INDUSTRY-INSTITUTION INTERACTION - SOME CASE STUDIES ON THE ELECTRICAL TESTING OF COMMERCIAL INDUCTION MOTORS

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1. INTRODUCTION :

The importance of industry - institution interaction is, day by day, being recognised to a great extent by both the academicians and the people associated with the manufacturing of techno-commercial products. The increasing recognition is due to the advantages felt by both the sides; that means, academic institutions and industries. Today, the academicians strongly feel that solving or approaching to solve a real technical problem faced in the shop-floor makes the teaching methodology rich. On the other hand, from the interaction with the academicians, the people working in shop-floor get their theoretical background enriched.

As a part of this activity, the technological institutions are in need to do some consultancy jobs. The authors, in this paper, discuss, some case studies in relation to consultancy services and show ultimately how the learning process of students get improved directly or indirectly by conveying the methodology of the work in the class-room.

2. THE NATURE OF INDUSTRIAL PROBLEMS FACED :

The problems which were faced by the local industries and put before the institution for possible solutions can be stated as :

(i) Actual prediction of the temperature-rise of the winding of a three phase induction motor.

(ii) Approximate prediction of the full-load current of cage type induction motors which were not bearing name plate, at all.

3. ORIGIN OF THE PROBLEMS AND INVOLVEMENT OF THE INSTITUTION :

The highlighted problems were faced by most of the local small-scale industries. The surface of the stator casting of the induction motors (which are coupled with load) became hot day by day in due course of running. But the industries, due to the lack of people with strong theoretical backgrounds and also due to the lack of good instruments, were not in a position to

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assess the actual thermal condition of the winding and associated insulations. So, it was decided to arrange for an actual testing of the motors.

Another area of problem is centered around the forecasting of approximate full load current of induction motors on which, somehow, name-plates were missing. The industrial people faced two main problems arising out from the missing of the name-plates as stated below:

(a) How-to-load a motor which has no name-plate.

(b) If this type of machine is used in practice, what will be tariff paid to the concerned authority of the State Electricity Board because the fixation of tariff is mainly based on H.P. rating of the machine.

Therefore, some method of testing for prediction of approximate full load current of H.P. rating was in need.

From the institutional side, we, the faculty members were always in touch with the different industries through official connections, attending industrial seminars or workshops and arranging students' technical tour. As a consequence of these activities, we were able to open a "Consultancy Window" in the institute. This window is basically a section of the office of the institution and it receives the industrial problems or industrial projects and after sorting out, sends them to the concerned departments. Through this window only, the institution got involved with the specific technical problems.

4. TEACHERS' AND STUDENTS' INVOLVMENT WITH THE INDUSTRIAL PROBLEMS.

When the department received the assignment, firstly it was necessary to decide whether our faculty members and the associated technical staff will be able to take up and complete the job in proper time or not. As a first step, a meeting at the departmental level was arranged to sort out the matter. Secondly, we proceeded on the following lines : The nature of the industrial problems pertain to the area of electrical machines. So the teachers who were teaching electrical machines to the students were offered the assignment. Another important point is that the faculty member who possesses some working experience in shopfloors of the industries will be preferred to be involved in the job of solving industrial problems. As a third consideration, we evaluated our existing infrastructural facilities (e.g. laboratory facilities) and finally decided to take up the assignment. As this type of activity is a part of industry-institution interaction, to get the students involved in the assignment is a must. The strategy for making the students involved in the work is based on the following aspects :

(a) To give assignments to the students of the final year class so that each individual can submit term paper on the detailed discussion on the nature of the problems and possible method of solutions.

(b) As the consultancy job, already mentioned, is related to the area of electrical machines, some part of the consultancy work were given to the students who are engaged in doing their academic project work in that particular area. Simultaneously it is seen that no student should be over-loaded with the extra assignment.

The purpose behind making the students involved in the work is mainly to make them aware about the fact that before passing out from the institution they will be able to get exposure about the real shop-floor problems. Another reason which is of secondary importance is that the time required for completing the job will be less.

5. DISCUSSIONS ON CASE-STUDIES:

5.1 Case-study (1)

Temperature-rise test on the commercial 3 phase squirrel cage Induction Motors by "Resistance Measurement Method" was performed in the laboratory. The scheme of the experimental method (excluding the details like wiring, instrumentations etc.) is shown in Fig. 1. This method is known and mostly used in the shop-floor of the motor manufacturing industries. But generally the students do not get an opportunity of doing this type of experiment in the laboratory. The test method is described as follows. The test motor was directly mechanically coupled to a D.C.Generator which is generally available in the laboratory. The generator was loaded through a loading rheostat. A thermometer was put on the stator casting of the motor. The cold resistance of the stator winding was measured and the corresponding ambient temperature was recorded. The I.M. was loaded to its rated capacity. In accordance with the I.S. specification [1], after each half an hour, the thermometer reading and other readings like current, voltage etc. were recorded. When the difference between two consequtive thermometer readings became within 1 degree celsius, the motor was switched off and immediately the hot resistance of the winding was measured. From the hot and cold resistances of the winding the temperature-rise was calculated using the simple formula [1,2,3] given below:

$$t = [(R_{hot} - R_{cold}) / R_{cold}]$$
$$(235+T_A) - (T_2-T_A) \quad \text{.... (2.1.1)}$$

where,

t = Rise in temperature of the winding above the ambient temperature (in degree celsius)

R_{hot} = Hot resistance per phase in ohms

R_{cold} = Cold resistance per phase in ohms

$1/235$ = Temperature - coefficient of resistance of copper in per degree celsius

T_A = Ambient temperature at the time of starting the test (in degree celsius)

T_2 = Ambient temperature at the time of switching off the motor (in degree celsius)

5.2 Case-study (2)

It is well-known that the correct data of full load current of a motor can only be predicted by the temperature rise test. But in the institutional laboratories most of the motor-generator sets are direct coupled because for the purpose of students' exercise this type of coupling is always preferred. So decoupling the existing motor from the coupled set and coupling the test I.M. with the existing generator was one solution of the problem. But according to the size of the shaft of the test motor, availability of a suitable coupling arrangement and also to find a suitable generator of equivalent capacity are tough problems.

To avoid these types of troubles due to the lack of the infrastructural facilities of the academic institutions, the principle of mixed-frequency loading [4] was implemented on the test motor for performing the temperature-rise test.

The principle of the mixed-frequency loading is that if three terminals A_1, B_1, C_1, of the stator winding are supplied from the alternator and the other three terminals A_2, B_2, C_2, are supplied from the 50 Hz bus then by decreasing the frequency of the voltage generated from the alternator, the motor can be loaded even without being coupled to a physical load or a generator. Fig. 2. shows the scheme of the test method.

Initially by decreasing the frequency of the auxiliary supply (i.e. from the alternator), the current of the motor was allowed to increase. Then a trial value of current was set and the machine was allowed to run continuously carrying this much amount of current. For measurement of the temperature of the surface of the stator casting, a thermometer was inserted in the hole on the surface where normally eye-bolt is put on. After the surface temperature got stabilized as dictated by the thermometer reading, the motor was switched off and immediately the hot resistance of the winding was taken. Knowing the cold resistance, temperature rise calculation was done by using eq. (2.11). If this calculated value is very much lower than the allowable value corresponding to the class of insulation used another heat run on the machine (to be restarted from cold condition) with the auxiliary frequency more reduced (with more current) is necessary. Thus after such a few number of trial & hit-runs, the somewhat correct value of full load current (which corresponds to a temperature-rise by "Resistance Measurement Method" near about the value as allowed by the class of insulation) was predicted.

One important point is that how to know the class of winding insulation used if the machine has no name-plate at all. The way out from this stage is that firstly to open the endshield of the machine (of either side) and to take out the rotor and secondly to see the quality of the insulation paper one can judge the class of insulation on the basis of his experience.

6. CONCLUSIONS OF THE CASE-STUDIES :

Case study (1) :

The temperature rise of the winding based on cold and hot resistances was found to be 10 degree celsius more than the temperature-rise permitted by the class of insulations used. As the motor had been used for more than ten years, it was suggested to buy a new motor instead of repairing the existing one.

Case-study (2) :

Approximate full load current of the motors were declared. Based on this value of current and physical dimensions of the machines (like frame size, core-length etc.) standard catalogues of the common manufacturers were consulted and thus approximate H.P. ratings (for paying the tariff to the electricity boards) were declared.

For both the case-studies test certificates were issued to the concerned authorities of the industries.

7. ADVANTAGES DERIVED FROM THE INTERACTION :

Due to the help from the academic institution, the concerned management of the industries did not further need to call a technical expert from outside or from the supplier's side to solve the problem. This is the greatest advantage for them financially and manual effortwise. Generally the small scale industries employ large number of diploma holder engineers. As they are not theoretically too much strong, after interacting with the academic people they gain some knowledge regarding the theoretical background of the trouble shooting problem. As a specific example, the management of some industries got assurance from us that in future we would be ready to train their diploma holder engineers for a better understanding of the technical problems. This is also another advantage derived by the industries from the interaction activities.

The institution gets some part of the consultancy fee paid by the industries. This type of financial gain helps the institute to raise its fund which can be used in future for its infrastructural development.

The faculty of the concerned department of the institution get financial remuneration for completing the assignment. This is obviously a plus point in favour of doing the interaction activity but the most important point is that as the teachers solve the practical problems, more their subject-knowledge gets matured.

As engineering curriculum is based on the study on the performance of an engineering system, the above case-studies explained by the teacher concerned in the class-room, obviously, make the students more interested to know about the practical problems. The effects are as follows.

(a) Effects of Case-study (1)

(i) Students will get a clear idea of the heating and cooling mechanisms of the machine.

(ii) They can realize clearly the heat balance equation because only when the heat lost from the winding will be equal to the heat gained by the surrounding, the temperature of the outer surface of the stator will become steady.

(iii) They can think deeply on the appearance of the term(T_2-T_a) in equation (2.1.1) and this will enhance their exposure of knowledge to practical aspects.

(b) Effects of Case-study (2) :

(i) The traditional teaching methodology, generally, train the students to rely on the idea that by only coupling the physical load with the shaft, the motor can be loaded. The concept and methodology of mixed-frequency loading break this tradition and obviously it helps the students to get a better exposure to the industrial world.

(ii) If the students can be involved in the experimental work they will get scope of practically dismantling and reassembling the induction motor which they normally do not get in their curriculum.

(iii) Principle of mixed frequency loading is not new but depending on the nature of the problem the particular testing methodology was implemented to cope up with the existing infrastructural facility of the laboratory. So the philosophy of deciding the strategy to solve a troubleshooting problem is the key knowledge to be conveyed to the students.

4. CONCLUSIONS :

Some case-studies in context to the industry-institution interaction are discussed.

The positive effects of the interaction activities on the learning process of the students are mainly highlighted.

There remains one more important academic aspect of the industry-institution interaction which is the pinpointed effects on the teaching methodology. This is not discussed in this paper because for the completeness of this aspect it needs further investigations into the large scale interactions with the industries like handling of software and hardware based projects.

9. REFERENCES :

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4. Meyer A. and Lorenzen H.W. - "Two-frequency heat run - a method of examination for three phase induction motors", I.E.E.E. Transactions on Power Apparatus and Systems, Vol. PAS - 98, No.6, Nov./Dec.1979.

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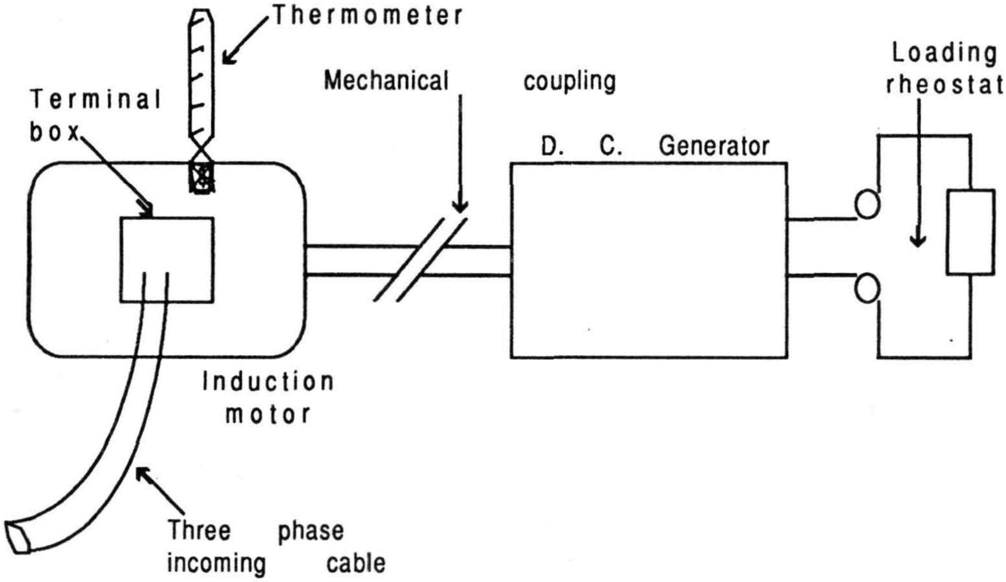

Fig. 1 Schematic diagram of temperature - rise test of three phase induction motor by "Resistance Measurement Method".

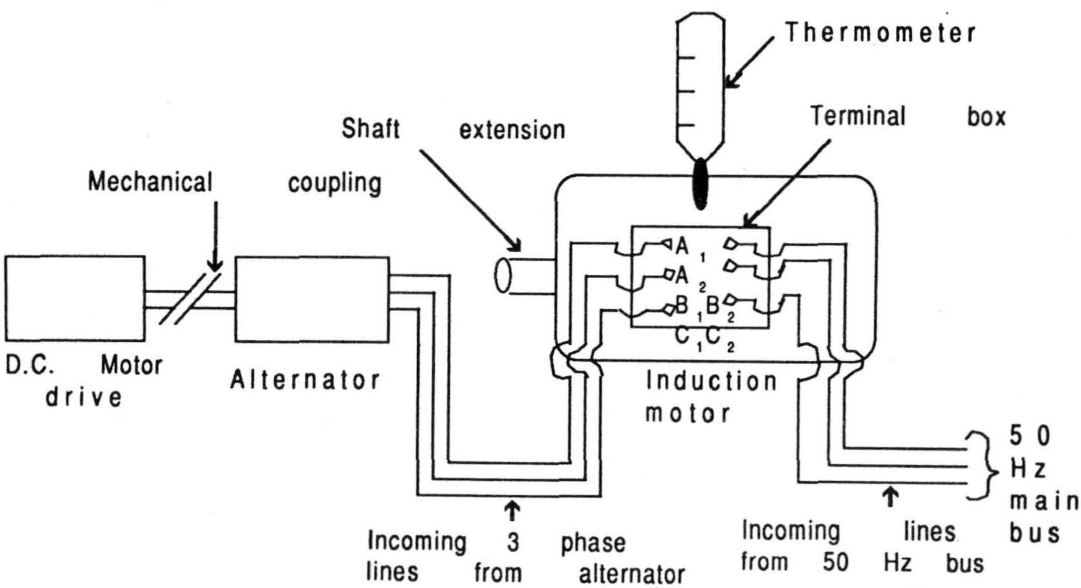

Fig. 2 Scheme of the heat - run on three phase induction motors by "Mixed Frequency Loading Method".