DESIGN AND VALIDATION OF MECHATRONIC ACTUATOR VIA SPRING LOAD APPROACH

Mr Bisahu Ram Sahu, Dept. of Information Technology

Dr. C.V. Raman University, Bilaspur

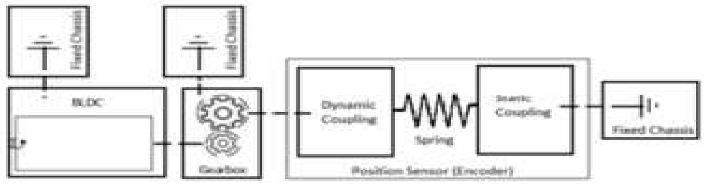
Abstract-In Mechatronic actuators are device which is widely used for different industrial applications such asaerospace, automotive, communications, biomedicine, robotics etc. Researchers are being carried out in order to design a suitable Mechatronic actuator.The production of a new test system is time consuming and cost too much which make it difficult to compensate a mistake caught during performance tests. In this study, a load test system with a spring is designed and a verification studies are made for test system are used for development of a Mechatronic system. In this study, a low cost and high efficiency loading system is takenwhich will be used during the tests of a Mechatronic system.

INTRODUCTION-Mechatronics Systems are system produced by a combination of electronical, mechanical, software (computer) and controller parts. Mechatronics has gained wide application in areas of the aviation industry and in areas such as automotive, communications, biomedical[1] etc.

Mechatronics Actuators are one of an important part of mechatronic systems. it have wide application in actuator applications with hydraulic systems. They have power on lower volumes. They are preferred over hydraulic systems, for low cost, less maintenance requirements and the potential low risks [2][3][4].

In this study, a spring based test system based on Mechatronics Actuators is proposed for testing a DC motor. Firstly, the spring is chosen in order to give a proper opposite effect and then the mechanical parts are designed according to the chosen spring and the system is integrated. Results obtained from the system are compared with the theoretical calculations. The developed test system is intended to be a guide for other researchers with similar research areas.

DESIGNS OF THE SPRING LOAD SYSTEM- Designing a spring load Mechatronics Actuators system steps need to take under consideration arecreating a block diagram of the system, selecting components and sub-systems, three dimensional (3D) draft modeling, 3D real modeling, and finally the production, assembly and re-design of the system[5]. Before starting the design block diagram is being created which shows components, sub-systems and their connections.



Conclusion is derived on analysis of the system are

- Mechatronics Actuator system, which is the BLDC, rotates the shaft and transfers the motion through the gearbox.
- Gearbox regulates the speed and torque of the motor, rotates its shaft and transfers the motion to the coupling system.
- Dynamic coupling rotates and causes the spring to twist around the rotational axis between the static coupling and the dynamic coupling.
- Absolute encoder measures the angular position between the dynamic coupling and the static coupling, and calculates the twisting angle of the spring.
- Spring produces torque, of which the magnitude is proportional to the twisting angle, and transfers the load to the DC motor through the reverse direction to the motion flow.

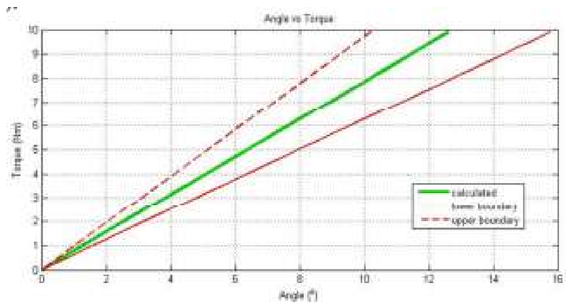
After drafting, 3D model of the spring load system is created. Inwhich coupling system is located at the end of the gearbox shaft, where the absolute encoder is located whereGearbox simulates the whole system's transfer mechanism. Its output shaft directly drives the dynamic coupling. Whereas, fixed chassis holds the static coupling. Thus, the torsion spring between the dynamic coupling and the static coupling twists and causes the load on the mechatronic actuators.[6]

CALCULATION OF THE SPRING PARAMETERS-The base parameter for spring design is the elasticity of the material. Here High Carbon Spring Wire which has a Modulus of Elasticity (E) around 207E9 Pa is taken. While parameters like wire diameter (d), mean coil diameter (D) and coiling number (N). For an efficient spring design, the rate between the nominal circle diameter (D) and the wire diameter (d) has to be greater than 4 and smaller than 20. Spring torque versus twisting angle graph is plotted using the formulas given below [7]:

$$R = \frac{d^4 \times E}{10.8 \times D \times N}$$

$$Q = R \times T$$

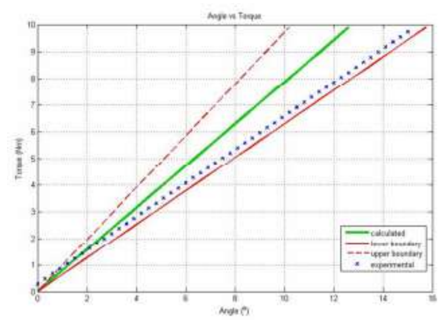
Using the modulus of elasticity (E) and the spring parameter valuesspring torque versus the twisting angle is calculated as shown in fig



COMPARISON OF COMPUTATIONAL AND EXPERIMENTAL RESULTS-

The spring is loaded with torque load.Twist angle of the loaded spring was calculated using the position sensor. Data is collected. First Connection between the dynamic coupling and the gearbox is disassembled. The torque rod is connected to the dynamic coupling and the end of the rod is loaded by mass. Then, the angle through the rotational axis is measured with the position sensor. Finally, the applied torque is calculated using the length of the torque rod, mass and the measured angle.Linearizationresult obtained from the experiment is plotted.

Test	*Angle (°)*	*Torque (Nm)*	*Angle (°)*	*Torque (Nm)*	*Angle (°)*	*Torque (Nm)*
1st test	2.72	1.94	8.48	5.73	14.50	9.34
2nd test	2.69	1.92	8.52	5.75	14.48	9.33
3rd test	2.70	1.93	8.49	5.74	14.50	9.34
Aver.	2.7	1.93	8.5	5.74	14.50	9.34



Result shows that the experimental result mostly lays inside the boundaries of the computational result. At lower torque values between 0-0.25 Nm, no angular movement of the load bar is observed because of friction of the system. The production uncertainties also cause a difference between the experimental and the calculated results. In this graph, the experimental result is very close to the lower boundary. Considering the production parameters, it can be said that the actual wire diameter could be less than the theoretical one and the mean coil diameter could be more than the theoretical one. Alsoheat treatment of the spring can also affect the stiffness []. Even if the material of the spring is defined, applied heat treatment level on the produced spring is related with strength and stiffness[8].

CONCLUSION-In this study, a low-cost torsion spring was designed for Mechatronics Actuator. General system model consisting spring load mechanism, gearbox and Mechatronics Actuator is modeled. Then the spring load parameters are calculated using the mathematical equations and the spring technical drawing is prepared. Finally the designed spring is produced, and tested using a torque rod. The experimental results and the computational results were compared. It was observed that the experimental results lay between the boundaries of the calculated results.

In this study, a torque rod was utilized to verify the stiffness of the spring. As it is difficult to take many measurements using the torque rod, as future work we plan to utilize the MA to directly measure the torque generated by the spring to eliminate the use of the torque rod.

REFERENCES-

[1] R. S. Silva Filho and C. J. Budnik, "An integrated model-driven approach for mechatronic systems testing," in *Proceedings - IEEE 5th International Conference on Software Testing, Verification and Validation, ICST 2012*, 2012.

[2] C. Zheng, M. Bricogne, J. Le Duigou, and B. Eynard, "Survey on mechatronic engineering: A focus on design methods and product models," *Adv. Eng. Informatics*, 2014.

[3] A. Beghi, F. Marcuzzi, P. Martin, F. Tinazzi, and M. Zigliotto, "Virtual prototyping of embedded control software in mechatronic systems: A case study," *Mechatronics*, 2017.

[4] E. Balaban, A. Saxena, P. Bansal, K. F. Goebel, P. Stoelting, and S. Curran, "A diagnostic approach for electro-mechanical actuators in aerospace systems," in *IEEE Aerospace Conference Proceedings*, 2009.

[5] R. Rajamani and J. K. Hedrick, "Adaptive Observers for Active Automotive Suspensions: Theory and Experiment," *IEEE Trans. Control Syst. Technol.*, 1995.

[6] J. Wang and T. Yu, "Design of spring load testing and separating system," in *CCIE 2011 - Proceedings: 2011 IEEE 2nd International Conference on Computing, Control and Industrial Engineering*, 2011.

[7] R. Budynas and K. Nisbett, "Shigley's Mechanical Engineering Design, Ninth Edition," *McGraw Hill Inc.*, 2009.

[8] T. Senthilkumar and T. K. Ajiboye, "Effect of Heat Treatment Processes on the Mechanical Properties of Medium Carbon Steel," *J. Miner. Mater. Charact. Eng.*, 2012.