

DESIGN OF THE TORSIONAL PROPERTIES MEASUREMENT STAND FOR RUBBER-METAL ELEMENTS IN MOTOR VEHICLES

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Abstract: This paper describes design and application of a torsional property measurement stand used for analyzing rubber-metal components. The paper covers mechanical, electrical and control systems. Design of the stand takes into consideration reusing existing components, that come from a measuring stand that was used for analyzing automotive dual-mass flywheels. Paper covers initial design proposal as well as final design in CAD model form and the finished assembled stand. A Section of this paper is dedicated to describing the components and software used to control the stand and collect data from sensor. Programming of the excitation movement cycle in TIA-Portal software is also covered in this section. Lastly it covers experimental analysis. Our findings and evaluation of the machine itself is found in the conclusion chapter.

KEYWORDS: rubber – metal component, bushing, torsional stiffness, programmable logic controller

1 INTRODUCTION

Rubber-metal components in automobiles are crucial for eliminating the transmission of vibrations and dampening them, which increases driving comfort [1]. During driving, individual parts of the car are dynamically stressed, so it is important to analyse rubber-metal components not only under quasi-static but also dynamic loads, especially since the dynamic properties of elastomers used in rubber-metal components depend on the frequency and amplitude. Therefore, the idea arose to create a testing station for analysing the torsional properties of rubber-metal components under various loads, both quasi-static and dynamic [2].

Based on the agreed-upon requirements, the goal of this project is to design a measuring station for measuring the torsional properties of rubber-metal components that meets the specifications of an excitation frequency range from 1 Hz to 100 Hz and an angular amplitude range from 0.5° to 30°.

By modifying an existing machine, a new measurement stand was designed to measure the torsional properties of rubber-metal components, with its mechanical, electrical, and control systems. With the created program, it is possible to start the machine, induce torsional oscillation and carry out experimental analysis.

2 DESIGN OF A MEASUREMENT STAND

Based on requirements for higher precision and cost effectiveness, a design concept was proposed. The design a modification of an existing measuring stand used for analysing dual mass flywheels [7]. The concept consists of a Servo motor, subject rubber-metal component and torque sensor. Rubber-metal component is mounted using interchangeable adapters, which allow the measuring stand to be reconfigured to test different kinds of cylindrical rubber-metal components.

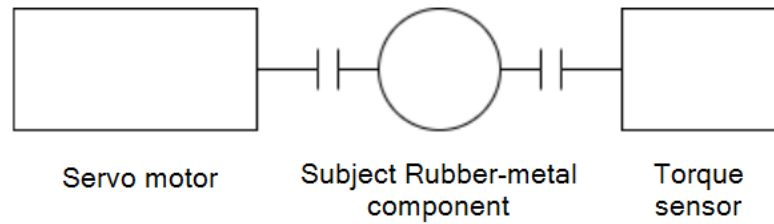


Fig. 1 Schematic of the measuring stand

Components of the measuring stand were designed to be manufactured using subtractive manufacturing. Mounts for the torque sensor were milled out of aluminium. Mounting adapters for mounting the rubber-metal component were turned out of high tensile steel in order to endure the torsional loads.

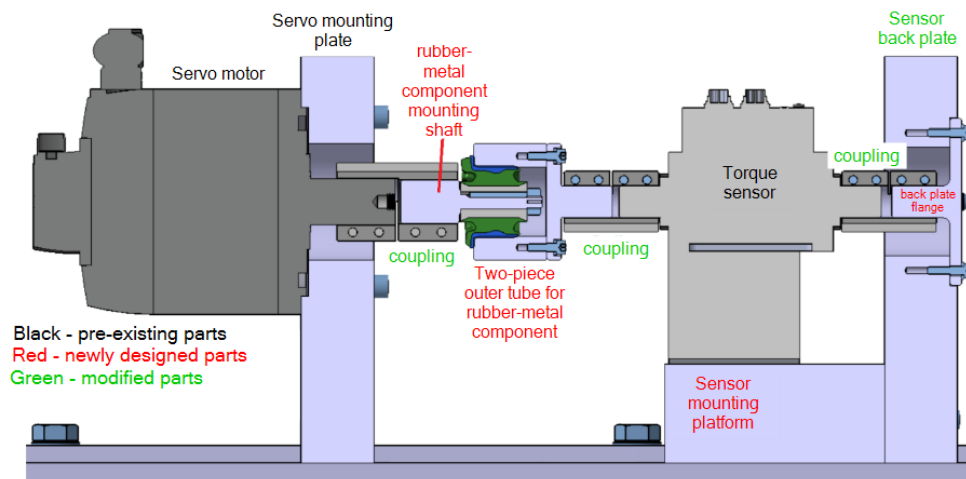


Fig. 2 Cross section of the design of the measuring stand

Final design consists of five newly designed parts and four parts that were modified for this use case. Rubber-metal component mounts using the mounting shaft and is secured with a keyway pin and a nut. This shaft is then coupled to the servo motor using a modified shaft coupling. The coupling had an enlarged inner diameter to fit correctly onto the servo motor. Outer part of the rubber-metal component is pressed into a two-piece outer tube. The outer tube consists of a cylinder with four tapped holes for screws and a hub that bolts to it with those screws. The back side of the hub is then coupled with the torque sensor. Torque sensor is mounted on a platform to ensure coincidence of the axes. Other side of the torque sensor is rigidly secured to a back plate with a flange and a hub using another coupling [5].



Fig. 3 Assembled measurement stand

Figure 3 shows a photo of the finished and assembled measurement stand. Subsequent chapter will cover the control system for the motor.

3 CONTROL SYSTEM FOR THE MEASUREMENT STAND

Control system consists of following components: SINAMICS S120 frequency controller, SIMATIC S7 PLC and a personal computer. SIMATIC S7 PLS [6] contains Siemens 6ES7531 analog-digital converter, which allows us to capture output signals from torque sensor as seen in Figure 4 [4].

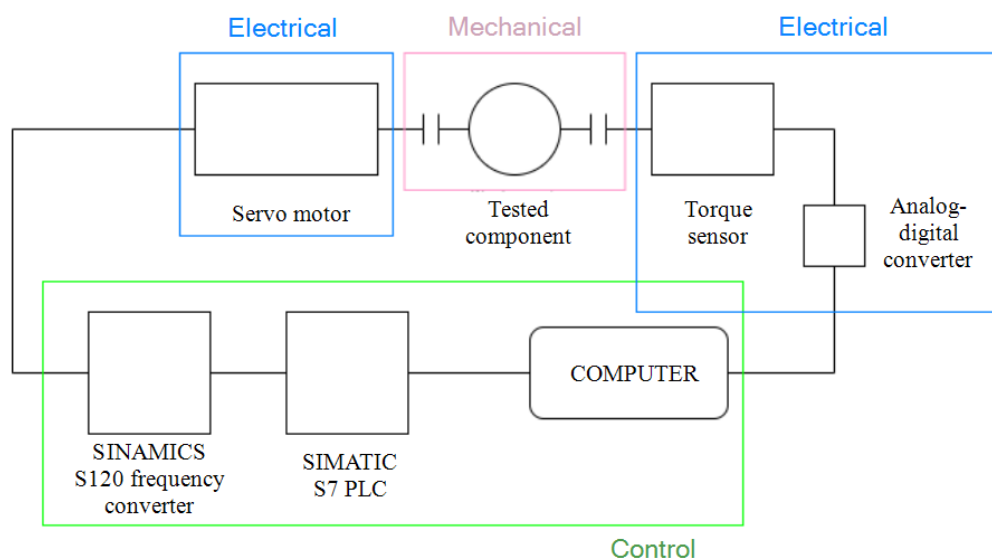


Fig. 4 Complete schematic of the measurement stand

In order to utilize the measurement stand and perform an experimental analysis, a program had to be created. Control software called TIA-Portal by Siemens allows us to specify a movement cycle for the servo motor. For our specific experiment, a sine wave was chosen as the load for rubber-metal component. TIA-Portal allows us to specify the amplitude, in this case degrees of rotation and frequency at which this sine wave happens []. On top of these two main parameters, it allows us to set speed, acceleration and jerk parameters. Figure 5 shows a screen shot of the specified movement of the servo motor.

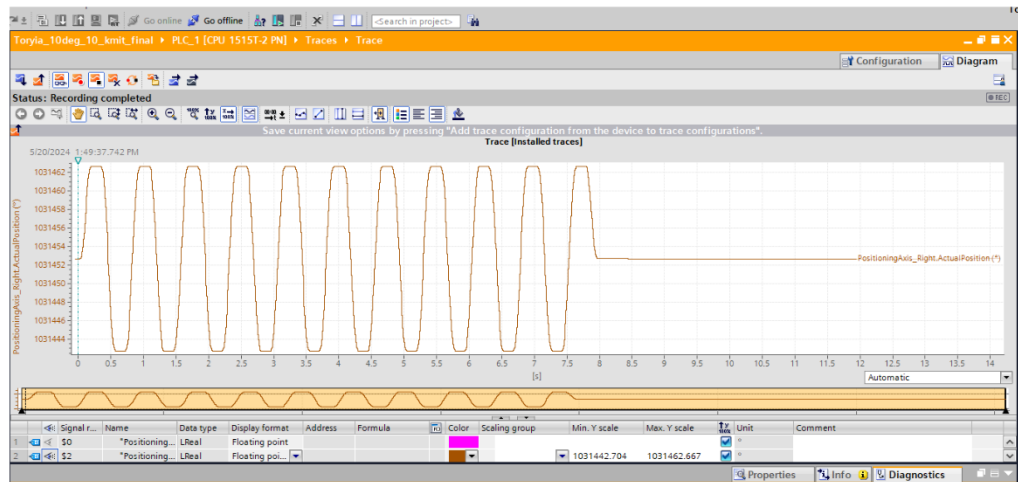


Fig. 5 Sine wave movement of the servo motor

4 EXPERIMENTAL ANALYSIS OF A RUBBER-METAL COMPONENT

Subject rubber-metal component is an automobile suspension bushing shown in Figure 6. Its used in an upper control arm of a double wishbone suspension. This bushing requires high radial and axial stiffness, but torsional stiffness should be low. This is due to the requirement of upper control arm being able to move without much resistance [3].



Fig. 6 subject rubber—metal component, suspension bushing

Subject component will be loaded torsionally by a sine sweep at following amplitudes and frequencies:

Table 1 Torsional loads

Analysis	Frequency [Hz]	Angular displacement [°]
1	1.6	5
2	0.4	10
3	1	10
4	1.25	15
5	1.3	20

First output graph from the analyses displays relation between input displacement produced by the servo motor and output torque reaction of the subject component measured at the torque sensor. X axis represents time of the analysis Figures 7 and 8 show results from analysis number 3.

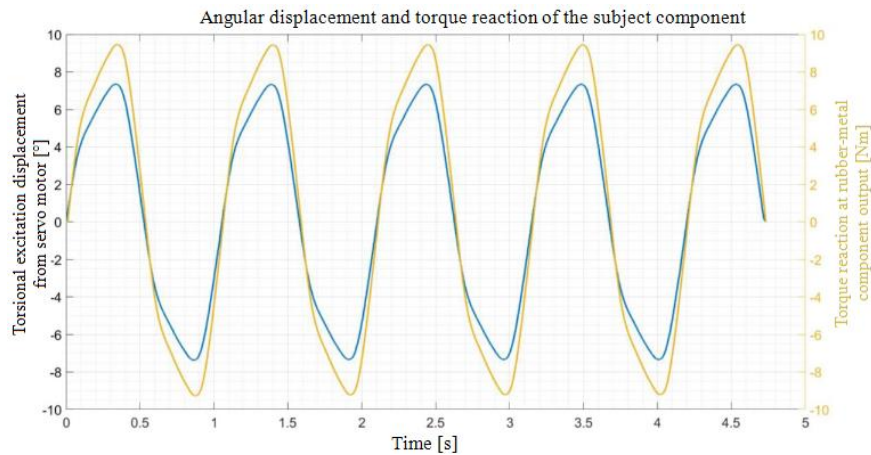


Fig. 7 Angular displacement and torque reaction

Second output graph displays hysteresis curve and torsional stiffness of the subject rubber-metal component.

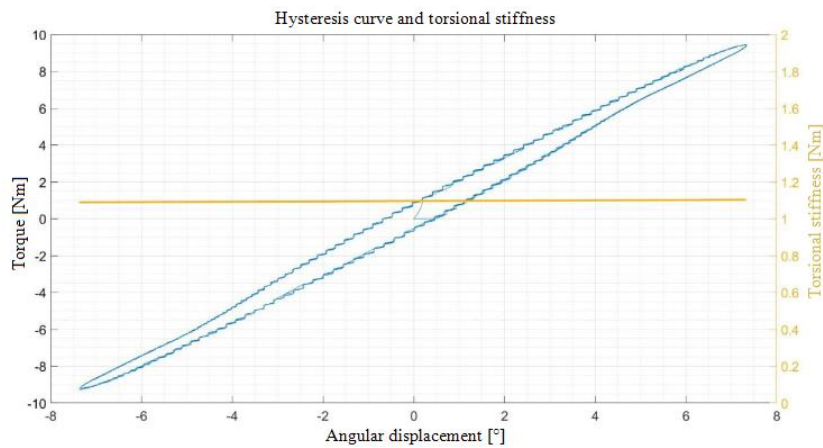


Fig.7 Hysteresis curve and torsional stiffness

CONCLUSION

The aim of this paper was to design a measuring station for assessing the torsional properties of rubber-metal components based on agreed-upon requirements. The paper covers the design of the machine, the electrical section, the control section. The paper concludes with experimental measurements of the torsional properties of a selected part.

By correctly designing the parts with appropriately chosen tolerances, coaxial alignment was achieved, allowing for trouble-free assembly, disassembly, and exchange of fixtures at the station. Measurements of torsional properties at various excitation frequencies and amplitudes were also successful

The advantages of the measurement stand are its simplicity, versatility, and low cost due to the use of an existing machine. It can efficiently measure almost any rotational rubber-metal part once the adapters are made. While we were not able to achieve full frequency range from 1 Hz to 100 Hz during experimental analysis, its believed that with further adjustments in the programming of the excitation movement cycle its possible to achieve the whole range.

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