DC MOTOR WITH SEPARATE EXCITATION

1. ASSIGNMENT:
   A) Examine static mechanical characteristic.
   B) Examine motor behavior in armature control regime and excitation control regime

2. SCHEMATICS:

3. NOMINAL PARAMETERS OF MACHINES:

<table>
<thead>
<tr>
<th>DC Motor with Separate Excitation</th>
<th>Dynamometer</th>
<th>Tachodynamo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>4.4 kW</td>
<td>5.7 kW</td>
</tr>
<tr>
<td>Armature Voltage</td>
<td>230 V</td>
<td>220 V</td>
</tr>
<tr>
<td>Armature Current</td>
<td>19.2 A</td>
<td>32.6 A</td>
</tr>
<tr>
<td>Excitation Voltage</td>
<td>230 V</td>
<td>220 V</td>
</tr>
<tr>
<td>Excitation Current</td>
<td>0.85 A</td>
<td>1.2 A</td>
</tr>
<tr>
<td>Revolutions</td>
<td>1400 RPM</td>
<td>1600 RPM</td>
</tr>
</tbody>
</table>

4. MEASUREMENT PROCEDURE:

4.1. Measurement preparation

4.1.1. Calibrate the tachodynamo

- Set the dynamometer’s excitation current to nominal value.
- Set the tachodynamo’s excitation current to nominal value.
- Connect dynamometer to the power source.
- Change the voltage slowly in order to avoid current surges.
- Increase the voltage and measure revolutions by tachometer till they reach a value of 1000 RPM.
- Adjust the tachodynamo’s excitation current in order to set a convenient transfer constant, such as 1000 RPM / 100 V.
• Write the revolutions calibration constant value into prepared Excel spreadsheet.
• Disconnect dynamometer armature from power source.

4.1.2. Start DC motor
• Set the motor’s excitation current \((I_f)\) to nominal value.
• Connect motor to the power source. You must ensure that the motor will have same rotation direction as dynamometer.
• Change the armature voltage \((V_a)\) slowly in order to avoid current surges.

4.2. Static mechanical characteristics
• Static mechanical characteristics will be measured in two control regimes:
  o Armature control regime – Excitation current \((I_f)\), armature current \((I_a)\) is constant. Motor is controlled by armature voltage \((V_a)\).
  o Excitation control regime – Armature voltage \((V_a)\), armature current \((I_a)\) is constant. Motor is controlled by excitation current \((I_f)\).

4.2.1. First area - Armature control regime
• Set \(I_f\) to nominal value.
• Control revolutions \((n)\) by voltage of dynamo connected to dynamometer in preferred intervals.
• Adjust armature voltage in that armature current remains constant at set value.
• Read torque and revolutions and increase revolutions until armature voltage reaches chosen value. Then motor control turns in to excitation control regime.
• Record revolutions, torque, armature voltage, armature current.

4.2.2. Second area - Excitation control regime
• Keep armature voltage constant.
• Control revolutions by voltage of dynamo connected to dynamometer in preferred intervals.
• Adjust excitation current in such a way that armature current remains constant at set value.
• Read torque and revolutions and increase revolutions until excitation current reaches minimal allowed value \((0.4 I_{fn})\) or until revolutions reach maximal allowed value \((1800\ RPM,\ at\ 1900\ RPM\ the\ dynamometer\ protection\ shuts\ a\ whole\ machine\ unit)\).

4.2.3. Results
• Plot measured values for both control regimes in common graph. Mark distinction line between regimes.
• Calculate and plot mechanical power in the same graph as the torque.
• Calculate motor efficiency and plot it in a separate graph \((\eta = f (n))\).

\[
\eta = \frac{P_{out}}{P_{in}} = \frac{\omega \cdot T}{V_a \cdot I_a + V_f \cdot I_f} = \frac{\pi \cdot n \cdot T}{30 \cdot (V_a \cdot I_a + V_f \cdot I_f)}
\]
4.3. Motor behavior in armature control regime and excitation control regime

4.3.1. Motor behavior in armature control regime
- Measure for two or three values of armature current (e.g. 0.25 \(I_a\), 0.5 \(I_a\), \(I_a\)).
- Excitation current is constant during whole measurement time.
- Control revolutions by dynamo voltage connected to dynamometer in preferred intervals.
- Control armature current by armature voltage in the manner that armature current remains constant at set value. First set of measurements perform at the lowest armature current, in the following set increase armature current.
- Record values of torque, revolutions and armature voltage.
- Measure for whole voltage range – from 0 V to nominal armature voltage (5 values are enough).
- Create two graphs common for all values of armature current. On first graph plot the dependency of torque on revolutions, in second one plot the dependency of armature voltage on revolutions.

4.3.2. Motor behavior in excitation control regime
- Measure for two or three values of excitation current (e.g. 0.4 \(I_f\), 0.6 \(I_f\), \(I_f\)).
- Measure at decreased armature voltage (≈ 0.6 \(V_a\)). Armature voltage is constant during whole measurement time.
- Set such a revolutions, that armature current will be nominal at chosen armature voltage.
- Set excitation current to a preferred value. This value remains constant during whole measurement. Start with the highest excitation current value and in the next measurement set use lower value.
- Record values of torque, revolutions and armature current.
- Increase revolutions in preferred intervals by dynamometer. With increase of revolutions the moment should decrease. Measure 8 or more values.
- Repeat measurement at lower excitation current. You should achieve higher values of torque at similar revolutions then in previous measurement and also you should be able to reach higher maximal revolutions. Do not let revolutions exceed 1800 RPM.
Create two graphs common for all values of armature current. On first graph plot the dependency of torque on revolutions, in second one plot the dependency of armature current on revolutions.

Armature control: $I_a$ const.
$V_a = f(n)$

Excitation control: $V_a$ const
$I_a = f(n)$

Figure 3: Motor behavior in anchor control and excitation control regime, $I_{a1} < I_{a2} < I_{a3}, I_{f1} > I_{f2} > I_{f3}$

5. MEASUREMENT REPORT:
Each student will create measurement report. The report will contain:
- Name of laboratory exercise.
- Date of measurement.
- Student’s name.
- Assignment.
- Schematics.
- A brief summary of the procedure.
- Measured data.
- Graphs plotting measured data – create them in the similar way as in Figure 2 and Figure 3.
- Conclusion – evaluate the measurement.