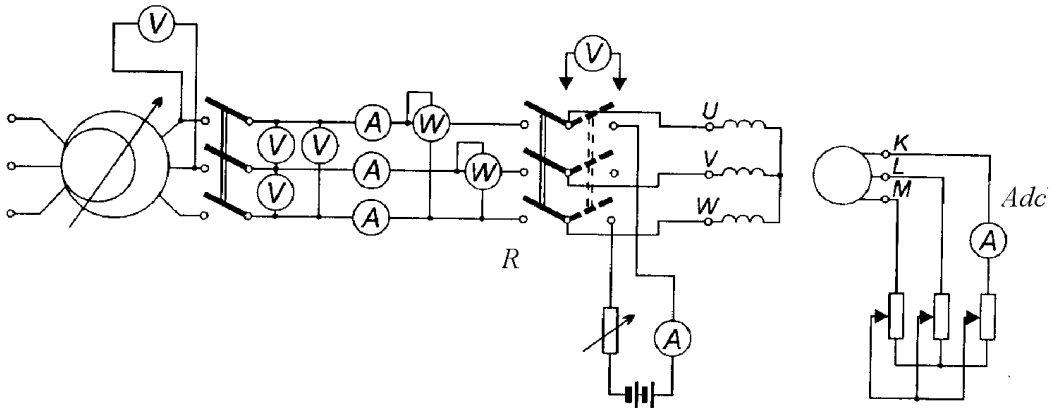
WARSAW UNIVERSITY OF TECHNOLOGY
INSTITUTE OF ELECTRICAL MACHINES
ELECTRICAL MACHINES LABORATORY

3-PHASE INDUCTION MOTOR TESTS
(SI 2)

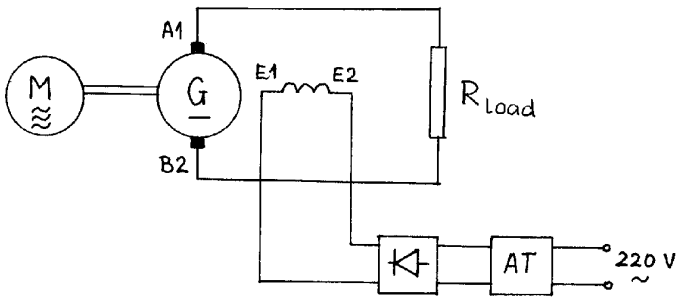
2.1. Load characteristics of induction motor

Measuring circuits of the motor:



R - two-position disconnector

Scheme of generator being a load to the motor:



Separately excited generator, applied as the load to the motor, operates at R_{load} = const. Regulation of its output power - hence the control of motor output power - can be realized by the variation of generator exciting current.

During the test the motor is supplied with its rated voltage, while the load is varied from the no-load state to full load. The measurements should allow calculating the motor output power by means of the losses and power balance.

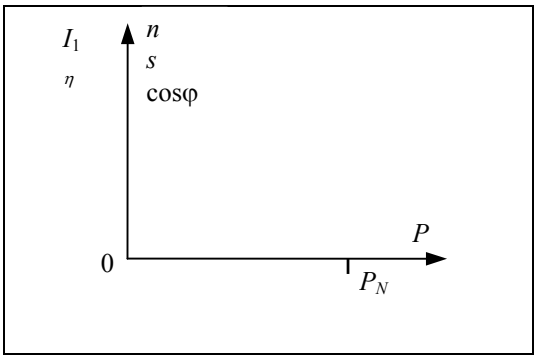
$U=U_N$ = ... R_1=...

No of read	I_U A	I_V A	I_W A	P_a W	P_b W	T Nm	n rpm	I_s A	P_{in} W	s pu	cosφ -	P_{out} W	η %
1													
2													
3													
...													

$$I_s = \frac{I_U + I_V + I_W}{3}; s = n_s - n$$

$$P_{in} = P_a + P_b; P_{out} = 9.55Tn$$

$$\cos\varphi = \frac{P_{in}}{\sqrt{3}U_N I_s}; \frac{P_{in} - P_{out}}{P_{in}}100\%$$



Draw the characteristics:

I_1; n; cosφ; η = f(P)

and determine nominal values of motor current, speed, power factor, efficiency and torque.

2.2. Temperature-rise test $\Delta\vartheta$=f(t) for $U=U_N$; $I=I_N$

Aim of the test: determination of the average temperature rise for stator winding during the load operation of the motor, for $U=U_N$.

Winding temperature measurement method: by means of the stator winding resistance measurement and calculation of temperature rise from the relation of the resistance as a function of temperature.

Motor data:
P_N = 1.7 kW
U_N = 220/380 V (tested motor is already Y connected)
I_N = 6.6/3.8 A
n_N = 1420 rpm.

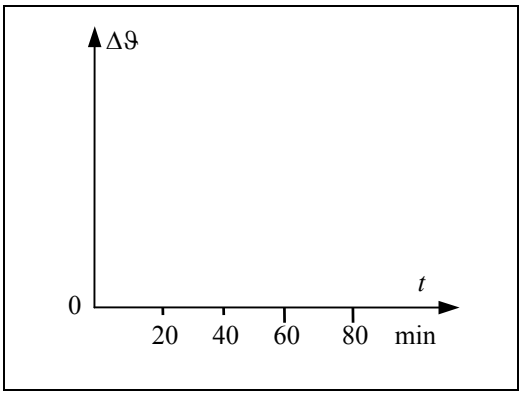
Measuring circuits of the motor: as in p. 2.1 but for squirrel-cage motor and with only one voltmeter and ammeter (to simplify the test).

Ambient temperature ϑ_a=...^{o}C

T I M E	MEASUREMENTS OF RESISTANCE AND TEMPERATURE				
	U	***I***	***R***	R_1	$\Delta\vartheta$
min	V	A	Ω	Ω	K
start					
end					
...	$R=\frac{U}{I};R_1=\frac{1}{2}R$ $\Delta\vartheta=\frac{R_{1h}-R_{1c}}{R_{1c}}\cdot 235$				

The sequence of measurements and calculations:

1. Measure the resistance of one phase of stator winding in the cold state R_{1c};
2. Start the motor and load it to its rated current ($U=U_N$; $I=I_N$),
3. At chosen intervals of time (for example 20 min) de-energize and stop the machine, measure the resistance of stator winding and start machine again (*possibly minimum time is suggested for this operation)*. In the meantime calculate the temperature rise corresponding to the resistance increase,
4. At the end of the test stop the machine and measure the stator winding resistance in the "hot" state R_{1h}



Draw the calculated temperature rise points as a function of time

2.3. CAM temperature-rise test $\Delta\vartheta=f(t)$ for $U=U_N$; $I=I_N$

Aim of the test: determination of temperature rise in different points of the motor structure during operation with nominal current under nominal voltage.

Temperature measurement method:

Computer-aided-measurement (CAM) system consists of:

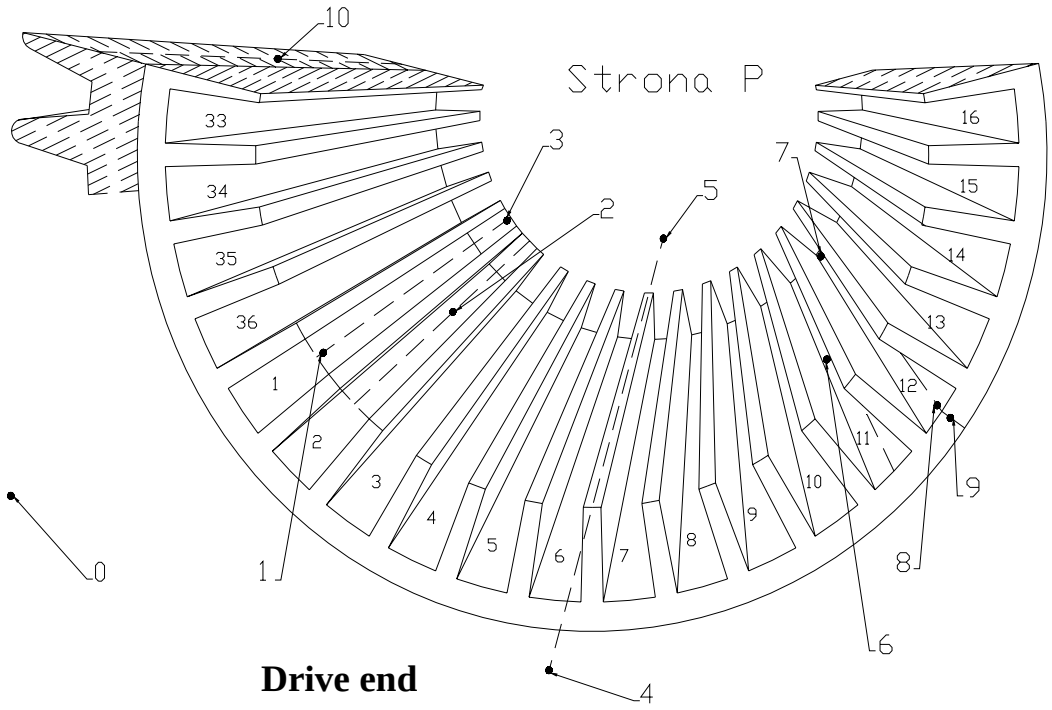
a) Iron-constantan thermocouples (thermocouples of J type) inserted inside the stator of tested motor (see figure);
b) Multiplexer and amplifier board (card) PCLD-779 providing:
   - acquisition (input) of 7 thermocouples' analogue signals (7 channels),
   - galvanic separation (isolation) of thermocouple circuits and computer hardware circuits (by means of capacitors),
   - relay multiplexing of channels,
   - amplification of DC signals,
   - software compensation and linearization of thermocouple signals;

c) DC signals converting board (card) PCL-711 providing:
   - DC voltage signals measurements (those from PCLD-779),
   - analogue to digital (A/D) conversion of signals),
   - multiplexer control;
d) LABTECH-NOTEBOOK software for controlling the operation of PCLD-779 and PCL-711 cards, data acquisition and visual presentation in real time.

Tested motor is loaded by means of DC generator. During the temperature-rise test the load of the motor should be as to have $I = I_N$ for $U = U_N$.

Circuit diagram of motor and DC generator connections: as in p. 2.2.

Location of thermocouples in the stator:



Connections of thermocouple sensors and print details:

No of channel	No of sensor	Location	Colour of curve shown	Mark applied at the print
Ch 1	0	Surroundings (ambient temperature)	Black	—
Ch 2	10	Stator housing	Black	?
Ch 3	2	Slot's top	Green	+
Ch 4	4	End parts of stator winding	Red	*
Ch 5	6	Slot's bottom (core centre)	Blue	•
Ch 6	8	Slot's bottom (core end)	Turquoise	×
Ch 7	9	Stator iron	violet	◊

Procedure of test:

- Switch on the PC with floppy disc "LABTECH NOTEBOOK SET-UP" inserted in drive B and follow the procedure by appropriate commands:
  - *press any key to continue*,
  - *SAVE/RECALL* – mouse,
  - *RECALL – ENTER*,
  - *sil1800s* – write in & *ENTER*,
  - *RUN* - mouse;
- Start the motor, excite DC generator and adjust the load as to have $I = I_N$ in the motor supplying circuit (check $U = U_N$);
- Observe the behaviour of temperature-rise curves at the monitor;
- After ½ hour (1800 s) the programme is concluded and printing is made automatically;
- *ESC*
- Quit Norton Commander
- Switch off PC.

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