Design of Automated Lift Door Mechanism

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Abstract — **This paper describes design of Automated Lift Door Mechanism. In existing lift door mechanism, standard controllers are used. As this controllers are costly hence, increase the cost of the lift. In order to reduce the cost, Field Oriented Control is used to design the driver. The supporting frame analysis is carried out in ANSYS 16.0 and observed that there is a deformation in the ranger of e-6mm and hence system is found to be safe. Thus, various components were designed and fabricated for the automatic doors of the lift and it was controlled using a DSP micro-processor.**

Keywords—FOC = Field Oriented Control; DSP = Digital Signal Processor; PMSM = Permanent Magnet Synchronous Motor; Car = Lift Cabin; ALDM = Automatic Lift Door Mechanism

I. INTRODUCTION

To overcome the difficulties faced in manual lifts, and to eliminate human interface with components, development of automatic lifts has evoked the markets. It provides many advantages for humans to commute. Automatic lifts work on a basic principle of a motor controlling the door of the lifts to open and close. Many safety factors are the purpose for the design of the controller. Along with these factors, the reliability and accessibility criteria are also taken into account while designing. The lift door controller receives many inputs and gives appropriate output to the mechanism for controlling the door.

With many iterations of testing, the mechanism is designed and modified accordingly. The mechanical system of this mechanism needs to be optimized such that it can help to reduce the cost.

Various motors are available in the market that fulfil the requirement but they lack in some characteristics like common DC motor don't have a high working torque, hence, a Permanent Magnet (PMSM) motor is selected. It has a low inertia, in built gear box to give high torque output and also attached with an encoder to give a feedback. Sensor such as Infrared sensors (Light Curtains) and position locating sensors (Proximity Switches) is used to ensure the safety purpose.

A controller helps to connect all the sensors and motors together and sends command to each component to work with the desired output. Thus the complete assembly help the working of automatic doors of lifts.

Developing a controller that holds the driver of the motor along with micro-processor help to reduce the cost and also reduce the usage of unnecessary and extra components. A driver is a device that gives commands to the motor to run at a specified speed and torque for the given time. It receives commands from micro-controller. Driver is designed using Field Oriented Control (FOC) method. PMSM motor is three phase motor, hence FOC method is the option chosen to design the driver. The safety parameters are then programmed and feed to the microprocessor.

II. OBJECTIVES

1. To design and manufacture a controller for the automatic doors of lifts.
2. To design and analyze the mechanical framework.
3. To implement FOC method for the design of driver.

III. LITERATURE SURVEY

PMSM is widely used for its high efficiency and stable performance. The control precision and quality of PMSM become important, and it is very crucial to know the advantages and disadvantages of control strategies. FOC is the most common control strategy in PMSM control system and the bandwidth of the current loop is a critical factor that influences the dynamic performance of FOC system, because of its inherent characteristics.

The current loop force the current feedback to follow the current reference command, which increases the static and dynamic characteristics of FOC system. To increase the control performance the control cycle should be as small as possible.

There are three control strategies
1) Hysteresis control
2) PI control and
3) Prediction control.

This paper includes the PI control which is used in FOC system. The mutual coupling between the quadrature axis and the direct axis affects the static and dynamic response of current, though PI control can achieve no static error in the rotating coordinate system.

Mathematical model of PMSM motor

$$u_d = L_d \frac{did}{dt} + R_s i_d - pwL_q i_q + f_d$$

$$u_q = L_q \frac{diq}{dt} + R_s i_q + pwL_d i_d + pw\emptyset + f_q$$

Where L_d and L_q stand for the d-axis and q-axis inductance id and iq Is the current of d-axis and q-axis u is the voltage of d-axis and q-axis p is the number of pole pairs

FOC control has a better high order harmonic suppression effect, whose current ripple is smaller therefore

FOC system is still occupies the absolute leading position in the field of PMSM motor control.

IV. METHODOLOGY

First the signal from the main car controller is received that the car is at the respective floor. Only then the door opens. If the car is between the floors, the controller does not allow to open the door. Also the controller should ensure and send signal to the main car controller that only after closing the door, the car should move from one floor to another.

When the car reaches the floor, the controller send signal to the encoder of the motor. Encoder turn on the motor. This encoder drive the motor first at a slow speed for a particular time limit and then increase the speed. At the end of opening, again the speed is reduced to ensure safety of the door. Once the door is opened, human enter or leave the car. A specified time limit is given to keep the door open. After this time limit, the door should close, but first ensure the safety conditions. The safety conditions involve checking of obstruction before closing of the door. This is done with the help of light curtains infrared sensor. This sensor check that there is no object in between the doors. And thus, it sends a signal to the controller to close the door. Again the closing of the door is done with variable speed.

Another safety parameter is considered and is called as torque reversing. While closing the door of the lift, if a human keeps his hand in between, the door should not take his hand along. There is a certain limit of torque value feeded such that if the motor torque value goes above this limit, the torque should reverse and thus the door should go back and open. This ensures additional safety purpose.

The motor is connected to pulleys and belt drives. The rollers move with the belt and thus doors also move. The doors are mounted on the upper frame. While opening of the door, the car door and the floor door gets locked together and hence both the doors open together. The framework is fabricated with sheet metal. Fabrication process involves, punching, blanking, laser cutting, bending and various sheet metal operations. After the sheet metal operations the components of frame are welded together. Some components like track, side post, hanger are skate are assembled with the help of fasteners.

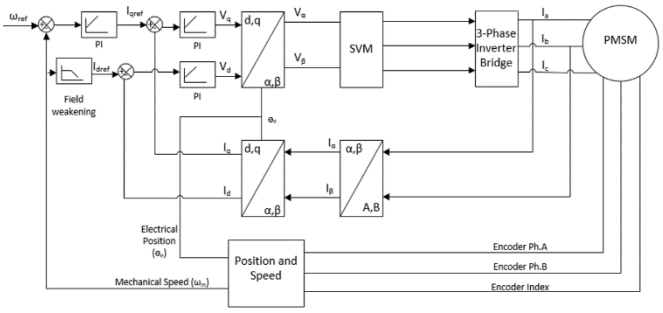

Fig-1 – Block Diagram of FOC method

As the PMSM motor is a three phase motor, to control it a driver is designed. To design the driver, Field Oriented Control Method is used [Fig-1]. It converts first the signal received from PMSM motor through encoders which is a three phase signal into a two phase signal. These two phase signals are then converted to "d,q" signals on which the required voltage is applied which is "Vd,Vq." Finally the signal is again transformed back to two phase signal and passed through SVM to give a PWM output to run the motor.

V. ANALYSIS OF SUPPORTING FRAME

The frame holds the complete assembly of the mechanism of the automatic door. On this frame the motor, belts, rollers are mounted together. The frame on which the complete assembly is mounted has been analysed on Ansys version 16.0 software.

Meshing of fine grade is chosen for the frame. Load of 800N is applied as fixed load that includes the load of motor and other sub-assemblies. The load of 500N as weight of doors which will slide on the frame is applied. Finally the stresses and strains induced are found and the total deformation is calculated.

The maximum stress after analysing from Ansys comes out to be 5.42e6Pa [Fig-2].

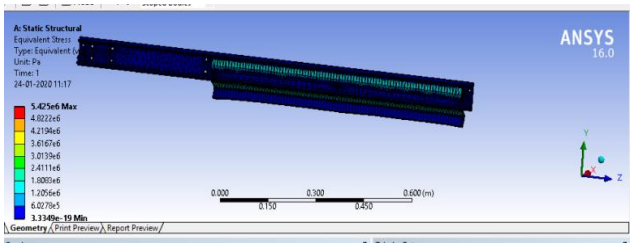

Fig-2 – Stress Analyses result

The maximum strain is 2.78e-5 m/m [Fig-3].

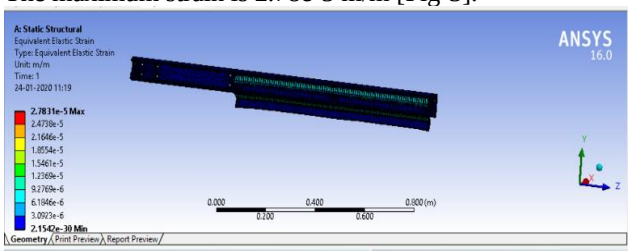

Fig. 3 Strain Analyses result

Total deformation is in the range of e-6mm [Fig-4], which is very negligible hence the design is safe and will not fail.

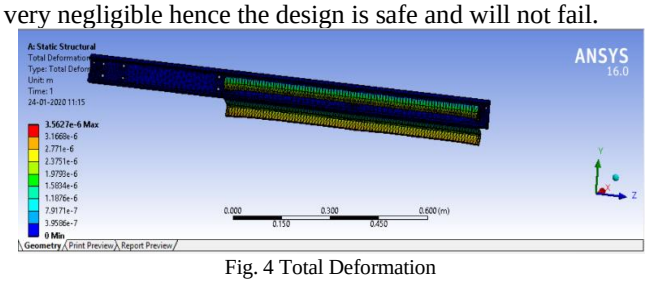

Fig. 4 Total Deformation

VI. CONCLUSION

Various components like frame, skate, and hanger are fabricated, designed and analyses of the effect of the forces acting on the frame is done. Designing of a controller using the FOC method for controlling the speed of the motor and microprocessor for performing the operation.

Complete logic building for all the safety parameters are fed using a programming language like 'Embedded C and Python'. After the program successfully runs, it enables the driver and send the respective command to the motor to operate such as open or close the door as and when required.

VII. ACKNOWLEDGMENT

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