Stress and deformation analysis of single actuator double acting electro-mechanical CVT Pulley

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ABSTRACT: This study focuses on the pulley's deformation and stress analysis of the Single Actuator Double Acting Electro-mechanical (SADAEM) Continuously Variable Transmission (CVT) system. The system operates by axially moving both sides pulley simultaneously which controlled by one DC motor. This system also uses electro-mechanical actuation to vary the gear ratio. The finite element analysis is performed using the Sim Solid software. The analysis is carried out in different working conditions such as under-drive, neutral and over-drive. For all investigated parameters, the value of maximum stress is 19.32 MPa which is below the value of pulley material yield strength 207 MPa. Then recorded value of the lowest maximum deformation is 0.003 mm at under-drive working condition. It grants the assurance that the analysis results on the pulley in different conditions is essential and can be referred to develop the prototype of the SADAEM CVT system.

Keywords: *Deformation analysis; Stress analysis; Pulley*

1. INTRODUCTION

The SADAEM CVT system is a transmission that has two types of pulley which are located at the drive side and the driven side. At each side, pulley is constructed of sheave cones facing each other. The input of the drive side is connected to engine and the driven side is coupled to the final drive. This system consists of one DC motor to supply direct current and control the axial movement of the pulleys at both sides with an assistance of power screw and top linkage mechanisms [1]-[2]. The drive and driven pulleys are connected via metal belt or variable rubber belt whereby it transfers and holds the different values of the force and torque from input to the output pulley sides [3]-[5]. Therefore, the stress and deformation behavior at pulley during different working conditions is essential to investigate.

2. METHODOLOGY

This study begins with the 3D modelling of the SADAEM CVT system pulley set in CATIA software. Both sides of pulley have same geometry and material properties which is steel. The analysis will concentrate at the driven side pulley since it received high force and torque from drive side pulley via metal belt during under-drive condition [6]. Figure 1 shows pulley and other assembled components at the driven side.

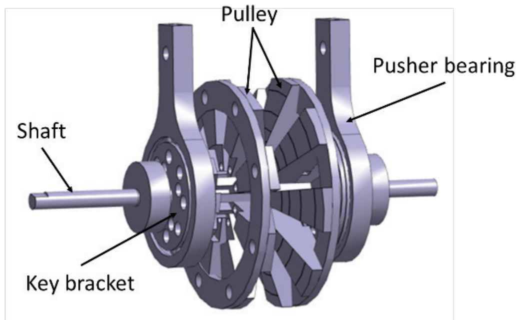

Figure 1 Driven pulley assembly

Then, in simulation using Sim Solid, the normal force acting between the pulley surface and belt are assumed to be same. The normal force is set to 21,000 N [6]. The position of normal force acting on the pulley surface is vary depends on the belt radius at under-drive, neutral and over-drive conditions as shown in Table 1.

Table 1 The belt radius at pulley in different conditions

Condition	Drive side (m)	Driven side (m)
Under-drive	0.022	0.064
Neutral	0.043	0.043
Over-drive	0.066	0.020

3. RESULTS AND DISCUSSION

This section explains the simulation results of the deformation and stress analysis occurred at the driven pulley in different conditions. Figure 2 shows the stress analysis on the driven pulley at under-drive condition. As shown in Figure 2, the maximum stress of the driven pulley is 19.32 MPa whereby the high stress is displayed by red contour and occurred at the belt radius clamped area. Moreover, this maximum value is still under the yield stress which is 207 MPa.

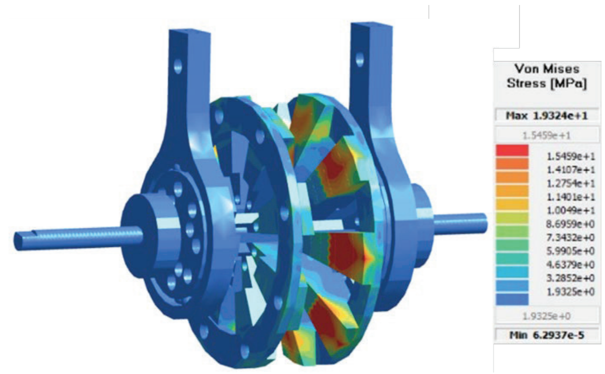

Figure 2 Stress analysis on driven pulley during under-drive condition

Figure 3 depicts the deformation analysis on the driven pulley at under-drive condition. Figure 3 shows the maximum deformation of the driven pulley is approximately 0.003 mm. The deformation is very small even at the high stress area. Most of the deformation is occurred on the pulley surface about 0.064 m radius and slightly deformation happened at the back of the pulley surface.

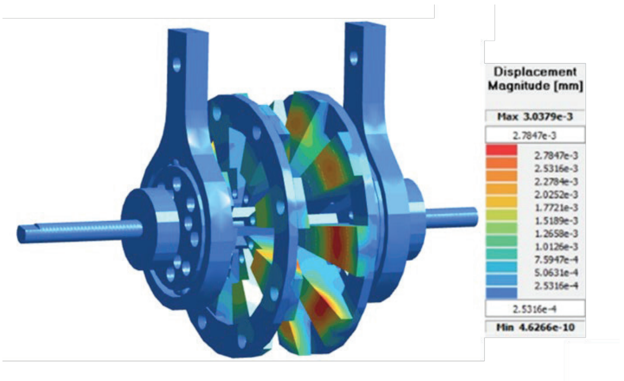

Figure 3 Deformation analysis on driven pulley during under-drive condition

The summarization results of the maximum stress and deformation values occurred at driven pulley during under-drive, neutral and over-drive are shown in Table 2. The results show that under-drive condition experienced high maximum stress and maximum deformation compared to other conditions. This is due to the concentrated force and stress on the specific pulley surface that occurred along the driven pulley radius.

Table 2 Maximum stress and deformation at driven pulley in different conditions

Condition	Stress (MPa)	Deformation (mm)
Under-drive	19.32	0.0030
Neutral	17.86	0.0020
Over-drive	10.26	0.0005

The outcome of this research work was compared with pulley analysis results of the EMDAP CVT system. Although the values are not same because of different pulley system design, both studies are stated the same conclusion, whereby the maximum stress and displacement are happened during under-drive condition at the driven pulley [6].

4. CONCLUSION

The analysis on the driven pulley during the under-drive, neutral and over-drive conditions was carried out successfully. The driven pulley was selected due to it received high force and torque transferred from the drive pulley via metal belt. In Sim Solid software, the deformation and stress were analysed and the maximum values were determined. For all investigated parameters and conditions, the driven pulley experienced the highest values of maximum stress and deformation but still below the yield strength. Therefore, the SADAEM CVT system pulley is capable to withstand the force and torque from the engine in any running conditions.

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