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# Electrical Machines Learning and Training in One2One Project

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***Abstract* — This paper describes induction motors learning as an important component of electric engineering education. Based on a few years experience this study introduces a new concept of learning in the training field. This concept is implemented by One2One Project. Because teaching in this field relies on electricity and magnetism, energy conversion, AC circuit, measurement method and concepts as well as applied power engineering, students in graduate educational programs find the topics cross-disciplinary, practical, and motivational.**

**The intention of One2one project is double: on one hand, to bring closer the needs of the companies to schools and, on the other hand, to improve the pedagogical methodology. This type of project is allowing teachers to pay attention to each singular student, and concerning about their own personal learning rhythms. In the present project, the student is going to know the component's parts of the induction machines and operating principals. Based on this, the student is going to identify an induction machine from the details on the machine rating label the terminal board, connect the motor according to a circuit diagram and operate the motor for recording the nominal performance values, calculate specified variables, using given formulae and measured values and draw the load characteristic curves from the obtained values. The student will indicate the value of nominal torque on the characteristic curves and comment the shape of the characteristic curves.**

***Keywords- learning, projectX , electrical machines***

## I. INTRODUCTION

In One2one Project, the professor pays attention to one singular student. The professor observes the ability and rhythm of student. The instrument used to make real this purpose is what we have called the *"*ProjectX*"*, a methodological guide for the student to carry out a concrete activity, one to one with the teacher, in which theory and practice are both perfectly integrated and are related to the existent workplace. The ProjectX "Checking the performance and load characteristics of an induction machine" it is developed upon the basis of Learning Outcomes. Furthermore, in One2one Project will create a tool based on the ECVET credit system that will allow mobility of students between the participating institutions [2].

In this way, we are aligned with the European Strategy 2020 which boosts the mobility of students and teachers in a high grade of quality.[1] ,[2],[3]

We decided to implement the ProjectX for induction machines because it is known that the induction motors are used in many activities. The induction motor is the widest used in most industries [4],[5],[6],[7].Because of this wide use of the motor, it is very important that students are used to know this type of electricmachine, interpret the electricand mechanical values, and make the electrical connections for starting motor. [8],[9],[10]

In this paper, it is presented induction machines learning and training in One2one project.

## II. BASIC KNOWLEDGE OF INDUCTION MOTORS

We desire to improve the knowledge's of students in electrical machines range following the steps:[11],[12]

- Describe the main parts of the induction machine;
- Read the operating principle of induction motor;
- Define the load characteristics of AC motor;
- Implement the electrical diagrams. Connect ammper, voltmeter and powermeter in electrical diagrams.

### *A. Components parts of induction motors*

The induction machine is the most common of all electrical machines. Induction machines are almost operated as a motor because undesirable characteristics as a generator.

The induction motor has many advantages:

- the induction motor is inexpensive and easy to maintain;
- the speed of induction motor is nearly constant for important torque applied by the shaft;
- the power of induction motors are in a large range, starting from few watts up to five hundreds.

Disadvantages of induction motor are:

- difficulty in speed control for the motor;
- when the motor is small loaded the power factor is too low;
- the staring current is four to eight times rated value load current.

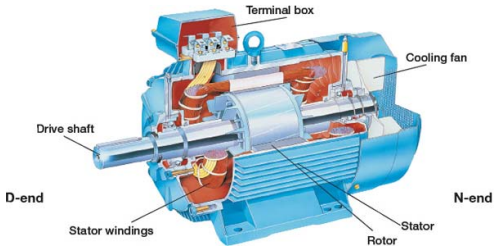


Figure 1. Parts of induction machines[14]

In figure 1 is presented the parts of induction machines.

Induction machines consist of an immobile part named stator and another part mobile –rotor machines. The rotor is mounted on bearings and separated from the stator by air-gap.

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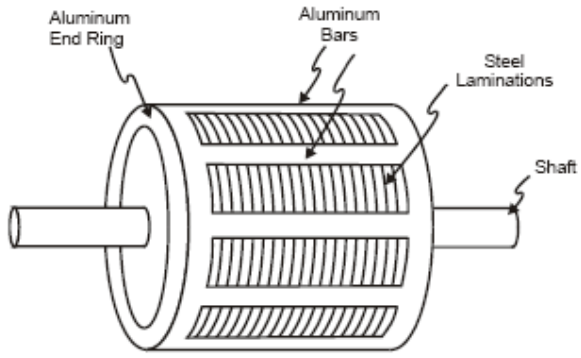


Figure 2. Squirrel cage induction motor rotor [15]

There are two types of rotors used in induction motors:

- wound rotor with poly-phase windings connected to slip rings by brushes;
- squirrel cage rotor with conducted bars connected to end rings presented in figure 2.

*B. Operating principle of induction motors*

In induction motor, the rotor is armature and the stator is field's windings.

If the machine has p poles, it can be written the formula of synchronous speed:

$$n_S = \frac{60 f_1}{2p} \tag{1}$$

where $f_1 = \frac{\omega}{2\pi}$ is the stator current frequency.

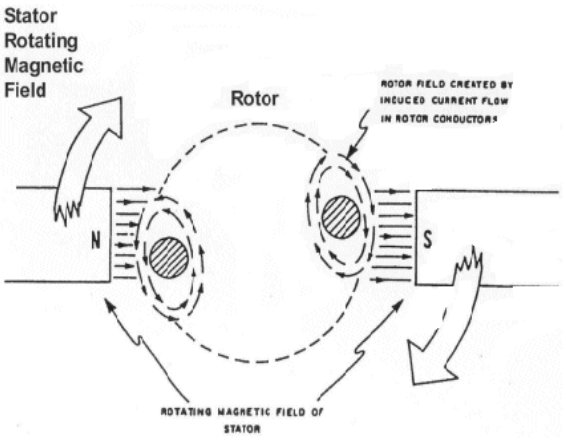


Figure 3. Operating principle of induction motor[16]

The principle of induction motor's operating is presented in figure 3.

The magnetic-field produce by the stator is intersected by the rotor's conductors and according to Lenz's law. Therefore, voltages are induced in these conductors. The induced voltages give rise to rotor currents. These interact with air gap fields to produce torque, which is maintained as long as the rotating magnetic field and induced rotor currents exist. Like a consequence, the motor starts rotating with a speed *n* in the direction of the rotating field. It is known that $n<n_s$($n_s$ =synchronous speed). It is obviously that if $n=ns$, there will be no voltage and current induced into the rotor circuit and motor torque is zero.[17],[18]

Slip of induction motor is defined:

$$s = \frac{n_S - n}{n_S} 100\% \tag{2}$$

Equation system of induction machines without core losses is presented as follow:

$$\underline{U}_1 = \underline{I}_1 R_1 + jX_{d1}\underline{I}_1 - \underline{E}_m \tag{3}$$

$$0 = \underline{I}'_2 R'_2 + jX_{d2}\underline{I}'_2 - \underline{E}_m \tag{4}$$

$$\underline{I}_1 + \underline{I}'_2 = I_m \tag{5}$$

$$\underline{E}_m = -jX_m \underline{I}_m \tag{6}$$

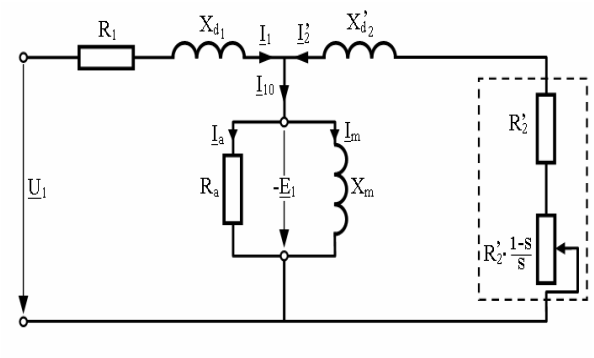


Figure 4. Single phase equivalent circuit of polyphase induction motor with core losses

In figure 4 are presented the single-phase equivalent circuit of induction machine.

The notation used in equations, and equivalent circuit are as follows:

- $R_1$ is per-phase stator resistance;
- $R'_2$ is simply per-phase rotor resistance referred to the stator;
- $R_2' \frac{1-s}{s}$ is a per-phase dynamic resistance that depends the rotor speed-corresponds to the load of the motor;
- $X_{d1}$ is the leakage stator reactance per-phase;
- $X'_{d2}$ is the leakage rotor reactance per-phase referred to the stator;
- $R_a$ is resistance corresponds to active core loss;
- $X_m$ , $I_m$ are magnetizing reactance and magnetizing current of core;
- $I_1$ and $I_2$ are stator current and rotor, respectively.

*C. Load characteristcs of induction machine*

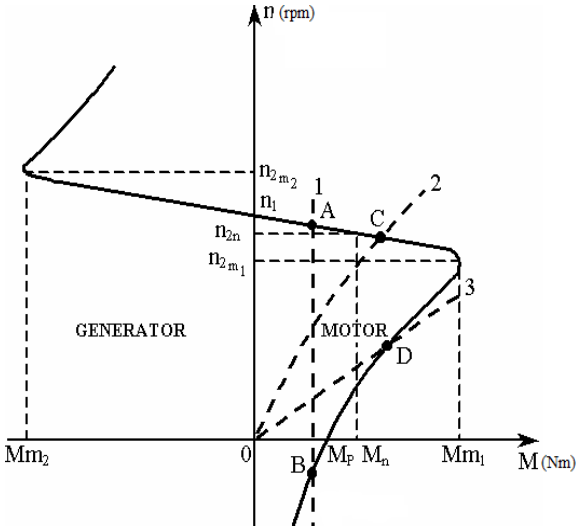


Figure 5. Load characteristic of induction machine

For the student is very important to know the load characteristic of induction machines. This characteristic is presented in figure 5.

## III. PRACTICAL ACTIVITIES IN PROJECT**X**- INDUCTION MOTOR OPERATING

Practical activities' done by the students in this project are:

- This course is designed to convey practical know-how on the topic of three-phase asynchronous machines;
- Experiment-based investigations of the asynchronous motor are the focus and cover;
- Recognize a three-phase asynchronous motor from the rating label and terminal board;
- Connect an induction motor with slip-ring rotor and operate the motor for the purpose of recording the load characteristics;
- Calculate the delivered power, the power factor, the apparent power, efficiency and slip;
- Draw the load characteristic curves from the values obtain by measurements and calculations;
- Indicate the value of nominal torque on the characteristic curves;
- comment on the shape of the characteristic curves.
- specialist knowledge about the terms used in the electrical machines;
- technical knowledge about of electrical equipments symbols in wiring diagrams;
- student familiarize with standard procedure imposed on electricity;
- establishing an interdisciplinary knowledge required students to obtain the best results in learning;
- understanding the performance of the electrical equipment, the command and measurement circuits.

In during work, the student must pay attention some aspects as follows:

What could be the main problems?

A different problematic situation could appear due to wrong connection of ammeter, voltmeter or power meter to the circuit with the permanent damage for these.

One problem that can appear is that students don't follow the correct connection in the electrical installations according to the schematic. Because of this, the connection of the motor should be done without load connected to the shaft. In case that such error appears, the protection elements of the energy source should protect the circuit.[17],[18]

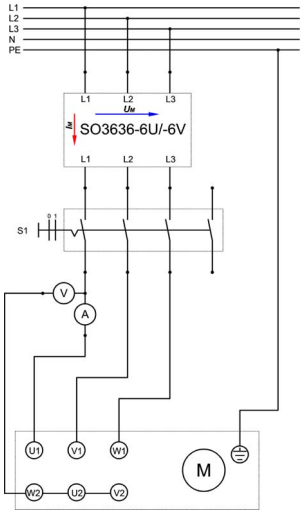


Figure 6. Electrical circuit for connection to power suplly of induction machine[19]

First of all, it is presented the student's steps in practical activity.

For the beginning, the student knows general instructions on handling equipment:

Figure 7. Booth of induction motor's parameters[19]

- Check that the knurled screws through the base of the motor and the coupling sleeves (power grip) on the motor shaft are all securely fastened, presented in figure 7.
- Use shaft and coupling guards.
- Any prolonged running of the machines when operating under high loads can subject the machines to excessive heating extreme case of the machine being prevented from rotating entirely.
- The may only arise briefly.
- All the machines are equipped with a thermal circuit-breaker, which triggers when the maximum permissible operating temperature is exceeded. These switching contacts are accessible on the terminal board and must always be connected to the corresponding connection sockets of the mains supply and control unit.

The second activity step represents connection, as it is presented in figure 6, and starting of electrical machines through:

- Identify the terminal connections of the motor and operate the motor as a three-phase asynchronous motor on a three-phase mains network
- Utilize the nominal data for the motor based on the rating plate.
- Measure the phase voltage and phase current
- Put the motor into operation in star configurations
- Assemble the circuits as specified in the indicated circuit diagram and setup instructions.
- Put the motor into operation without the brake
- Putting the asynchronous motor into operation and recording the load characteristics.
- Record the load characteristics of the motor

The third activity step it is represented by calculation of the delivered power, power factor, apparent power, efficiency and slip.

The other activity is drawing the load characteristic curves from the values obtain by measurements and calculations.

And finally the student writes in his notebook his observations of the whole process. It has to be written also a brief explanation of the function of the induction machines.

## IV. CONCLUSIONS

This ProjectX is important in this subject because the students taking this ProjectX get used with the main operations required to:

- checking the performance,
- to start an induction motor,
- draw the load characteristics of an induction machine.

This project is important for the industry because by working on ProjectX "Checking the performance and load characteristics of an induction machine" students build both technical and soft skills required to operate in the workplace. Including real work life situations ensure that the skills pupils acquire are those needed in the labour market.

In near future will be analysed the competences gained by the student once to perform this project. The competences will be settled according to European Qualifications Framework.

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