
- Different types of cylinders

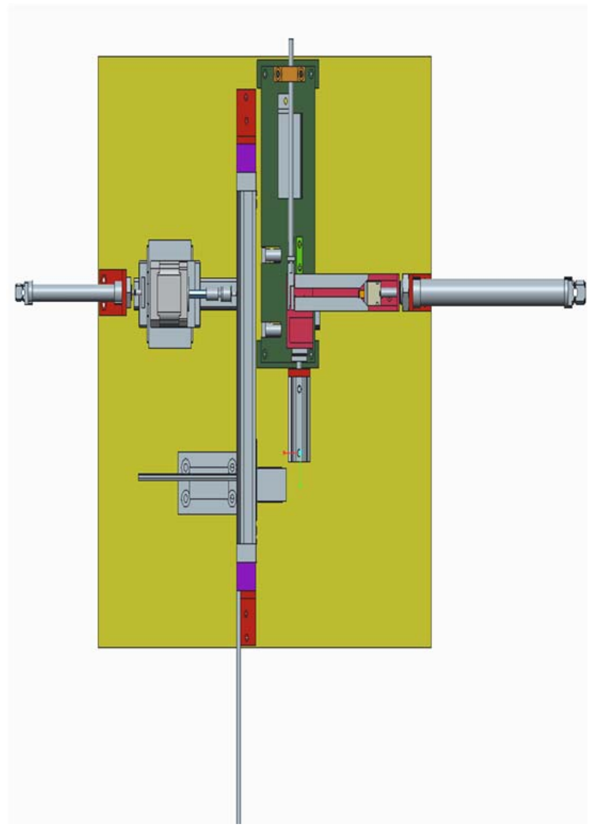

Fig. 3: Front View of SPM

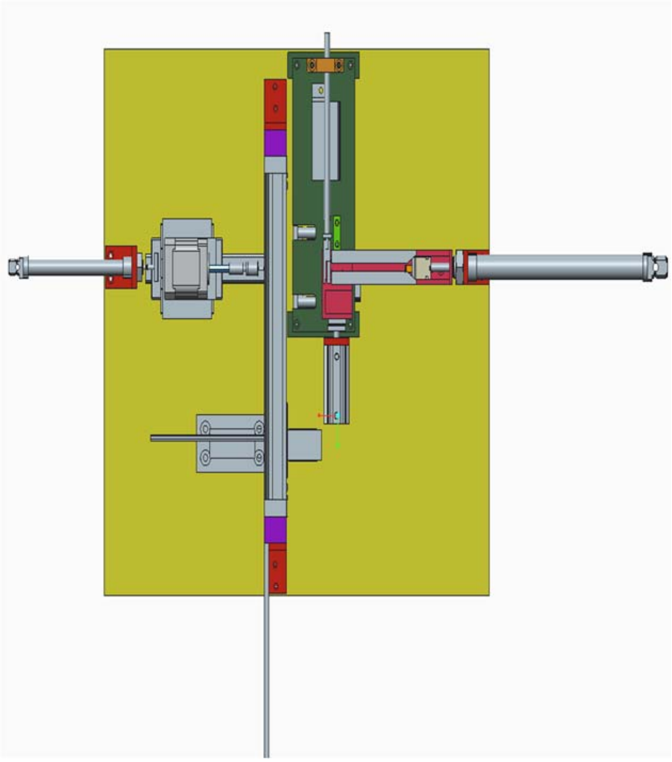

Fig. 4: Top View of SPM

3.1 Flowchart for Operation of SPM

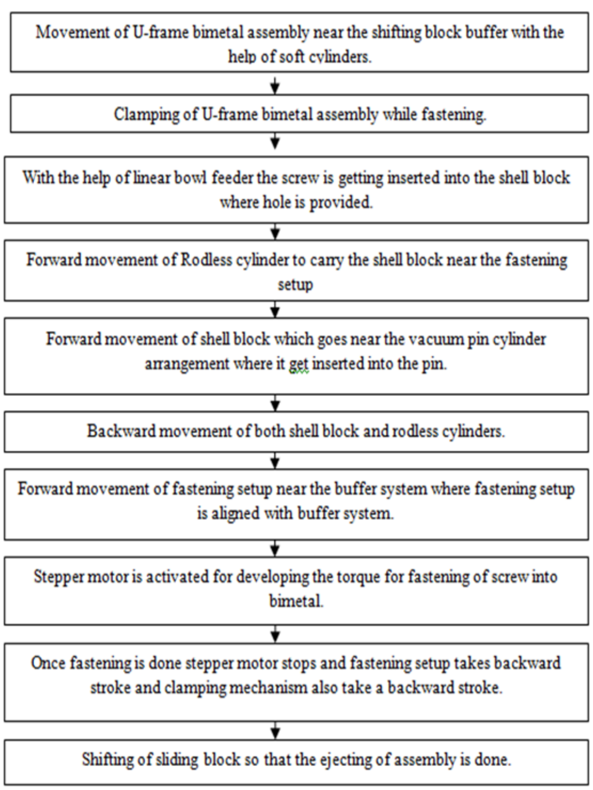

Fig. 5: Flowchart for operations of SPM

4. RESULTS

4.1 Theoretical calculation-

1. Torque required for fastening the screw into U-frame bimetal subassembly.

Torque required for metric screw thread M2, T=0.17 Nm..... {Maryland Metrices Technical Data chart}

This much amount of Torque is required for Fastening of screw into U-frame bimetal subassembly.

Maximum RPM is 16000 for 0.25 pitch... {Maryland Torque-RPM Technical Data chart}

$$RPM = 16000 \times 0.25$$

$$RPM = 4000$$

This much amount is required of RPM is required for 0.17 Nm.

2. Torque generated by NEMA-17 stepper motor for fastening the screw into U-frame bimetal subassembly.

T=0.2Nm, Different losses which is accounted as 10%.

Therefore, Final Torque =Torque-%losses =0.18Nm

3. Axial Force acting due to cylinder on Screw. Cylinder selection is done on FESTO software according to required stroke. Cylinder type DSNU-10-75, Operating Pressure is 5 bar

Axial Force, F=39.2695 N...... {FESTO Catalogue}

4. Force acting on U-frame bimetal subassembly while reaching near the fastening area.

Cylinder selection is done on FESTO software according to required stroke. Cylinder type Soft Cylinder DSNU-16-150, Operating Pressure is 2 bar

Axial Force, F=10 N...... {FESTO Catalogue}

The above theoretical calculation are used in Creo Simulate software for calculating stresses and strain Developed in Screw and U-frame assembly due to forces and Torque.

4.2 Results

Creo Simulate is a structural, thermal and vibration analysis solution with a comprehensive set of finite elements analysis (FEA) capabilities that allow you to analyze and validate the performance of your 3D virtual prototypes before you make the first part.

From the theoretical calculation, F=39.2695N, T=0.18Nm which is applied on the screw and F=10N is applied on the U-frame assembly are given as inputs to the software and corresponding results are obtained.

Steps which is done in stress Analysis

Step 1- Designed model is opened in Creo Simulate.

Step 2- Give material properties and assign the material whose analysis is to be done.

Step 3- Give inputs such as a Force, Torque, and Displacement constraint to the component.

Step 4- Auto Gem, create p-mesh for geometric element modeling.

Step 5- In Analysis and Study

a] Run the analysis.

b] If analysis is completed, Review the results of finite element analysis.

Step 6- If results obtained is less than allowable limit, then it is safe otherwise go back to Step 2.

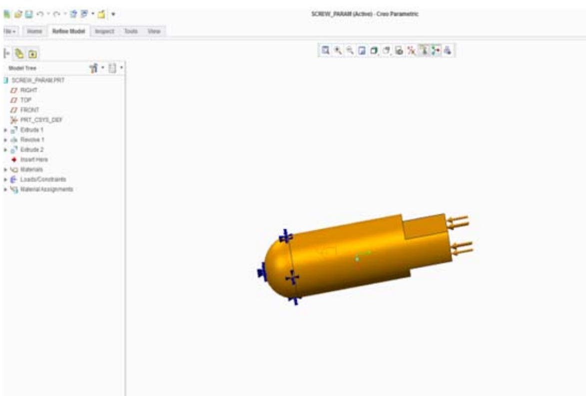

Fig. 6 Application of Force and Torque on Screw

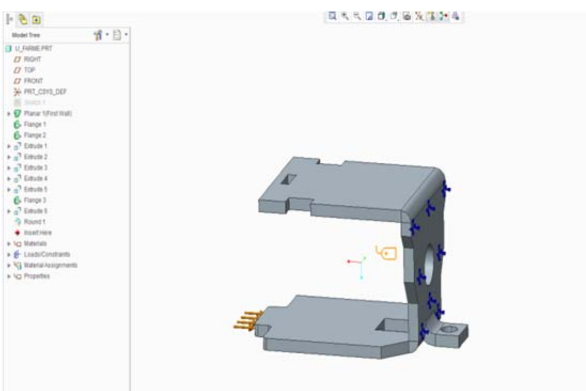

Fig. 7 Application of Force on U frame Assembly

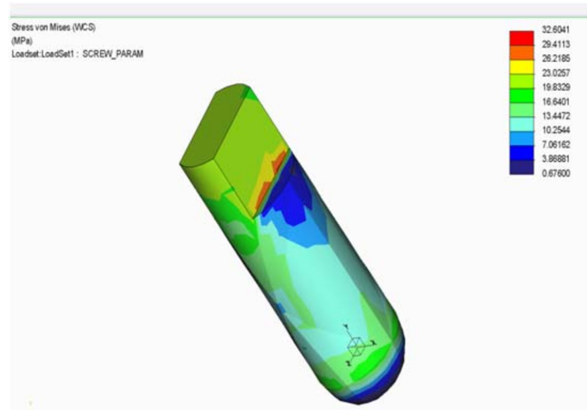

Fig. 8 Stress Analysis of Screw

Fig. 9 Stress Analysis of U Frame Bimetal Assembly

Table 1 Simulation Results

Sr. No	Material	Component Name	Allowable Stress(MPa)	Max. Induced Stress	FOS
1	Brass	Screw	72	32.06	6
2	Copper	U-frame	290	26.9	6

From above results it is clear both screw and U-frame assembly is both safe, as induced stress is less than Allowable stress. (Allowable stress for both materials is taken from material design data book)

5. CONCLUDING REMARKS

Due to its limitation; for manual fastening of screw into bimetal which consumes more time has been overcomed by developing the special purpose machine. In partnership with the operator, the SPM act as a tool to increase the productivity by reducing the fatigue level and human intervention. Development of automated special purpose machine for fastening of screw into U-frame bimetal assembly so that human operator can be eliminated and fastening of screw can be done in a faster and simpler way as compared to existing process. Stress Analysis of moving components are done on different loading conditions and its results are found safe.

REFERENCE

[1] Bennett, S. (1993). “A History of Control Engineering” 1930-1955. London: Peter Peregrinus Ltd. On behalf of the Institution of Electrical Engineers. ISBN 0-86341-280-7.

[2] Bennett, S. (1979). “A History of Control Engineering” 1800-1930. London: Peter Peregrinus Ltd. pp. 47, 266. ISBN 0-86341-047-2.

[3] K Feldmann(1), M Steber(1992) “Screw fastening in Flexible Automated assembly with Computer Integrated Process Control”.

[4] S.S. Malek, Y.J. Chiang and J.E. Mason(1993) “Multivariable Effects on an Automatic Screw Torquing Process”.

[5] P. Howie, "Graphic Simulation for Off-line Programming," Robotics Today.

[6] Nitin Dhayagude, Zhiqiang Gao and Fouad Mrad(1996) “Fuzzy Logic Control of Automated Screw Fastening”.

[7] Mrad, F, Ahmad,S- Adaptive control of Flexible joint using position and velocity feedback.