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**MIDDLE EAST TECHNICAL UNIVERSITY**

**Department of Electrical and Electronics Engineering**

**EE564: DESIGN OF ELECTRICAL MACHINES**

**Take Home Exam**

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**Date:** 22/01/2025

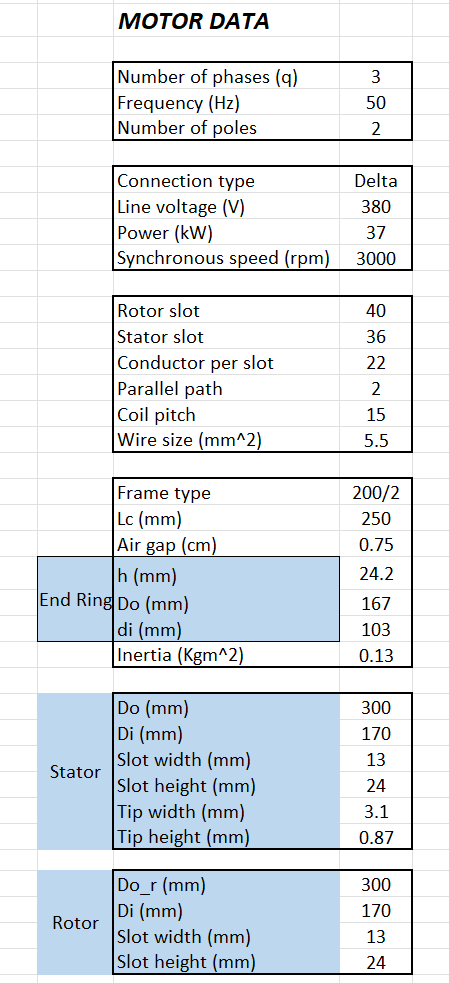
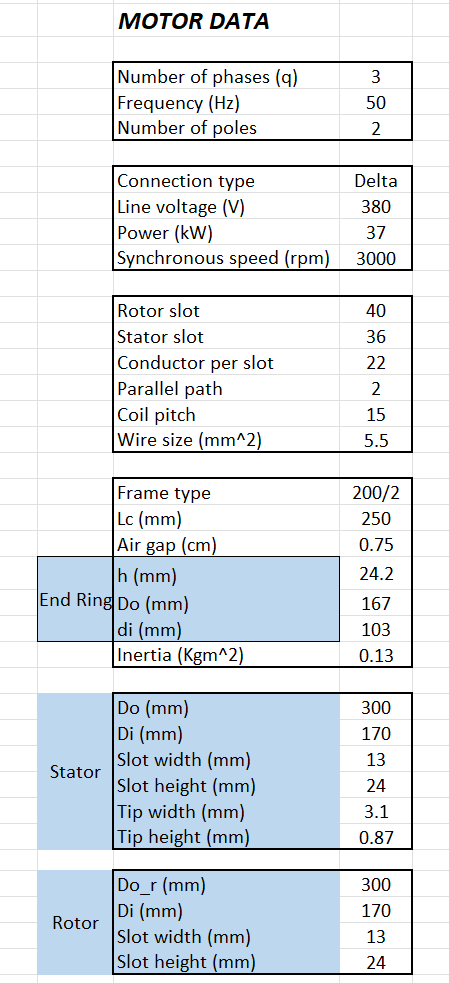
## **Introduction**

The goal of this exam is to find the parameters o an induction motor given using both test data presented and the motor parameters. Firstly, motor parameters and the test data will be presented. After that, motor parameters will be calculated using both the test data and the motor data presented, and finally, performance of the two methods are compared by calculating the torque, power and the current values.

## **Motor Data**

The motor given to me is a 200 frame 37 KW squirrel cage induction motor. To calculate the motor parameters, one should now more than just the power and the frame of a motor. Thus, the given parameters of the motor are presented below.

Figure 1. Motor data given initially



Some of the values given in the figure is directly given by the exam question. Other parameters, especially dimensions of the rotor, stator and the slots are taken from the figure given in the exam sheet as well. Some main dimensions are show in figure below.

diyagram, taslak, çizim, metin içeren bir resim

Açıklama otomatik olarak oluşturuldu

Figure 2. Main dimensions of rotor and the stator

Also, while calculating the parameters, we will need the core loss, DC permeability and BH curves. These curves are extracted from the given plots and plotted using the data points on the graph in MATLAB. The figures are shown below.

metin, diyagram, çizgi, öykü gelişim çizgisi; kumpas; grafiğini çıkarma içeren bir resim

Açıklama otomatik olarak oluşturuldu

Figure 3. DC magnetization and permeability curves

metin, öykü gelişim çizgisi; kumpas; grafiğini çıkarma, çizgi, diyagram içeren bir resim

Açıklama otomatik olarak oluşturuldu

Figure 4. Core loss curve

## **Test Data**

Since the parameters will be calculated using two methods namely analytical and the test, one should know the test data namely open circuit test and short circuit (locked rotor) test. Open circuit and short circuit test setups are given in figure below. Also, the test values are given below.

a) b)

Figure 5. a) Open circuit test b) Short circuit test schematics

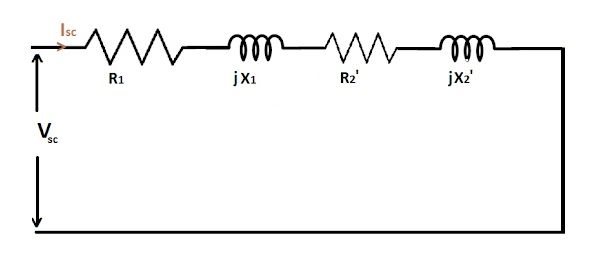
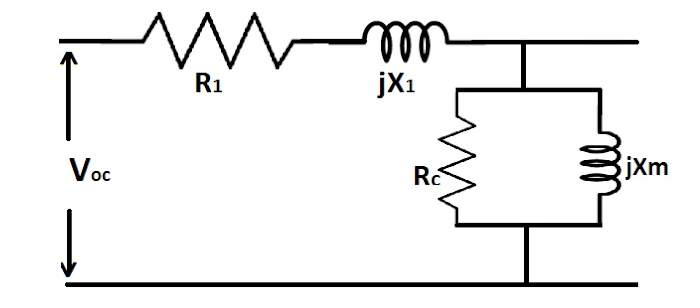
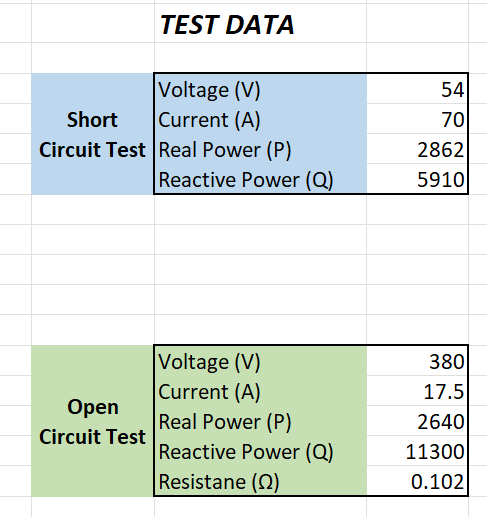
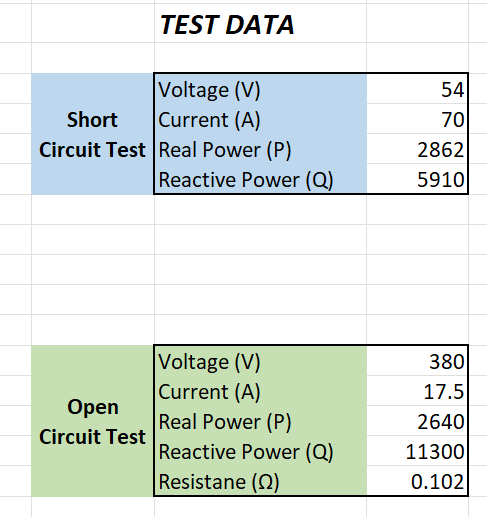


Figure 6. Test data initially given



## **Parameter Calculation Using Test Data**

Parameters of the induction motor namely phase resistances (R1 and R2), leakage reactances (X1 and X2), magnetizing reactance (Xm) and core loss resistance (Rc) can be calculated from the results gathered from open circuit and short circuit test experiments. It is said by the instructor that the parameters should be calculated in a way that it is calculated in the book called “Electric Machinery by A.E. Fitzgerald”. The procedures and the formulas to calculate the parameters will be given in this section.

To calculate the phase resistance R1, the measured resistance value in the open circuit test should be used. Since the motor in this project is delta connected, the resistance can be calculated as follows:

Now, core losses should be calculated in order to find the core loss resistance. According to the book, core loss can be calculated as below. Note that if the rotational power is not given, take it as 1% of the rated power.

Core loss resistance can be calculated as follows:

After this part, it is time for the calculation of leakage reactance. Firstly, no load reactance can be calculated as below:

Also, blocked rotor reactance and the blocked rotor resistance values should be obtained. To obtain the blocked rotor reactance value, one should know the test frequency. In general, as it is stated in the book, test frequency is equal to rated frequency for the motors with HP smaller than 25. For the motors with higher HP values, test frequency is approximately equal to 25% of the rated frequency. Thus, the frequency ratio in this calculation is 4.

Blocked rotor resistance can be found as below:

Now, leakage reactance of primary and the secondary referred values can be calculated. In general, for induction motors, X1 and X2 values are very close and assumed to be equal for simple calculations. Any of the reactance values can be found by solving the second order equation found by equation the X1 and X2 values.

Magnetizing reactance now can be found as the leakage reactance is found.

Finally, secondary side referred phase resistance (R2) can be found as given below:

The R1 and R2 resistances should be comparable and do not differ significantly. When the values found are considered they have very small difference between them which shows that the calculations done are not so faulty. In the following section, same parameters will be calculated using the motor data.

## **Parameter Calculation Using Motor Data**