# Introduction

In this project, an electric machine for heavy duty electric vehicles is designed. The purpose of the designed machine is to use directly with heavy duty platforms without using any gear mechanism. The intended usage of the machine can be exemplified as 10-12 meter public buses, delivery trucks, work trucks like garbage trucks, shuttles etc. In order to meet the specifications of the heavy duty vehicles, 250 kW machine with 1500 rpm nominal speed and 3000 rpm maximum speed is going to be designed.

As the usage of the machine will be heavy duty vehicles, while deciding type of the machine, efficiency should be an important factor. Because power consumption of the heavy duty vehicles are very high and losses should be minimalized. On the other hand, cost of the machine is an important factor but heavy duty machines are expensive itself, so cost of the machine can be handled by vehicle producers. Therefore Permanent Magnet Synchronous Machines can be used for these applications.

Although volumes of the electric machines are very critical in passenger vehicle applications, it can be considered that more volume can be reserved for electric machine in heavy duty vehicles by the help of nature of the vehicle. On the other hand, manufacturing of the machine can be ease by topology selection. Therefore Surface Mount PMSM is selected as topology of the machine.

# Analytical Calculation & Sizing

Some important design criteria for the machine can be stated as follows;

* 250 kW output power at 1500 rpm
* Surface Mount PMSM topology
* Liquid cooling
* Inverter driven with 650V nominal DC-link voltage
* 750-550V DC-link range (1200V Power semiconductors used in inverter)

Suggested electrical loading of liquid cooling PMSMs is 150-200 kA/m therefore, 175 kA/m is selected as electrical loading of the machine. On the other hand, magnetic loading of the machines can be obtained from average airgap flux density over a pole which is between 0.8-1.05 T in PMSM, so 1 T of magnetic loading is selected for the design. Also, winding factor of the fundamental component can be considered as 0.95 for initial design. Based on these numbers, specific machine constant can be calculated as follows;

Air gap of the machine can be defined according to following formula.

For heavy duty machines result of the formula can be increased up to 60%. Therefore, 1.045 mm can be raise up to 1.67 mm. It seems that air gap clearance of the machine can be selected as 1.5 mm for initial design of the machine.

As machine will be driven with inverter and maximum speed is about 3000rpm, by taken switching frequency as 12kHz and electrical frequency should be consider with at least 20 times of switching frequency, maximum electrical frequency can be considered as 600 Hz coincide with 3000 rpm. Therefore pole number of the machine can be chosen as;

Pole number of the machine is chosen as 24, polepair is 12.

Aspect ratio of the machine can be calculated as;

Although aspect ratio is found as 0.23, it may be taken as 0.5 because application area is electric vehicles.

Outer diameter of the machine can be calculated as;

Axial length of the machine is half of the outer diameter and it is 0.1825 m.