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Door Design and Control System In High Speed Train - Case Study Kereta Cepat Merah Putih (KCMP)

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ABSTRAK

Pengembangan riset di bidang kereta cepat merupakan kemandirian teknologi transportasi dan link and match antara industri dan akademisi, khususnya perkeretaapian di Indonesia. Penelitian bersama dari konsorsium perguruan tinggi INKA dan KAI berencana untuk merealisasikan kereta cepat yang dinamakan Kereta Cepat Merah Putih (KCMP). Desain pintu penumpang dan teknologi kontrol merupakan perangkat pendukung di dalam gerbong kereta. Pembuatan pintu geser plug memiliki keunggulan dalam hal keandalan dan pengurangan kebisingan. Skema yang digunakan dalam pengendalian pintu terdiri dari pembukaan, penutupan dan tindakan ketika terjadi gangguan atau kondisi jebakan dalam operasi.

Kata Kunci- *Sistem Kontrol Pintu, Kereta Api Cepat, Pintu Geser, Kondisi Gangguan.*

ABSTRACT

The development of research in the field of high speed train is an independence of transportation technology and a link and match between industry and academia, especially trains in Indonesia. Joint research from college consortium INKA and KAI plans to realize a high speed train called Kereta Cepat Merah Putih (KCMP). The passenger door design and control technology are supporting device in the train carbody. Making sliding plug doors has advantages in terms of reliability and noise reduction. The scheme used in door control consists of opening, closing and action when there is fault or trap condition in operation.

Keywords*: Door control system, High Speed Train, Door Sliding plug, Fault Conditio*

1. INTRODUCTION

Transportation is the one of major factors affected to country economic growth. The development of economic mega-urban in 2045 pushed government to realize multi transportation mode that connected in among region. The better transportation facilitated citizen to move in one region to others easily. The movement of people related with each other exchanged oney so the even distribution reached.

High speed train development research already conducted by Japan, China, France, Italia, Maroko, South Korea, UEA. The faster train to transport made time efficiency of travelling. The on-going research about Indonesian high speed train conducts by concortium researcher. By this project, Indonesia going to build high speed train helped by College Consortium, Indonesian Railway Industry (INKA) and Indonesia Railway Company (KAI) which named Kereta Cepat Merah Putih (KCMP).

Door components are one of the supporting factors in railway construction which also has a vital function. The design of the railway door consists of driving door and also a passenger door. In passenger doors, the selection of types of train door designs, especially in high-speed trains, should have a high level of reliability, be easy to operate and reduce noise [3]. Based on the driving factor and its structure, the following are the types of passenger doors contained in the construction.

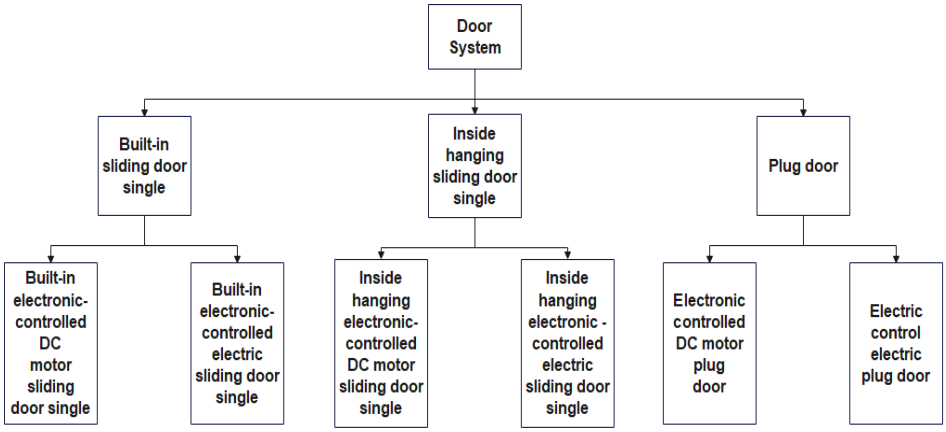

Figure 1. Passengger Door Types

Based on the type of door mentioned in figure 1, slidding plug door is a type of door that has high reliability, because the plug factor is a door lock and slidding is an automatic drive that makes it easier for passengers to get in and out. In addition, the sliding plug door has high noise suppression, so that the fast train track has better performance than other types of doors [4]. Train doors are a complex electrical and mechanical system that performs the task of getting passengers on and off the train. It is a key component that isolates the indoor and outdoor environments of high-speed trains, effectively reduces obstacles and noise during train operation, and provides a comfortable travel environment for passengers.[7].

High-speed trains have posed significant challenges in designing for vehicle noise, vibration and harshness. In particular, wind noise becomes a significant source of noise on high-speed trains due to the loss of engine noise. To prevent wind noise, water and dust from entering the interior of the vehicle, the inner door belt weather strip is attached to the door trim and contacts the side door glass through an elastomer-based part called the lip. Thermoplastic elastomers are increasingly being used. significant attention as a weatherproofing material due to its recyclability and lighter weight compared to thermoset elastomers.[8]

Entrapment accidents, such as fingers hitting doors and passengers accidentally being dragged by trains, are serious problems. Accidental pulls are often caused by a thin bag, strap, walking stick, or stroller wheel accidentally getting caught between a closed door. To prevent such accidents, several safety devices and systems have been developed. For example, anti-trap control system, camera-based anti-trap protection system [9].

Designing high speed train door system cannot be separated from calculating error factors when failure occurs. Fault detection is important to ensure train and passenger safety [5] so reilway control systems are considered as being safety criminal [1][2] one of which is when the passengers are not finished in the process of exiting or entering, the door is automatically closed. From the case study in this study, research was carried out on the design of the door control system by paying attention to the fault condition in the design of the slidding plug door.

2. METODOLOGI

2.1 Mechanical

In accordance with the High Speed Train operational plan in Indonesia, the design and material of the door engine must be able to withstand the environmental conditions in Indonesia[10], as below:

1) Relative humidity between 40% - 90%
2) Ambient Air Temperature between 18 °C – 40 °C
3) The average height above sea level is 1200 mm

According to the application, the door will be designed as an outside single sliding plug with a door mechanism designed for Left Hand (LH) and Right Hand (RH) types. The Door Engine System must meet the following characteristics:

1) Reliable
2) Easy to assemble
3) Easy to maintain
4) Light
5) Safe to use
6) Sturdy and anti-corrosion
7) The speed of opening and closing is medium
8) Control system according to the application

2.1.1 Dimensions

Dimensional design relates to automatic door control systems. The dimensional designs created and simulated in Autodesk Inventor software include: Door System Width, System Door Height, Door Portal Thickness, Opening Width, Opening Height, Door Leaf Thickness.

2.1.2 Material

Wrought aluminum alloy 6005 T5 is used as the train structure material. The material has several better properties than other types of Aluminum, such as suitable extrusion and easy surface maintenance. The characteristics of Aluminum alloy 6005 T5 are that it is versatile, can be heat treated, is very easy to form, can be welded, and has quite high strength coupled with excellent corrosion resistance. Properties of Aluminum alloy 6005 T5[11][12].

Coconut fiber has a similar structure to existing dampers. on the other hand, Indonesia produces coconuts in large quantities. According to the Central Statistics Agency, in 2021 the area of coconut

plantations in Indonesia reached 3,343.60 ha. And according to the Central Statistics Agency, coconut production in Indonesia will reach 2.87 million tons in 2022. From the abundant coconut harvest in Indonesia, a very abundant by-product in the form of coconut fiber will be produced. This is because the coconut fiber content produced from a coconut is around 35% of the weight of the fruit. However, not all available coconut fiber is used optimally. Therefore, in designing this door system, we plan to add material to the door in the form of coconut fiber, where coconut fiber meets the sound dampening requirements according to the ISO 11654 standard[6].

2.1.3 Work Steps

1) Automatic or semi-automatic doors and door operation must be smooth and bump-free. Seamless during travel and while the door is opened and closed must be.
2) The door operating speed can be controlled easily. If using a pneumatic system, air mufflers are provided at the exhaust port to reduce noise levels.
3) An automatic door sensor is provided to prevent serious damage if an item is trapped between the door leaves. The sensitivity of this tool will be adjusted according to the door's needs.
4) Manual locking will be provided to isolate electrically or pneumatically if there is damage and the door cannot close completely.
5) Electrical or pneumatic components are easy to remove, easy maintenance access, repair and replacement are also easy.
6) Alarm and indicator lights are provided on the outer wall near the door.

2.2 Electrical

Electrical is a scientific principle that covers things that require electrical power in their application. The electrical system in the door system is an electrical circuit that is arranged to carry out a certain function. In other words, all systems that utilize electrical energy sources fall into the category of train electrical systems[13]. There are several functions of the electrical system in the door system:

a. Assist in the process of turning on the door system components, so that the door system can work according to its function.
b. As a security and safety system in machine components.

2.2.1 Power

To produce electrical power in the door system, there is distribution of electrical power from the Pantograph which is tasked with distributing electricity intake from the LAA (Listrik Aliran Atas) cable then to the main switch box then channeled to the DC converter and distributed to the SIV (Static Inverter) so that the door system gets power from the SIV.[14]

2.2.2 Control

The process of setting or controlling one or several quantities (variables, parameters) so that they are at a certain price or within a certain price range. Opening and closing the train doors is operated by the monitor display on the dashboard, where the monitor display commands the TCMS and distributes the command to all DCUs on the High speed train.

2.2.3 Safety

Train safety protection sensor network is a modern equipment capable of autonomously monitoring working condition and actively control emergent faults[15]. The train door machine control and monitoring system is a system that aims to ensure the safety and comfort of train passengers. This

system works by controlling and monitoring the train doors so that they can open and close properly, and ensure that no passengers are pinched or trapped inside the doors. This system is very important to prevent accidents and ensure the safety of train passengers. In operation, this system uses sophisticated sensor and control technology to ensure the train doors function properly and safely.

3. METHODS

Electrical design relates to the automatic door control system on the slidding plug door. The electrical control design is simulated on Arduino and Proteus software, here is the research flowchart:

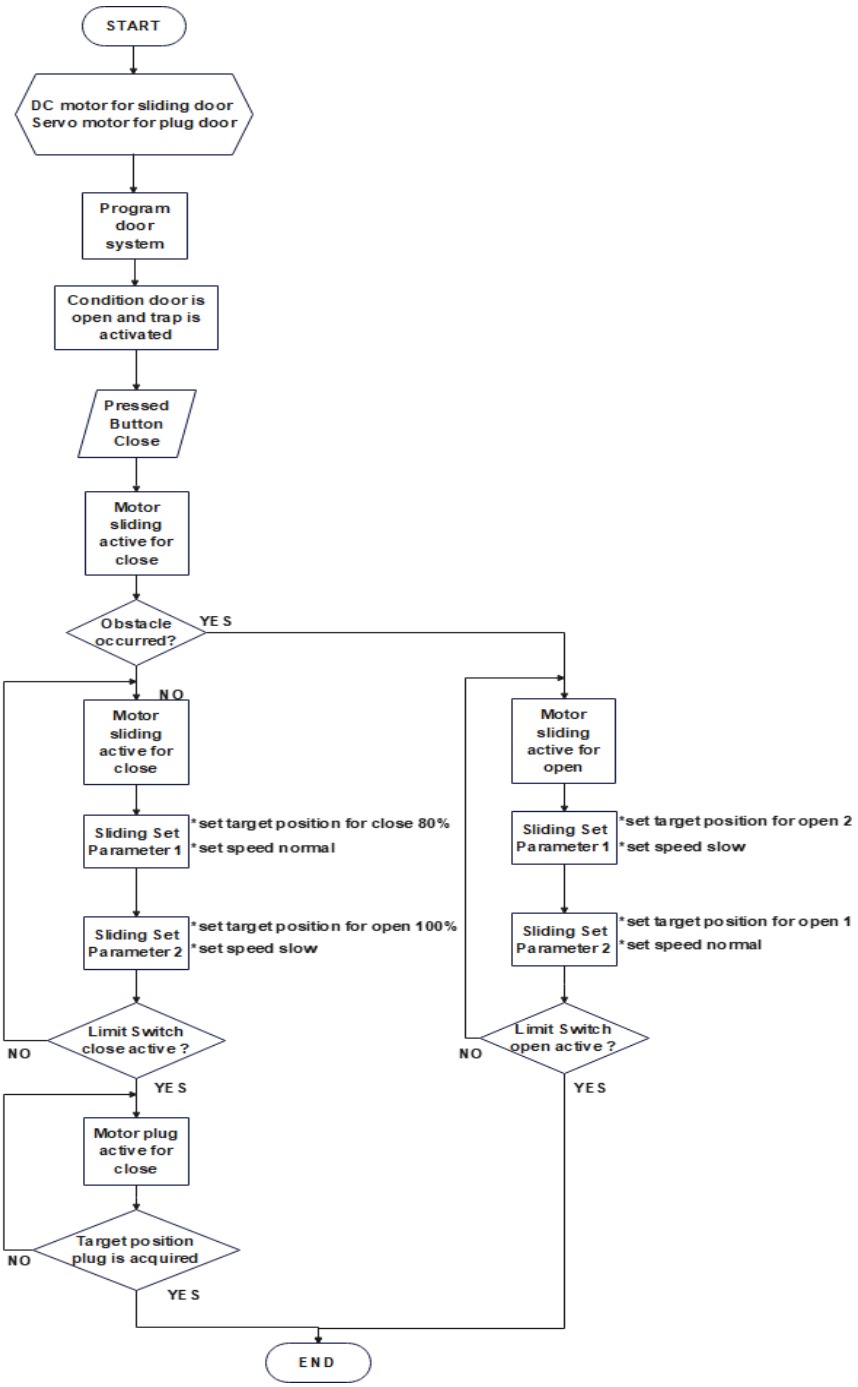

Figure 2. Flowchart of Electrical Design

The following are the security system steps for the high speed train door system starting when the door is open and about to close. DC motor for sliding door servo motor for plug door use Program door system with Condition door is open and trap is activated. To close the door Pressed Button Close and opomatis Motor sliding active for close. If not Obstacle occurred Motor sliding active for close and Sliding set parameter 1 (set target position for close 80% set speed normal) and Sliding set parameter 2 (set target position for close 100% set speed slow) until Limit Switch close active. If Limit Switch close not active, repeat steps from Motor sliding active for close until Limit Switch close active. If Limit Switch close active, Motor plug active for close and Target position plug is acquired. If Target position plug isn't acquired, Motor plug active for close again until Target position plug is acquired.If any Obstacle occurred Motor sliding active for open, Sliding set parameter 1 (set target position open 2 set speed slow) and Sliding set parameter 2 (set target position open 1 set speed normal) until Limit Switch open active. If Limit Switch open not active, repeat steps from Motor sliding active for open until Limit Switch open active. If want to close the door again, repeat steps from Pressed Button Close**.**

4. RESULT AND DISCUSSIONS

4.1 Mechanical Design

Mechanical design of the sliding plug door consists of one door that moves sliddingly to open and close followed by closing the door into carbody. The movement of the door is carried out by the DC motor and the plug condition is carried out by the stepper motor. Train door uses a sliding plug mechanism in which there are several supporting parts to run the sliding door plug mechanism, among others, namely Details of mechanical design described as:

4.1.1 Slider

The function of this slider is to move the position when the situation is closed and then move when the door is open. This slider is driven by supporting motors, namely stepper motors and AC Phase motors which are related to the v-belt.

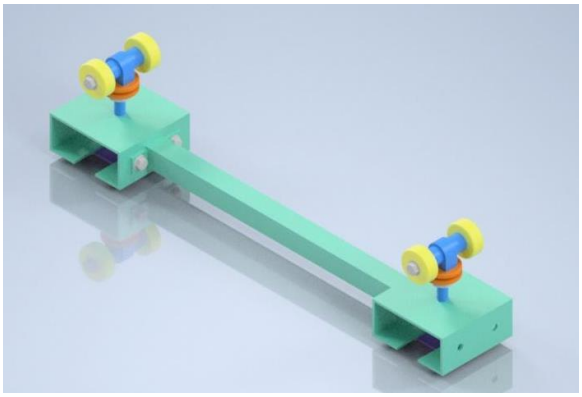

Figure 3. Slider A

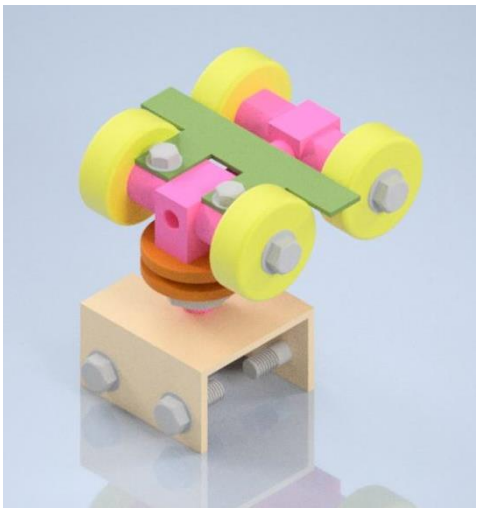

Figure 4. Slider B

4.1.2 Runway

The position of the runway is to support the track of the slider, when the doors are closed, the position of runway B will remain and the slider B will move forward. Then if the door opens Runway B will be stationary, and Slider B moves backwards towards Runway A, from Runway A directed by slider A towards the side to fulfill the open door command.

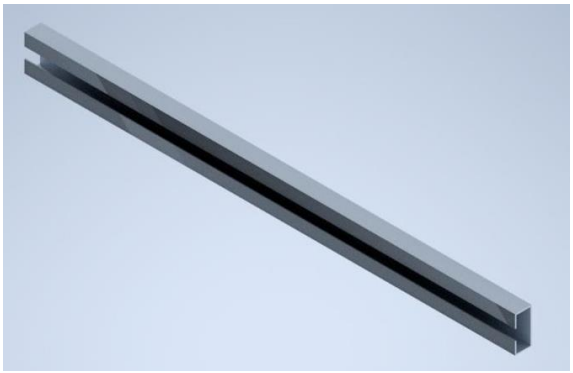

Figure 5. Runway A

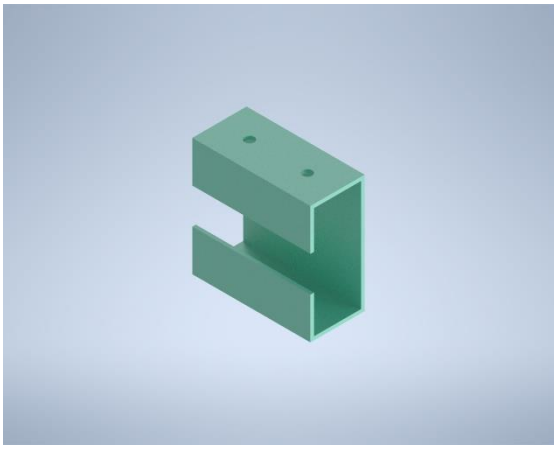

Figure 6. Runway B

4.1.3 Roller

The function of the separate roller is to help smooth the road to fulfill orders for closed or open conditions.

4.1.4 Door Design

Door design using sliding plug system for reliability and reduce noise in high speed train, there is additional material made from coconut fiber which will be placed in the middle between the metal plates. Design showed in figure below:

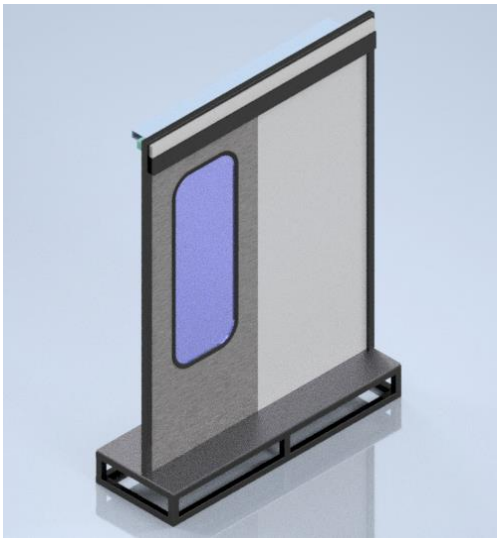

Figure 7. Door Sliding Plug Design

4.1.5 Door Design Dimensions

The following are drawings as well as dimensions of Door Design and Control System In High Speed Train - Case Study Kereta Cepat Merah Putih (KCMP).

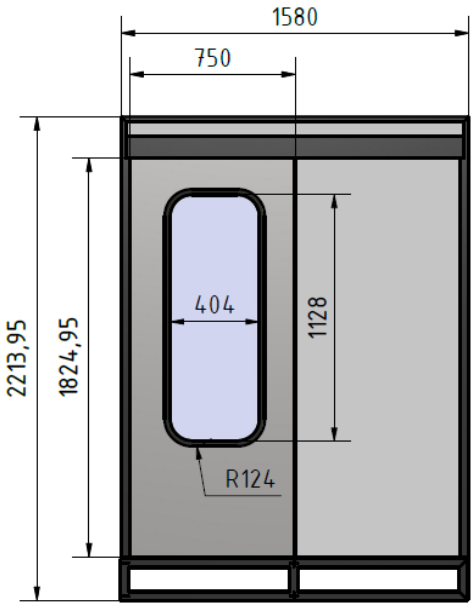

Figure 8. Door Dimensions

Door System Width : 1580 mm
Door System Height : 2214 mm
Door Portal Thickness : *adjusts to sidewall
Opening Width : 750 mm
Opening Height : 1825 mm
Door Leaf Thickness : 45 mm

4.2 Electrical Door Control System Test

Testing the design of the door control system is carried out according to the following scheme:

4.2.1 Operation Test

Sliding plug door opening and closing tests are carried out by testing the performance of the door drive, which is in the form of a DC motor for sliding and a servo motor for plugs. The process of opening and closing doors is carried out by looking at the scheme of changing the speed of the drive in the sliding and plug process as follows:

Table 1 Operation Mode Test

COMMAND	ACTION	STATUS
The door opened completely without obstacle detected	- Button open ON; - Motor plug active for open; - Motor sliding active for open; - Sliding door limit switch active.	Success
The door closed completely without obstacle detected	- Button close ON; - Motor sliding active for close; - Sliding door limit switch active. - Motor plug active for open;	Success

4.2.2 Trap Condition Test

Trap testing is carried out as a preventive measure if there is an accident or failure of the door work while operating. Here are the results of the trap condition test:

Table 2 Trap Condition Test

COMMAND	ACTION	STATUS
The door re-open with obstacle detected	- Button close ON; - Motor sliding active for close; - Obstacle detected and current sensor active detected over current; - Motor sliding active for open; - Sliding door limit switch active.	Success

5. CLONCLUSION

Door design and control system are carried out as research part related to high-speed train which produced by INKA, KAI dan college consortium named Kereta Cepat Merah Putih (KCMP). Slidding door plug type has advantage of reliability and reduce noise which affected to high speed train construction. Mechanical design focussed on door construction mechanically, and electrical design focussed on door control system. Door control system that has 3 conditions in service to passengers, namely opening, closing and fault operation occurs. In normal operation, door opened and closed for passenger support then trap identification when passenger crashed by the door. The current sensor is used to identify trap condition. the current spike form nominal indicated abnormal condition of someone trapped. Driving door conducted by servo motor for plugging and DC motor for slidding.

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