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Implementation of Ball Screw Drive Mechanism in MRT Putrajaya Line Platform Screen Door

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Abstract: A platform screen door with a belt system was used on the Putrajaya Line. This method has several drawbacks and adds to a number of issues when the door is opened and closed. Maintenance is difficult due to the tight area and location of the belt system. As a result, if a problem with the belt or motor arises, it takes longer to resolve. The belt needs to be adjusted as well, as it may loosen with time. To overcome this difficulty, a ball screw drive mechanism is developed with better performance. This project will compare the belt drive and ball screw drive mechanism with the goal of developing a new drive mechanism for the Putrajaya Line.

Keywords: Platform Screen Door, Drive Mechanism

1. Introduction

Given that public safety has risen to the pinnacle of government responsibilities, mass transportation networks have been undergoing a sea shift in terms of safety ideas and activities. Platform screen doors have been gaining huge popularity in fast-growing metropolitan centers, with both governments and the general public expressing a need for safety devices [1].

Platform screen doors are a new type of secure security system that is used in subways and on platforms to separate the platform from the train. Fixed and sliding doors are installed and fixed at a secure location near the platform edge, approximately 10-20 cm away [2]. Sliding doors interact with car doors, opening and closing as a signal to operate at a designated place. They are a relatively new addition to many metro systems around the world, some having been retrofitted to established systems. They are widely used in the Asian and European metro systems [3][4].

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For every ASD, the PSD door drives consist of a motor, driving gear, control, and monitoring equipment. It also includes electrical actuators and belt drive systems, as well as complete bi-parting door operation [5]. The motor will operate the two-door leaves through the belt drive mechanism, which is placed on resilient mounting, and the door trolley assembly [6].

To ensure that train operations are not disrupted, high-reliability platform screen doors are necessary. In order to ensure that the MRT Putrajaya Line operates without a problem, the goal of this project is to develop a ball screw drive mechanism model that is highly efficient and repeatability.

1.1 Problem Statement

Putrajaya Line uses a belt mechanism that is difficult to maintain. Because of the limited space and placement of the belt mechanism, it can be challenging to perform the task during maintenance. As a result, adjusting the belt tension and motor takes much longer than the time allocated.

Establishing this project will compare both types of the drive mechanism and increase comprehension by emphasizing important features and issues so that future problems can be avoided. The information then can be used to develop a new ball screw drive mechanism for Putrayaja Line.

1.3 Objectives

The objective of this project is to determine the mechanism of the belt drive and ball screw drive. In the second, to develop a simulation model that is high in accuracy and repeatability. Then, to analyze the model’s performance in term of speed, repeatibility and moving load range.

2. Methodology

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study.

2.1 Ball screw selection

Focuses on the approach that will be utilized to meet the objectives of the project, and progress to develop a simulation model suitable for the MRT Putrajaya Line PSD.

The method for choosing the type and specifications of a ball screw to operate as a 3D model in the simulator is shown in Figure 2.1. Every specification must conform to the standards established by the MRT Putrajaya Line PSD. This is performed so that the model can be used in the PSD and have features and characteristics that are similar to those of the belt drive system. If the ball screw model does not comply with the required criteria, additional adjustments must be made to make the model more closely reflect the operational characteristics of the belt drive mechanism [7].

The ball screw specification need to be selected for evaluation, and its suitability for this project is shown. A few test are needed to prove the design's effectiveness after it has been developed. The lead angle accuracy must be ±0.09 mm/300 mm or higher [8].

A ball screw must have an axial clearance of 0.15 mm or less in order to meet the 0.15 mm backlash requirement [9]. Therefore, the developed model should follow this requirement to function accurately during the operation.

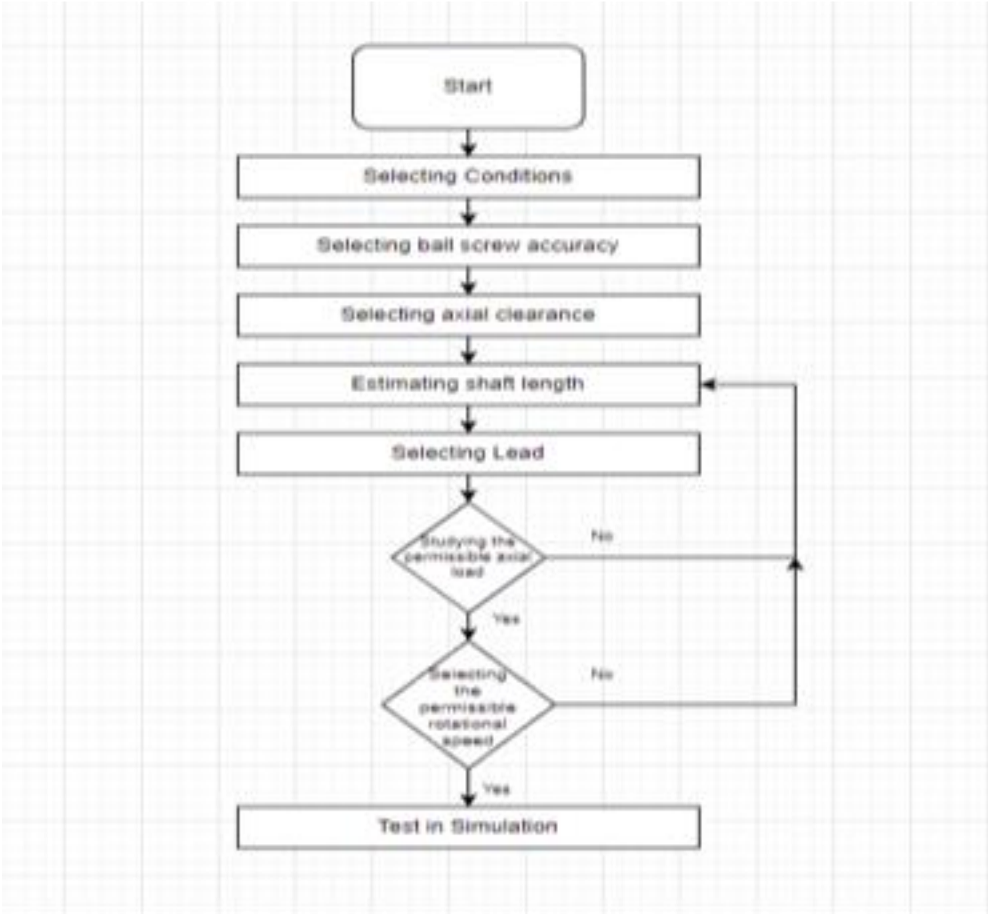


Figure 1: Workflow for selection of ball screw

2.2 Modelling of the Ball Screw Drive System

The 3D ball screw system and the architecture are designated at this point using Solidworks 3D CAD. At this stage, a model from the driving system utilized in Japan is being used as a guide. A prototype was made to capture the system requirements suitable for the PSD on the MRT Putrajaya Line. The result of this phase is shown in Figure 2.

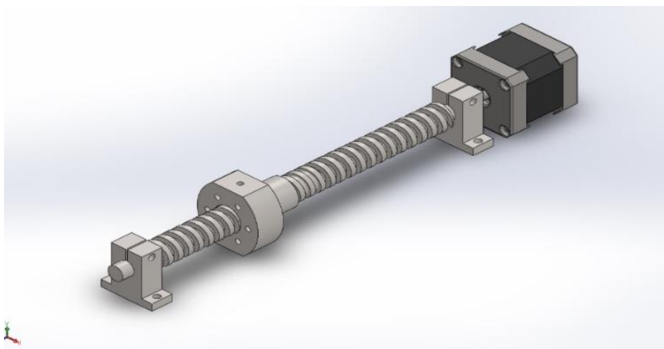


Figure 2: 3D model of ball screw system

2.3 Recurdyn for Dynamic Motion Simulation

The ball screw drive will be simulated in Recurdyn and Solidworks to compare the performance of the two drive mechanisms. The outcomes will be measured in terms of velocity, acceleration, and moving load range. Figure 2.3 shows a 3D representation of the ball screw driving mechanism. A simulation test will be performed to determine the new drive mechanism's dependability. Data will be gathered and recorded, and an analysis will be carried out to assess the ball screw drive mechanism.

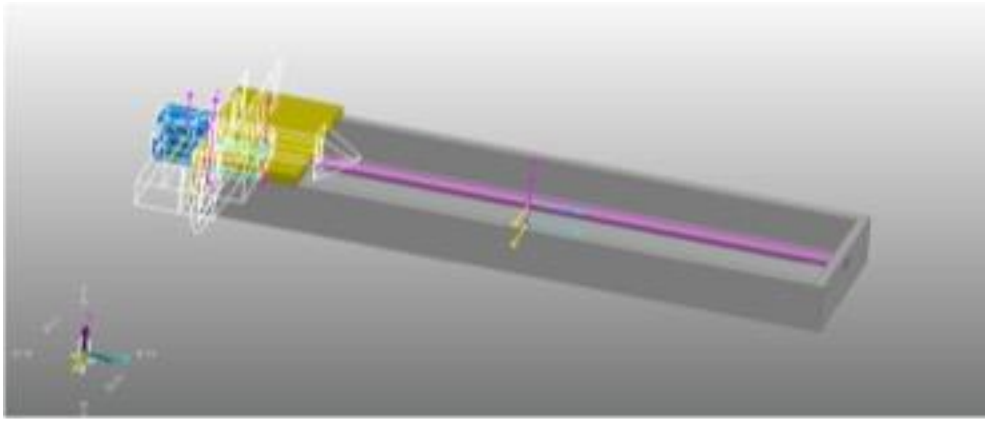


Figure 3: Multi-Body Dynamic of Ball Screw Drive Mechanism

2.4 Solidwork for Stress Simulation

To find out more about the stress load for ball screw and belt drive mechanisms, Solidworks SimulationXpress was used to simulate the situation. It is a quick analytical tool that can help with the assessment of design options. Without creating loads or boundary conditions, it may analyze stress, factor of safety, and deformation of the components. A calculated motion analysis research provides the necessary loads automatically. Only stress analysis will be performed for this paper, and it will show how motion loads affect one component's deformation and stresses. Belt and ball screw are the elements in this situation.

3. Results and Discussion

The idea and outcomes are shown in this chapter. The ball screw specification need to be selected for evaluation, and its suitability for this project is shown. A few tests are needed to prove the design's effectiveness after it has been developed.

3.1 Complete set up of the project

The project is being set up according to Figure 4. The 0.6 m/s speed that is appropriate for door operation was achieved by the ball screw model. Additionally, it has a maximum PSD load resistance of 5000 N. Figures 4 shows the components used for the multi-body dynamic set up in Recurdyn simulation. The guiderail will be fixed in place to ensure that the test only reflects stress and displacement on the ball screw.

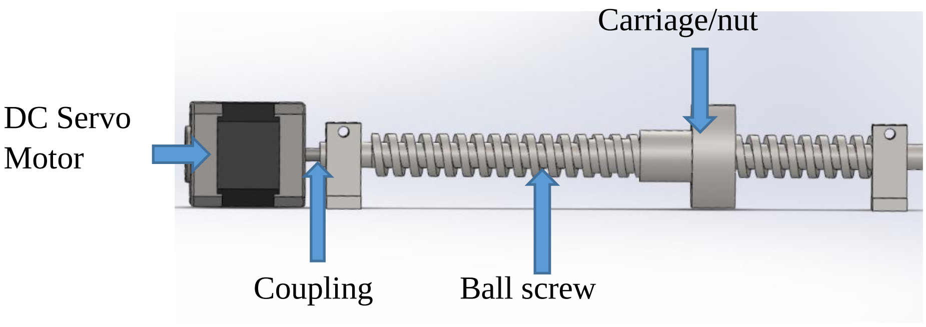


Figure 4: Complete set up of the project

3.2 Analysis of the data for the drive mechanism's speed in normal operation

Figure 5 shows the simulation output for the ball screw and belt drive under the specified operating circumstances. This simulates the operation of ASD opening during the operation time at the station. The ASD opening time curve parameter is 3.5±0.1s. The driving mechanism's speed shouldn't be higher than 0.6 m/s. There shouldn't be any operational issues as long as the drive mechanism complies with the specifications. The graph shows that the belt drive is slightly faster than the ball screw. The belt drive, however, has less steadiness. Fast RPMs caused by moving at a high speed resulted in belt tensioning over time, necessitating preventative periodic adjustments. Belt drive functions well at high speeds but poorly at low speeds and over short distances. The next analysis proves that the belt drive high speed contributes to lower accuracy and repeatability.

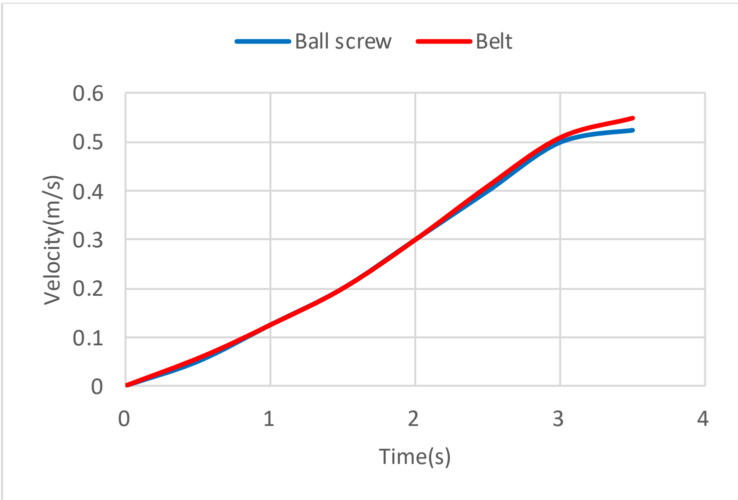


Figure 5: Normal operation speed

3.3 Analysis of the data for the drive mechanism in continuous operation

The efficiency of both drive mechanisms is shown in Figure 3.3. In the simulation, the motor ran for 500 cycles—two cycles every minute. The partial acceptance test, which requires that the PSD pass a 240-cycle test, sets the parameters. It can be seen how, for the belt drive, the velocity reduces over time due to the belt tension. Belt drives require periodic tensioning because some timing belt materials are prone to gradual elongation and are more susceptible to impact (shock) loads. Ball screw drives are more difficult to back-drive than belt drives. Thus, ball screws are preferred by heavy industries for use in heavy-duty operations. It can be seen that the proposed models can be used for time-dependent reliability assessment of drive systems.

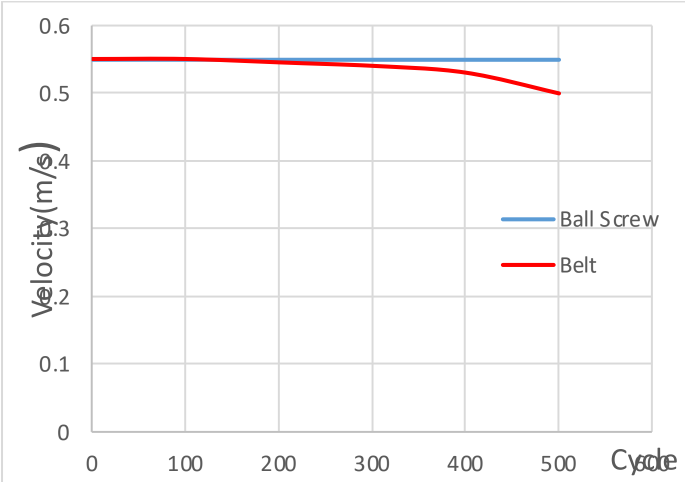
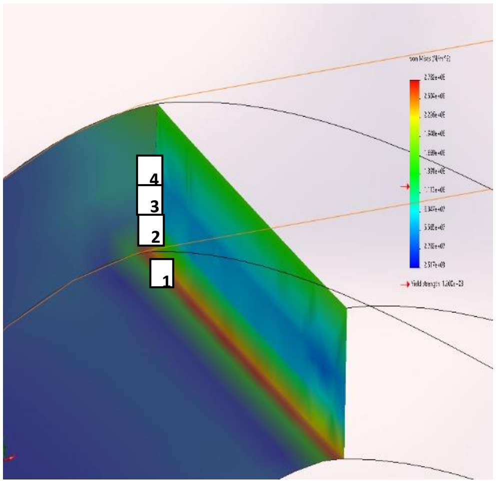


Figure 6: Continuous operation repeatability

3.4 Analysis of the bending stress



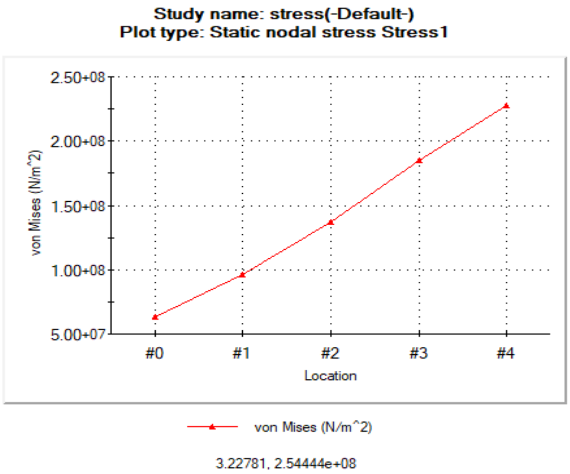


Figure 7: Belt bending stress

Figure 7 shows the bending stress on the belt. At the inward side of the belt, the stress level rises faster.

The pulley area has the largest tension, which increases inwards. With a load of 2500 N, silicone (permanent) deformation will begin. Silicone deformation does not indicate material failure; rather, it indicates that a component has been moved beyond its elastic capabilities, resulting in permanent deformation when unloaded. The belt may snap under full load of 2500 N. The analysis's findings regarding the distribution of stresses revealed that the pulley and belt's point of contact experienced the highest levels of stresses. The inner layer of the belt in a belt drive system is under tension, whilst the outside layer is under compression. The graph in Figure 7 demonstrated how the tensile stress on the belt's inner layer may result in silicon failure and belt crippling. Therefore, it is crucial to minimize these stresses. In actuality, there are two rollers on each side to sustain the load. The roller directs the belt while assisting in stress reduction.

4. Conclusion

The efficient implementation of safe and comfortable transportation while pursuing barrier-free facilities and increasing the quality of passenger services is thought to be the primary future issue for railroad traffic service providers. From this standpoint, a high reliability platform screen door with a high-performance drive mechanism is seen to be a valuable equipment to ensure a smooth train operation.

In this project a simulation model of the ball screw drive system was constructed based on lumped parameter model of ball screw feed system, which can be used to study the dynamic characteristics and motion behavior of the feed drive system. Taking a Japan ball screw drive system as an example, an electromechanical co-simulation model was built up. Simulation result shows that, the developed model of ball screw feed drive system is ready to use for MRT Putrajaya Line PSD. From the simulation result, the developed model of ball screw drive system could achieve a very good reliability and accuracy. he proposed models can be used for time-dependent reliability assessment of drive systems.

By prioritizing the concept of no train disturbance, this platform screen door drive mechanism unit has been designed to be extremely dependable, low-cost, easy to maintain and manufacture, and operable with stability for a long period of time.

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