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भारतीय प्रौद्योगिकी संस्थान मुंबई INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

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पाठ्यक्रम नाम/Course Name EN319 - Electrical

Machins & Power Electronics Lab

शाखा/प्रभाग/Branch/Div.

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SAMPLE REPORT for EN319

प्र.सं./Q. No.	1	2	3	4	5	6	7	8	9	10	11	12	योग/Total
आरंभिक पृष्ठ Starting Page No.													
अंक/Marks													

परीक्षा में बैठने वाले अभ्यर्थियों को निर्देश

- परीक्षा के पहले दो घंटे की अवधि में अभ्यर्थी को परीक्षा स्थल छोड़ने की अनुमति नहीं मिलेगी। दो घंटे के बाद यदि किसी अभ्यर्थी को प्रसाधन गृह जाने की आवश्यकता पड़ती है तो वह पर्यवेक्षक की अनुमति से जा सकता है और इस अस्थायी अनुपस्थिति की अवधि में वह प्रश्न पत्र और उत्तर पुस्तिका पर्यवेक्षक को दे देगा।
- हर अभ्यर्थी उनके लिए विशेष रूप से निर्धारित आसन को ही ग्रहण करेगा। पर्यवेक्षक के सूचनानुसार वह अपना आसन बदल सकेगा।
- अभ्यर्थी उत्तर पुस्तिका की दोनों ही ओर उत्तर लिखेगा।
- अभ्यर्थी इस उत्तर पुस्तिका के शीर्ष पर दी गई खाली जगह में अपना रोल नम्बर एवं अन्य विवरण लिखेंगे। उत्तर पुस्तिका के किसी भी स्थान पर अभ्यर्थी का नाम नहीं आएगा।
- अंतिम 10 मिनट की अवधि में अभ्यर्थी परीक्षा स्थल नहीं छोड़ेगा। पर्यवेक्षक द्वारा उत्तर पुस्तिका संग्रह किए जाने तक वह अपने स्थान पर ही रहेगा।
- अभ्यर्थी के उपयोग हेतु प्राधिकृत स्लाइड रूल, इन्स्ट्रुमेंट बॉक्स इत्यादि को छोड़कर, किसी भी पुस्तक, खुला कागज, लिखित टिप्पणी के पास पहुँच नहीं रहेगी। अभ्यर्थी को सलाह दी जाती है कि आसन ग्रहण करने के पहले किसी भी प्रकार की लिखित टिप्पणी अथवा पुस्तक अथवा अपना अन्य सामान पर्यवेक्षक द्वारा निर्दिष्ट स्थान पर ही रखें।
- अभ्यर्थी इस पुस्तिका के पृष्ठ की बाईं ओर में कच्ची गणना कार्य कर सकते हैं किन्तु यह गणना का कच्चा कार्य है इसका स्पष्ट संकेत होना चाहिए।
- अभ्यर्थी इस पुस्तिका का कोई पृष्ठ नहीं फाड़ेगा यदि रद्द करने की आवश्यकता होती है तो इसे इंक से स्पष्ट रूप से काट देना चाहिए।
- परीक्षा चलते समय परीक्षा हॉल में अभ्यर्थी किसी स्थिति में दूसरे अभ्यर्थी से बातचित या सम्प्रेषण नहीं करेगा। पूर्ण शांति अवश्य रखी जाए।
- खुली पुस्तक परीक्षा की स्थिति में, अनुदेश - प्रभारी के सुझावों के अनुसार केवल साइक्लोस्टाइल अथवा मुद्रित सामग्री के उपयोग की अनुमति है। परीक्षा हॉल में क्लास नोट (कक्षा टिप्पणी) की अनुमति नहीं है। यह सामग्री तथा स्लाइड रूल, ड्राइंग उपकरण आदि का लेन-देन वर्जित है।
- पर्यवेक्षक के किसी अनुदेश की अवज्ञा, या उनके साथ अशिष्ट या अभद्र व्यवहार नहीं करेगा।
- कोई भी अभ्यर्थी कदाचार या गलत साधनों का उपयोग करते पाया जाता है तो उसे परीक्षा हॉल से निष्कासित किया जा सकता है।
- पर्यवेक्षक जब भी पहचान पत्र की माँग करता है तो अभ्यर्थी उसके समक्ष प्रस्तुत करेगा।
- प्रक्रमणीय, परिकलित, सैल्युलर फोन, पेजर, इलेक्ट्रॉनिक गजेट की अनुमति नहीं।

Instructions to Candidates appearing in Examination

- No candidate shall be allowed to leave the examination hall during the first two hours of the examination. In case a student is required to go to the bath room after two hours he will take the permission of the invigilator, to do so and shall handover the question paper and his answer script to the invigilator during his temporary absence.
- Each candidate shall occupy the seat particularly assigned to him. He may be allowed to change the seat under instruction from the invigilator.
- Candidate shall write answers on both sides of the answer book.
- Candidates shall write their Roll number and other details in the space provided on top of this page of the answerbook. Name of the candidate will not appear anywhere in the answer book.
- Candidates shall not leave the hall during the last 10 minutes. They shall remain in their seats till the answerbooks are collected by the invigilators.
- The candidates shall not have access during the examination to any book, loose paper, written notes, etc. other than the slide rules, instrument box etc. authorised to be used. Candidates are advised to keep any written papers or books or other belongings in the space specified by the invigilator before occupying seats.
- Candidates may make rough calculation on the left side page of the answerbook, but such calculations should clearly be indicated as rough work.
- Candidates shall not tear off any page from the answerbook. If it is necessary to cancel a written page, it should be clearly crossed out in ink.
- The candidates shall not speak or communicate in any way with any other candidate in the examination hall while the examination is in progress. STRICT SILENCE MUST BE OBSERVED.
- In the case of open book examinations, only cyclostyled or printed materials as suggested by the Instructor-in-charge would be permitted for use. The class notes are not permitted within the examination hall. Borrowing and lending of any of these items as well as slide rules, drawing instruments, etc. amongst the students is not permitted.
- The candidates shall not disobey any instruction issued by the invigilator or behave in a rude or disorderly manner.
- ANY CANDIDATE FOUND GUILTY OF MISCONDUCT AND OF USING UNFAIR MEANS SHALL BE LIABLE FOR EXPULSION FROM THE EXAMINATION HALL BY THE INVIGILATORS ON DUTY. THE INVIGILATORS HAVE BEEN AUTHORISED ACCORDINGLY.
- Candidate should produce identity card in the examination hall as and when demanded by the invigilator.
- Programmable Calculators / Cellular Phone / Page / Electronic gadgets are not allowed.

EN 319 - Experiment no. 6

Performance Characteristics of a slip ring induction motor by brake test

Objective: To perform the brake test on a 3 phase, slip ring induction motor and obtain its performance characteristics.

Name plate details:

① AC slip ring induction motor

	Stator	Rotor
	240V	
• Voltage	240V (l-l) rms	200V (l-l) rms.
• Current	7.5A (max)	11.0A (max)
• Winding	Star	Star
• Power	4.0 hp.	
• Speed	1340 rpm. (rated full load)	

Insulation class : H

② 3 phase auto transformer variac

- Voltage : 0 - 415V (l-l) rms.
- Current (line) 10A.

Procedure: Apparatus:

- a) ~~After~~ • Power analyzer 0-10 kW digital - 1 no.
- Digital tachometer 0-9999 rpm - 1 no.
- Procedure: • ~~INVAR AC drive~~ (red = $\frac{1.5}{9.8} m$) - 1 no.
- Brake drum.

- a) After the name plate details are noted down, the required apparatus have to be collected.
- b) The connections have to be made as shown in the fig 1.

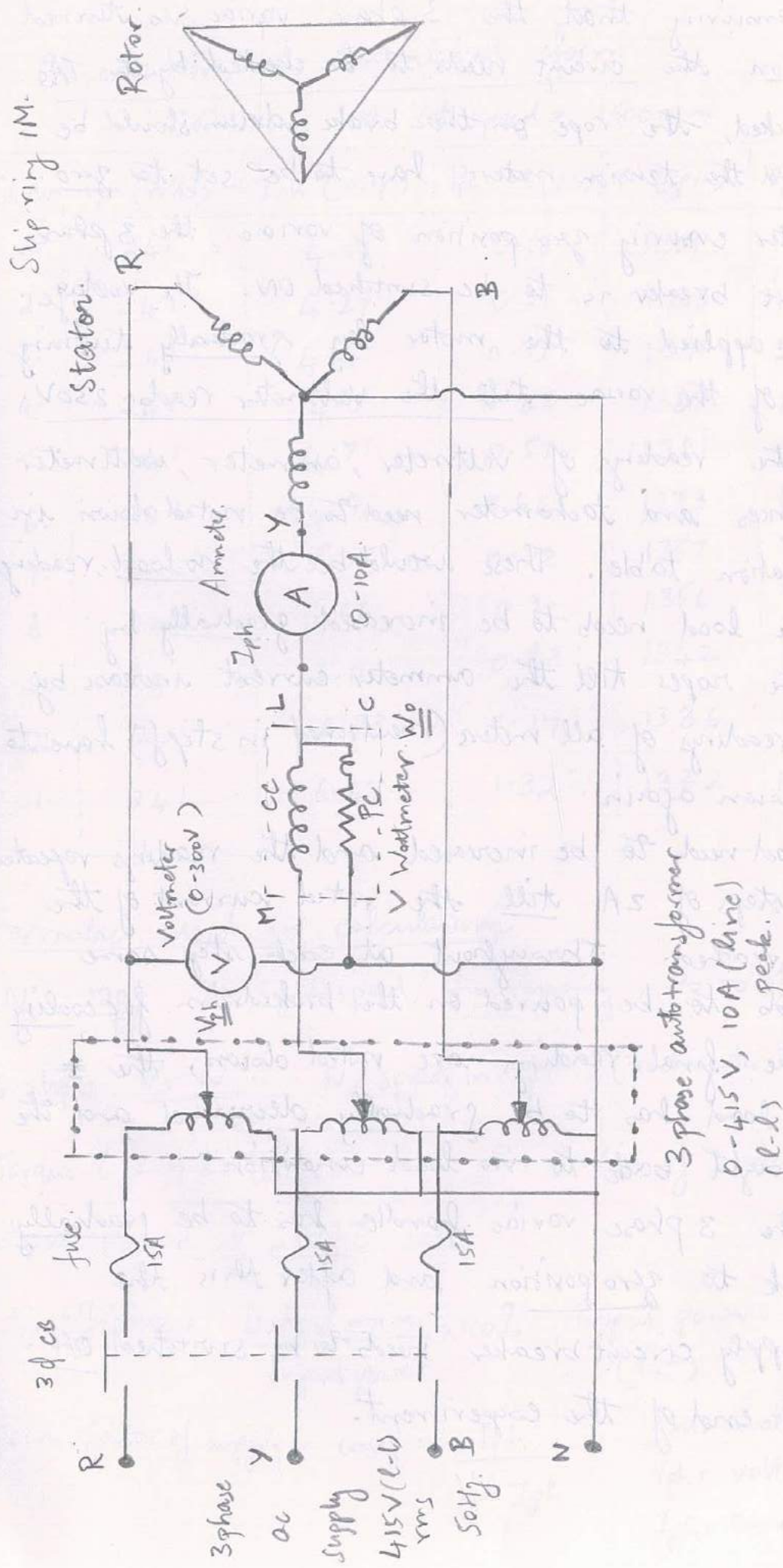


Fig 1: Circuit diagram for experiment no. 6
(Performance characteristics of slip ring motor by brake test.)

- c) After ensuring that the 3 phase variac is turned to zero position the circuit needs to be checked by the TAs.
- d) Once checked, the rope on the brake drum should be loosened and the tension meters have to be set to zero.
- e) Again after ensuring zero position of variac, the 3 phase supply circuit breaker is to be switched ON. The voltage has to be applied to the motor by gradually turning the handle of the variac. till the voltmeter reads 230V.
- f) Then, the readings of voltmeter, ammeter, wattmeter, spring balances and tachometer need to be noted down in the observation table. These would be the no load readings.
- g) Then the load needs to be increased gradually by tightening the ropes till the ammeter current increases by 2A. The readings of all meters (mentioned in step f) have to be noted down again.
- h) The load needs to be increased and the readings repeated ~~till~~ in steps of 2A till the rated current of the motor is reached. Throughout at each step some water needs to be poured on the brake drum for cooling.
- i) Once the final readings are noted down, the ~~3~~ phase load has to be gradually decreased and the motor brought back to no load condition.
- j) Then the 3 phase variac handle has to be gradually turned back to zero position and after this the 3 phase supply circuit breaker needs to be switched OFF.
- Thus the end of the experiment.

Observations in tabulated form.

Condition: at set speed = 1500 rpm

Sl. No.	V_{ph} (volts)	I_{ph} (amp)	$P_{ph} = W_0$ (kW)	N (rpm)	T_1 (kg)	T_2 (kg)	$P_{in} = 3P_{ph}$ (kW)
1.	241	4.17	0.16	1409	0	0	0.48
2.	241	4.27	0.26	1403	1.75	0	0.78
3.	241	4.4	0.39	1391	3.2	0	1.17
4.	241	4.5	0.46	1387	4.1	0	1.38
5.	241	4.71	0.57	1381	5.8	0	1.71
6.	241	4.9	0.64	1373	6.4	0	1.92
7.	241	5.05	0.72	1367	7.4	0	2.16
8.	241	5.66	0.90	1356	9.8	0	2.7
9.	241	6.0	0.99	1342	10.8	0	2.97
10.	241	6.23	1.17	1336	12.0	0	3.51
11.	241	6.47	1.32	1332	12.5	0	3.96

Formulae used in calculations.

- * $N_s = \frac{120f}{P}$ N_s = synch speed, f = frequency, P = no. of poles.
- * % slip = $\frac{N_s - N}{N}$ N = speed in rpm. (tachometer reading)
- * Torque $Z = 9.81 (T_1 - T_2) \times R$ R = radius of brake drum.
- * Output power = $\frac{2\pi N Z}{60}$ watt.
- * % efficiency = $\frac{\text{Output power}}{\text{input power}} \times 100\%$; input power = $3 \times$ Wattmeter reading (P_{in})
- * power factor of supply = $\cos \phi = \frac{P_{ph}}{V_{ph} I_{ph}}$
 P_{ph} = wattmeter reading
 V_{ph} = voltmeter reading
 I_{ph} = ammeter reading.

Sample calculations. (Tabulated)

Sl. no.	$Z = 1.5 \times (T_1 - T_2)$ (N-m)	$\omega = \frac{2\pi N}{60}$ (rad/s)	$P_{out} = Z \times \omega$ (kW)	$\% \eta = \frac{P_{out}}{P_{in}} \times 100\%$	$\cos \phi = \frac{W_o}{V \times I}$
1.	0	0	0	0	0.15921
2.	2.625	147.55	0.387	49.61	0.25266
3.	4.8	146.90	0.705	60.25	0.36778
4.	6.15	145.66	0.896	64.90	0.4242
5.	8.7	145.25	1.263	73.91	0.5022
6.	9.6	144.62	1.388	72.63	0.5420
7.	11.1	143.15	1.588	75.81	0.5923
8.	14.7	141.90	2.087	77.32	0.6598
9.	16.2	140.10	2.300	78.64	0.6721
10.	18.3	138.76	2.687	78.66	0.6634
11.	18.9	138.43	2.823	74.23	0.6421

From the calculations, the plot of efficiency vs. loading is as obtained. (attached graph sheet.)

Observations.

Following are the observations from the conducted experiment:

a) As in the case of all electric machines, the speed of rotation of the machine decreases as the load increases. The speed regulation is calculated from the table as.

$$\begin{aligned} \text{Speed regulation} &= \frac{N_{\text{no load}} - N_{\text{full load}}}{N_{\text{full load}}} \% = \frac{1409 - 1332}{1332} \times 100\% \\ &= \underline{\underline{5.78078\%}} \end{aligned}$$

This is approximately equivalent to the full load rated slip of the machine (slope of speed vs. loading would be having a negative slope.)

b) The efficiency curve increases, reaches a maximum and starts to decrease.

From the observations, the max efficiency occurs at a load of about 2.7 kW and is about 78.67%. This is near the maximum rating of the motor ($4 \text{ HP} = 2.9 \text{ kW}$). At this loading condition, the iron loss of the machine would be equal to the Copper losses.

c) The power factor of the machine also increases, reaches a maximum and then starts to decline. From the readings the machine seems to have a max pf. at about 0.6721 (lag) at a load of about 2.3 kW.

Conclusions

The brake test was performed on the given 3 phase slip ring induction motor and the efficiency vs. loading curve was obtained. Other performance curves such as power factor vs. loading, slip vs. loading, mechanical characteristics (ω vs T) or electric characteristics (T vs I_{ph}) etc. may also be obtained from the tabulated readings if required.

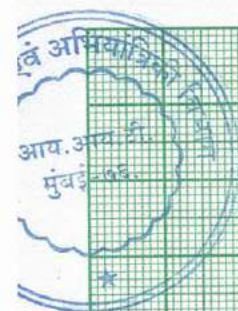
Answers to questions in the Manual.

A) The differences between a wound rotor and squirrel cage induction motor are as follows:

Squirrel cage IM	Wound rotor IM
<ul style="list-style-type: none">* rotor is simpler in construction and more rugged* rotor bars permanently short circuited hence external resistances cannot be inserted in the circuit.* Higher efficiency* low starting torque (approx 1.5 times full load torque.)	<ul style="list-style-type: none">* rotor is of wound type and is provided with brushes and slip rings (complex construction)* possible to insert external resistances into rotor circuit for<ul style="list-style-type: none">a) reducing starting current andb) speed control purposes.* Comparitively lower efficiency.* High starting torque obtained by inserting resistances in rotor circuit.

B) The core losses exist in both the stator and rotor circuits. But since the electric quantities in the rotor circuit have a frequency of slip times the stator frequency, the frequency is low. (slip of IM low.) Hence, the core losses of the rotor are usually neglected.

C) The leakage reactance of an induction motor is larger than that of a transformer. This is because of the presence of an airgap in the core of the equivalent magnetic circuit of the induction motor. The presence of an air gap also causes the magnetising current of the IM to be larger than that of a transformer. Hence the inrush current of IM is larger than that of the transformer.



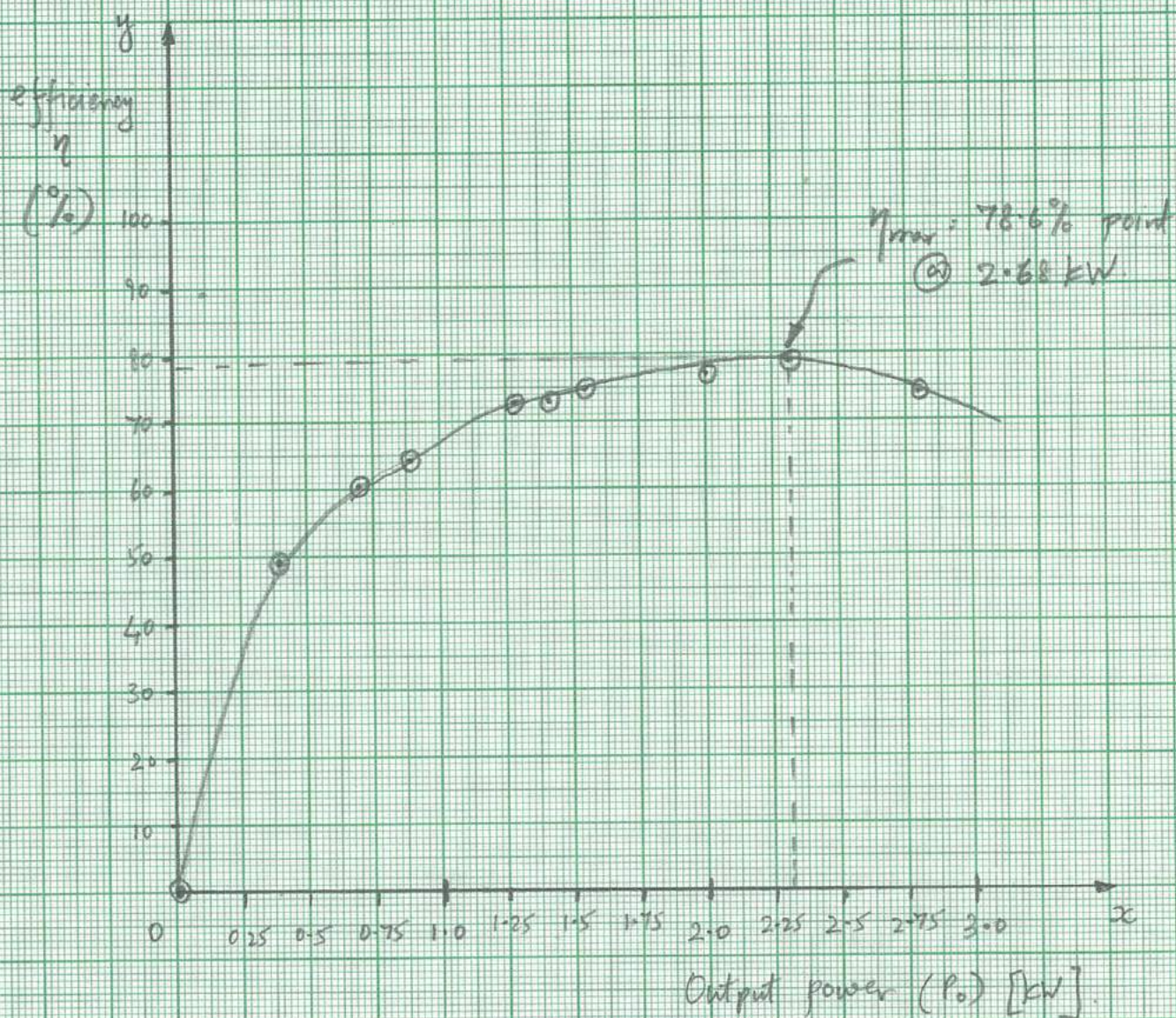
Plot for Expt 6

Batch # 08

Scale.

x axis: 1cm = 0.25 kW

y axis: 1cm = 10%



Expt 6 - Performance char. of slip ring IM.
(plot of efficiency vs o/p power)

Obsv: Smooth curve fitted increases, has maxima & then decreases