Conduct performance analysis of DC series shunt and compound motors

Objectives: At the end of this Exercise you shall be able to
- **measure the armature resistance**
- **measure the series field resistance**
- **connect the two-point starter for series and 3 point & 4 point starter for shunt and compound motor**
- **measure the speed of the motors**
- **vary the load of a DC series motor**
- **determine the performance characteristic of a DC series motor shunt motor and compound motor and draw the following curves**
  - **speed versus load**
  - **torque versus load**
  - **speed versus torque.**
- **determine the efficiency of the DC shunt motor at different loads.**

Requirements

Tools/Instruments

- Insulated cutting pliers 150mm - 1 No.
- Screwdriver 150mm - 1 No.
- D.E. spanner set 5mm to 20mm - 1 No.
- 500V Megger - 1 No.
- Multimeter/ohmmeter 0 to 2 K ohms - 1 No
- M.C.ammeter 0-15A - 1 No.
- M.C. voltmeter 0-300V - 1 No.
- Tachometer 300-3000 r.p.m - 1 No.

Equipment/Machines

- D.C. series motor 220V 3 H.P - 1 No.
- ICDP switch 250V 16A - 1 No.
- 2- Point starter - 1 No.
- Dial type spring balance 25kg capacity - 1 No.
- Prony brake system complete - 1 No.
- DC shunt motor 220V 2/3 HP - 1 No.
- 220V 4 - point starter - 1 No.
- Rheostat 100 ohms 2 amps - 1 No.
- Brake test arrangement with two spring balances of 25 and 50 kg rating - 1 Set
- 220V DC compound motor 2 or 3 with prony brake loading arrangement - 1 Set

Materials

- 2.5 sqmm PVC insulated multi-strand copper cable - 6 m.
- Fuse wire 5A &10A. - as reqd.
- Test lamp - 1 No.

PROCEDURE

TASK 1: **Conduct the load performance test on a DC series motor**

1 Note down the name-plate details.

2 Identify the terminals of the given DC series motor and test for insulation and ground.

3 Select and collect the required equipment, apparatus and cables, and connect the motor as per the circuit diagram. (Fig 1)

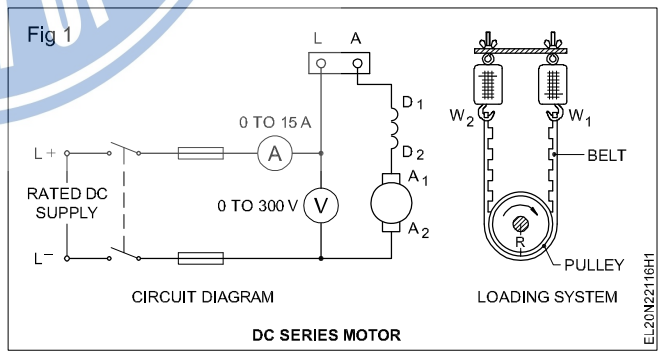
The DC series motor should not be started or made to run without load.

4 Start the DC series motor slowly by moving the starter handle to the 'ON' position.

5 Check the speed, load current and input voltage. Adjust the load current to 1/4th of the F.L. value by adjusting the load.

6 Measure the speed, load current, voltage and read the spring balance and record in Table 1.

Fig 1



7 Slowly increase the load in steps up to full load. Record the measurement for 1/2, 3/4 and full load.

8 Tabulate all the readings in the tabular columns provided in Table 1.

9 Stop the motor by switching it off after taking all the readings.

Do not remove the mechanical load before switching off.

10 Measure the radius of the pulley and calculate the torque, horsepower and efficiency.

11 Draw the following characteristic curves.

- Speed versus load
- Torque versus load
- Speed versus torque

12 Write your conclusion about the relationship between speed and load, torque and load, speed and torque and efficiency and load.

CONCLUSION

Input voltage = Voltage x Current

T = 9.81 x f x r

f = W1 - W2 r = Pulley radius

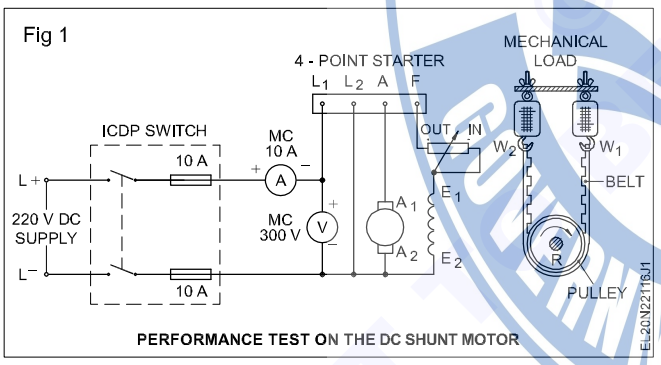
Table 1

Sl. No.	Load	Applied voltage (volts)	Line current (amps)	Spring balance W_1 kg	Spring balance W_2 kg	Radius of pulley (metre)	T_1 Torque in Kilogram metre	T Torque in N.M NM= 1 kg mx9.81	N Speed in r.p.m.	OP = $\frac{(2\pi NT)}{60}$ (where N is the speed in r.p.m. & T is the torque in newton metre)	Efficiency = $\frac{(OP \times 100)}{IP}$
	1/2 3/4 Full load										

TASK 2: **Conduct the load performance test on a DC shunt motor**

1 Connect the DC shunt motor as per the circuit diagram.(Fig 1) Keep the shunt regulator rheostat in the cut out position, and the mechanical load applied through the brake to zero value.

Fig 1



2 Switch on and move the 4-point starter handle, gradually up to `ON' position.

3 Measure the speed, and if necessary, adjust the speed to the rated value by adjusting the shunt regulator rheostat and note down the reading in Table 2.

4 Increase the load step by step by tightening the wing-nut.

5 Measure the speed each step read the meters and the spring balances and record them in Table 2. Load the motor up to its full load value.

6 Reduce the load gradually and switch `OFF' the motor.

7 Measure the radius of the pulley in metres and calculate the torque in kg. metres.

Torque in kg.m = (W_1 – W_2)kg x radius of pulley in meters where W_1 is the reading of the tight side spring balance and W_2 is the reading of the slack side of the spring balance in kilograms.

8 Draw the speed load characteristic curve, keeping the load (line) current in the X-axis and the speed in the Y-axis.

9 Draw the torque-load characteristic in the same graph sheet, keeping the load (line) current in the X-axis and torque in the Y-axis.

10 Draw the torque-speed characteristic in the same graph sheet, keeping the torque in the X-axis and the speed in the Y-axis.

Use different colours for each curve.

11 Write the conclusion by highlighting the relation between

- speed and load
- torque and load
- torque and speed.

11 Calculate the efficiency of the given DC shunt motor by applying the following formula and record it in Table 2.

$$= \frac{2\pi NT \times 100}{60 \times VI} \text{ percentage.}$$

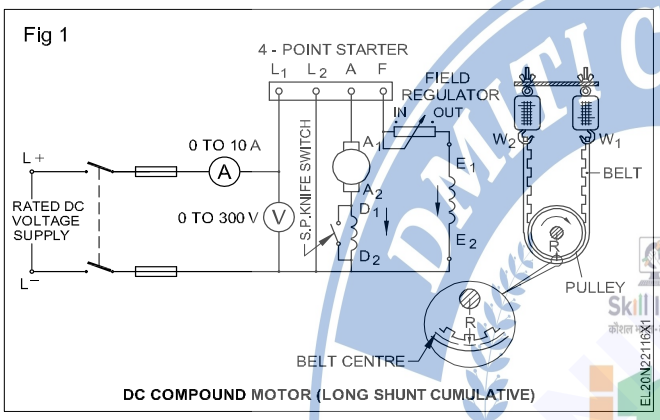
Table 2

Sl. No.	Applied voltage (volts)	Line current (amps)	Spring balance W_1 (kg)	Spring balance W_2 (kg)	Radius of pulley (metre)	T_1 Torque in Kilogram metre	T Torque in N.M NM= 1 kg mx9.81	N Speed in r.p.m.	OP = $\frac{(2\pi NT)}{60}$ (where N is the speed in r.p.m. & T is the torque in newton metre)	Efficiency = $\frac{(OP \times 100)}{IP}$

TASK 3: **Conduct the load performance test of a DC compound motor**

1 Connect the machine as a long shunt (cumulative) compound motor with the switches, fuses and meters and starter.(Fig 1)

Fig 1



DC COMPOUND MOTOR (LONG SHUNT CUMULATIVE)

2 Arrange the prony brake for loading the motor.

3 Keep the series field shorted by the S.P.S.T. knife switch.

This will enable the motor to start normally, even if it is connected as a differential compound motor.

4 Keep the field regulator in the `cut out' position. Switch on the supply and move the 4-point starter handle gradually up to the `ON' position.

5 Open the series field shorting switch.

6 Measure the speed and adjust it to the rated value and note down the readings in Table 3.

7 Increase the load step by step up to the full load following the instructions contained in step 8.

When applying the load, the speed may increase, if it is differential. Then stop the motor and interchange the connections of the series field for cumulative compounding Accordingly modify the connection diagram. (Fig 3)

8 Measure the speed for each step read the meters and spring balances and record them in Table 3. Increase the load up to the full load value.

9 Reduce the load gradually, switch off the motor.

10 Draw the torque-load characteristic in the same graph sheet, keeping the load current in the X-axis and the torque in the Y-axis. Use different colours.

11 Draw the torque-speed characteristic in the same graph sheet, using a different colour and keeping the torque in the X-axis, and the speed in the Y-axis.

12 Write your conclusion by highlighting the relation between – speed vs load

- torque vs load
- speed vs torque.

CONCLUSION:

18 Draw the curve showing the relation between load and efficiency of the DC compound motor in a separate graph sheet keeping the load in the `X' axis and the efficiency in the 'Y' axis.

Table 3

Sl. No.	Applied voltage (volts)	Line current (amps)	Spring balance W_1 (kg)	Spring balance W_2 (kg)	Radius of pulley (metre)	T_1 Torque in Kilogram metre	T Torque in N.M NM= 1 kg mx9.81	NSpeed in r.p.m.	OP= $\frac{(2\pi NT)}{60}$ (where N is the speed in r.p.m. & T is the torque in newton metre)	Efficiency = (OP x 100) / IP
1										
2										
3										
4										
5										

Dismantle and identify parts of three point and four point - DC motor starters

Objectives : At the end of this Exercise you shall be able to
- **dismantle the 3 points & 4 point starter**
- **identify the parts of three point starter**
- **identify the parts of four point starter.**

Requirements

Tools/Instruments

- Combination pliers 200mm - 1 No.
- Screw driver 200mm - 1 No.
- Multimeter - 1 No.

Equipment/machines

- 3 point starter 3HP 240V - 1 No.
- 4 point starter 3Hp 240V - 1 No.
- Series testing board - 1 No.

Materials

- PVC Insulated stranded Copper cable 4 sq mm - 10 m
- DPST main switch 250V 32A - 1 No.
- Insulated tape - 0.2m
- Fuse wire of required amps rating. - as reqd.

PROCEDURE

TASK 1: **Identify the parts and terminals of 3 point starter**

1 Write down the name plate details of the given DC 3 point in Table 1.

Table 1

DC starter _____	3 point
Volts _____	
Amps _____	
Serial No. _____	
Make _____	

2 Identify the different parts of the starter and draw the starter diagram and label the parts in your record.

3 Connect one lead of series testing board with the 'handle' of the starter and connect second lead with the other terminals of the starter. Keep checking the other terminals with the second lead till the lamp glows. When the lamp glows brightly with any one of the terminals, that shows terminal is 'L' (Fig 1).

4 Connect one lead of the series testing board with any stud of the resistance and another one with remaining two terminals respectively. The terminal on which the lamp glows dim is terminal 'F'. Connect the remaining third terminal and check lamp glow bright. (Fig 2)

Testing should be done carefully.

While identifying terminals, power supply should not be switched ON in the starter.

Fig 1

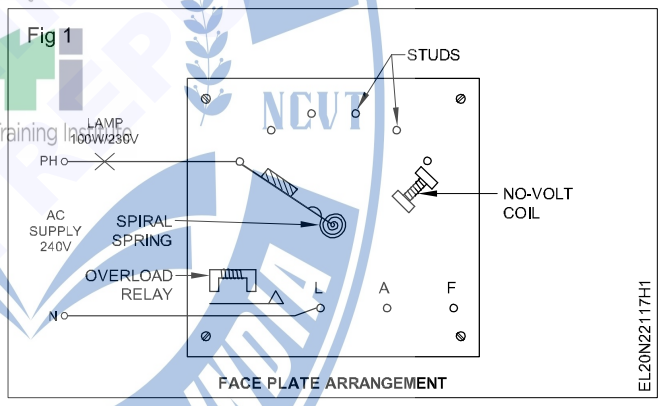
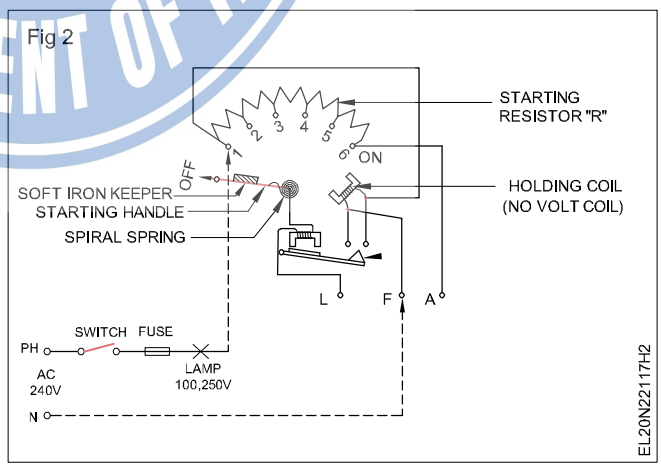


Fig 2



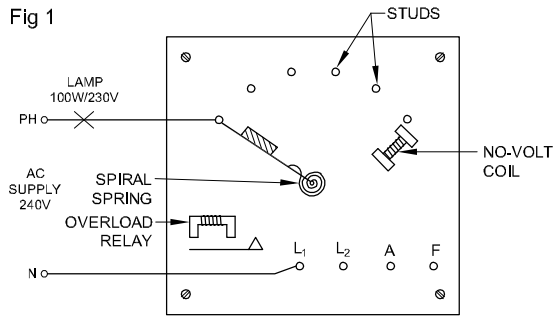
TASK 2 : **Identify the parts and terminals of 4 point starter**

1 Write down the name plate details of given DC 4 point starter in Table 2.

Table 2

DC starter	_____ 4 point
Volts	_____
Amps	_____
Serial No.	_____
Make	_____

Fig 1



FACE PLATE ARRANGEMENT

EL20N22117Y1

2 Identify the different parts of the starter and draw the starter diagram and label the parts in your record.

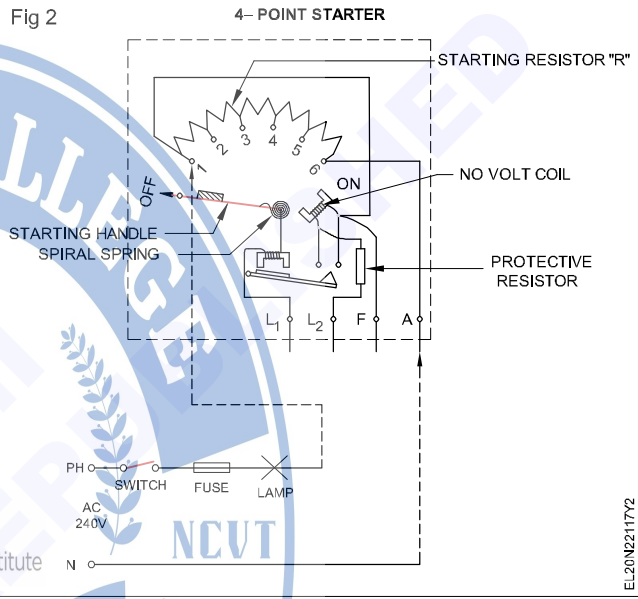
3 Connect one lead of series testing board with the 'handle' of the starter and connect second lead with the other terminals of the starter. Keep checking the other terminals with the second lead till the lamp glows. When the lamp glows brightly with any one of the terminals, that shows terminal is 'L_1' (Fig 1).

4 Connect one lead of the series testing board with any stud of the resistance and another one of the three terminals respectively. The terminal on which lamp glows more dim (or) spark on the terminals, that shows terminal is L_2. (Fig 2)

5 Connect one lead of the series testing board with any stud of the resistance and another one with remaining two terminals respectively. The terminal on which the lamp glows more bright is terminal 'F'.

6 The remaining fourth terminal is that of the terminal 'A'.

Fig 2



EL20N22117Y2

Assemble, service and repair three point and four point DC motor starters

Objectives: At the end of this Exercise you shall be able to
- **assemble, service repair three point starter and four point starter.**

Requirements

Tools/Instruments

- Combination pliers 200 mm - 1 No.
- Screw driver 200 mm - 1 No.
- Multimeter - 1 No.
- Flat file Bastard 150 mm - 1 No.
- Flat file smooth 150 mm - 1 No.
- Ammeter DC 0-30A - 1 No.
- Voltmeter DC 0 - 300 V - 1 No.
- Megger 500 V - 1 No.

Equipment/Machines

- 3 point starter 3 HP 250 V DC - 1 No.
- 4 point starter 3 HP 250 V DC - 1 No.
- DC compound motor 230 V 3HP 10 A - 1 No.

Materials

- DPST main switch 250 V 32 A - 1 No.
- PVC Insulated stranded copper cable 4 sq mm. - 10 m
- Insulation tape - 0.2 m
- Fuse wire of required amps rating - as reqd.
- Carbon tetra chloride - 50 ml.
- Sandal paper No. 1 - as reqd.
- Petroleum jelly - as reqd.

PROCEDURE

General maintenance and servicing

1 Write down the Name-plate details of the given DC motor starter in Table 1.

Table 1

DC starter

DC starter _____	3 point / 4 point
Amps _____	Volts _____
Make _____	Serial No. _____

2 Identify the different parts of the starter and draw the starter diagram and label the parts in your record.

3 Trace the internal connections of the starter and draw the schematic diagrams. Fig 1 and 2 are given for your guidance.

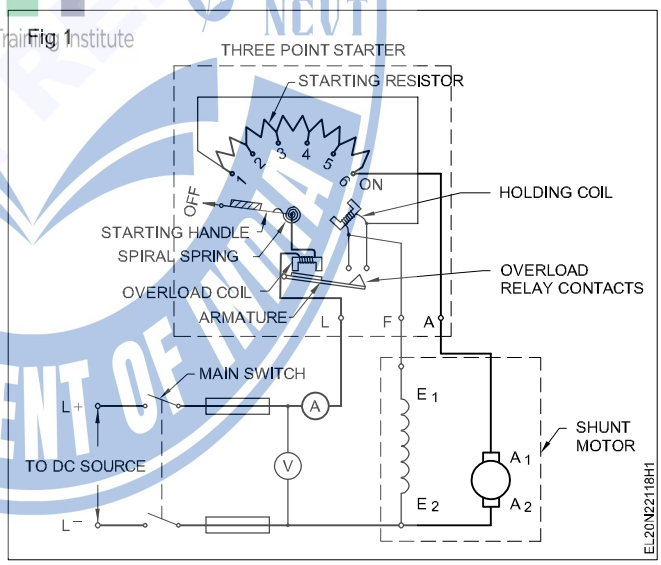
4 Check the contact studs (movable in handle and stationary in face plate of starters) and the starter resistance. Follow the procedure given in chart 1 to rectify the defects.

5 Visually inspect the colour and condition of the no volt coil and enter the details in Table 2.

6 Measure the resistance value of the holding (no-volt) coil as well as that of protective resistance and note the readings in the Table 2.

7 Measure the insulation resistance of the coil with respect to the core. Enter the value in Table 2.

Fig 1



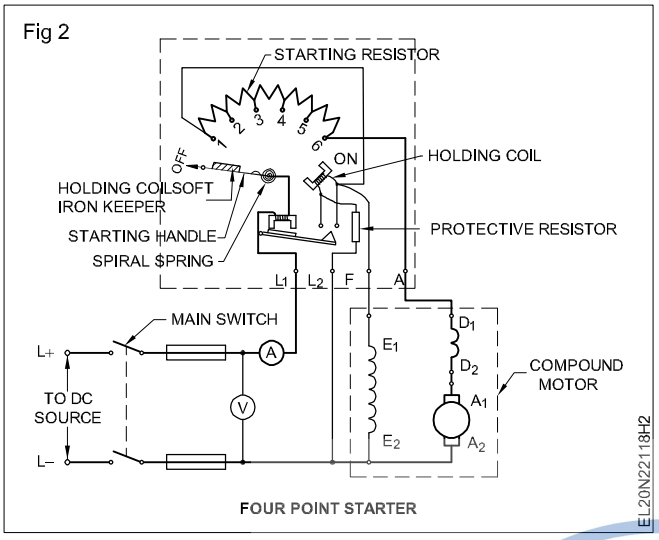
If there is any change in the present condition with respect to values obtained at the time of installation, discuss with your instructor. If necessary replace the NVC with a new one having same specification.

8 Set the overload relay for the same current rating as of the motor.

9 Connect the DC motor with the starter.

10 Make necessary loading arrangement for the DC motor.

Fig 2



FOUR POINT STARTER

11 Start the DC motor and load it to the rated current.

The starter should not trip at this settings. If it trips, increase the current setting of the overload relay to the next higher value by a small increment. In case the overload relay current setting is much higher, then also starter will not trip.

To find the correct setting reduce the current setting till the starter trips and then slightly increase the current setting till the starter holds. Accordingly recalibrate the overload current rating. Normal setting of the overload relay will be 1.5 times the rated current of the motor.

12 Check the starter operation in load condition. In case of any trouble follow the trouble shooting chart and rectify the defect.

Chart 1

General maintenance procedure for DC starters

Trouble area	Cause	Remedy
1 Check the stationary and movable contact studs for burns and pitting.	a) Loosely fitted studs	a) Tighten the nuts in the rear of the contact studs
	b) Over load	b) Reduce the load.
	c) Insufficient pressure on contact studs due to loosely fitted handle.	c) Add a washer or two over the handle and tighten the handle studs
	d) Improper operation.	d) Smoothly manipulate the handle from start to run condition.
		e) Light burns over the contacts could be cleaned with CTC (Carbon tetra chloride) Heavy burns and pitting need to be dressed with a sand paper or a flat file.
		f) Apply petroleum jelly over the movable and stationary contact points.
2 Check the starter resistance for open or shorts	a) open resistance are due to excessive heating resulted from: i) wrong starting method ii) excessive load	a) Do not keep the starter handle in starting position for a long time. i) Reduce the over load. ii) Replace the opened resistance with the equivalent material size and length.
	b) Shorted resistance due to: i) excessive vibration of the panel ii) loose mounting of the resistance	i) Reduce the vibration of the panel by proper mounting. ii) Properly mount the resistance.

Table 2

No volt coil

Sl. No.	Description	Initial condition at the time of installation		Present condition		Remarks
		Date of installation	Condition	Date	Condition	
1	Colour of the no volt coil (visual inspection)	1.8.2000	Yellow			
2	Resistance value of the no volt coil	1.8.2000	2500 ohms			
3	Insulation resistance between the no volt coil and the core	1.8.2000	5.5 Megohms			
4	Protective resistance of the 4 point starter	1.8.2000	1000 ohms			

Chart 2

Trouble shooting chart for DC Starters

Trouble	Cause	Remedy
1 Intermittent current flow in the motor through starter.	1 Loose connections. 2 Stud may not be firm. 3 Insufficient pressure of the handle 4 Formation of dirt.	1 Tighten all terminals / connections. 2 Tighten the studs. 3 Adjust the pressure 4 Clean the studs with contact cleaner.
2 Handle is not coming to off position when NVC is demagnetised	1 Insufficient spring tension. 2 Gummy material sticking to the faces of the magnet.	1 Replace the spring with a good one. 2 Clean the magnet faces.
3 Noisy magnet	1 Loose core. 2 Magnetic pole surfaces not making proper contact. 3 Dirt or dust on magnetic faces.	1 Fix the core firmly 2 Replace the magnetic assembly. 3 Clean with suitable solvent.
4 Failure to pick up handle in 'on' position.	1 Low voltage for no volt coil. 2 Coil open or short . 3 Mechanical obstructions. 4 Soft iron piece on the handle missing.	1 Check the supply voltage and rectify. 2 Replace the coil. 3 Clean and check up contacts. 4 Fix the soft iron piece on the handle properly such that it is attracted firmly on the magnetic pole face of the no volt coil.
5 Starter is tripping often	1 Incorrect setting of overload relay. 2 Sustained overload.	1 Set the overload relay properly. 2 Reduce the load.

Practice maintenance of carbon brushes, brush holders, commutator and slip rings

Objectives: At the end of this Exercise you shall be able to
- **inspect the DC machine and pre-test it to locate the fault**
- **dismantle the DC machine, overhaul it**
- **maintain and service the parts of the DC machine like carbon brushes, brush holders, commutator and slip rings.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.
- Bearing puller - 1 No.
- DE spanner set 2 mm to 20 mm - 1 Set
- MC ammeter 0-500 mA - 1 No.
- MC voltmeter 0-500 mV - 1 No.
- MC voltmeter 0-250V - 1 No.
- Growler external with ammeter - 1 No.
- Megger 0-50 meg ohms, 500 V - 1 No.
- Multimeter - 1 No.
- Wooden mallet 8 cm dia - 1 No.
- Electric air blower 240 V, 50 Hz - 1 No.
- Under cutting tool - 1 No.
- Soldering iron 60W 240V - 1 No.

Equipment/Machines

- Faulty DC machine 220 V, 3 HP - 1 No.
- Arbor press - 1 No.
- Dial test indicator - 1 No.

Materials

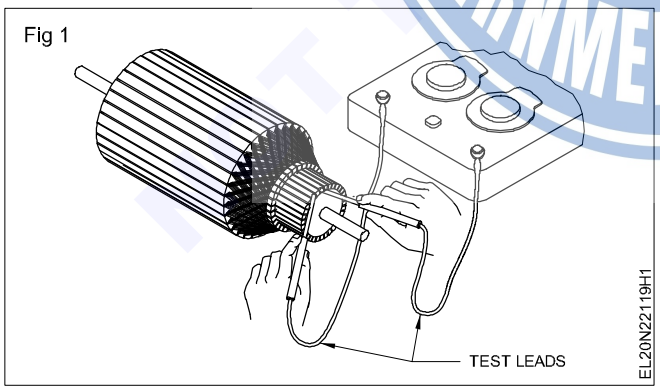
- PVC Insulated copper wire 2.5 sq mm, 250V grade - as reqd.
- Cleaning brush 3 cm dia - 1 No.
- Carbon tetra chloride (CTC) - 5 0 ml.
- Grease type and quantity - as reqd.
- Kerosene - 1 litre
- Lurbrication oil type and quantity - as reqd.
- Cotton cloth - as reqd.
- Sand paper/sand cloth-grade and quantity - as reqd.
- Solder 60/40 - as reqd.
- Soldering flux - as reqd.

PROCEDURE

TASK 1: **Service the parts of the DC machine as stated below**

1 Test the armature for short or open circuits by connecting the ohmmeter test leads to two adjacent commutator bars (Fig 1).

Fig 1

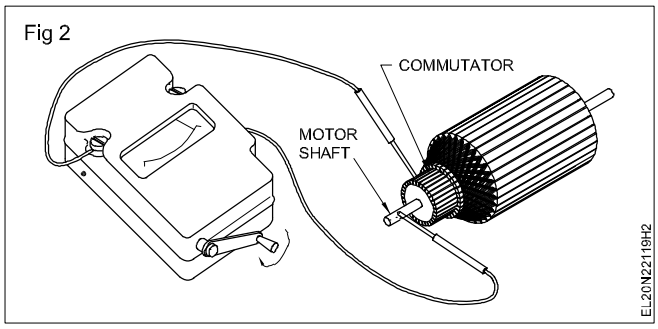


2 Set the meter range to get a reading as near mid- scale as possible.

3 Check that the meter reading is the same for all adjacent commutator segments. If not a) a high resistance indicates an open circuit b) a low resistance indicates a short circuit.

4 Test the armature/commutator for earth fault by connecting one lead of the Megger to the shaft and the other lead of the Megger to the commutator bar. (Fig 2) Enter the defect and the action taken to rectify the defect.

Fig 2



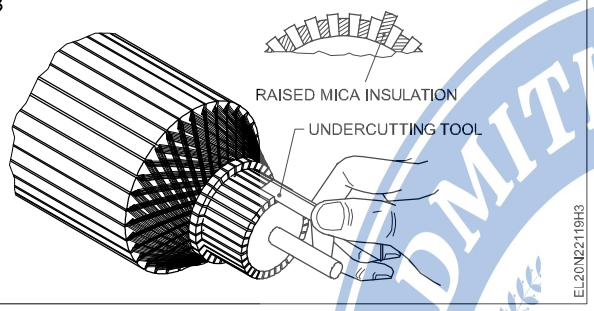
As the commutator is also a part of the armature winding a short or open shown by the above tests involves commutation. Hence check the commutator as explained here before suspecting a coil defect.

Alternatively the armature can be tested for short, open or grounded coils by a growler.

In case a single open or short or ground coil is detected in the above tests, the coil could be replaced with a similar coil; on the other hand if a number of coils are found to be defective, the armature needs to be rewound.

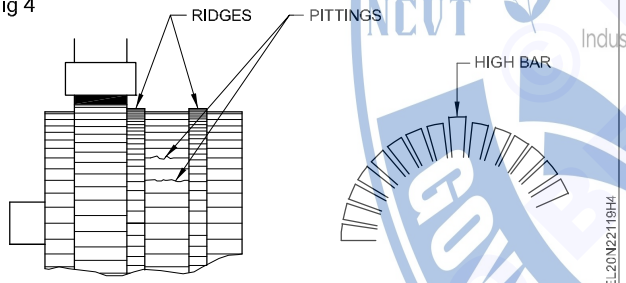
5 Check the commutator for raised mica insulation. If found, under cut the mica. (Fig 3)

Fig 3



6 Check the commutator for pitting, ridges and high bars. (Fig 4). If found, they could be removed by skinning the commutator. (Turning in a lathe)

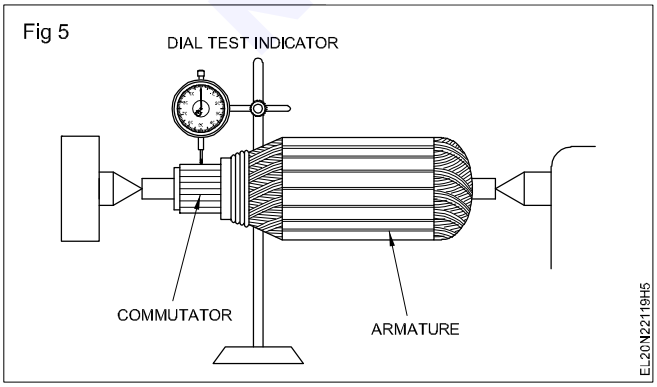
Fig 4



The commutator can only be turned to a minimum diameter specified by the manufacturer.

7 Verify before skinning (turning) check with a dial test indicator that the shaft centre is the true commutator centre. (Fig 5)

Fig 5



8 Get the help of a good turner and remove minimum copper from the surface of the commutator till the pitting, ridges and high bars are rectified.

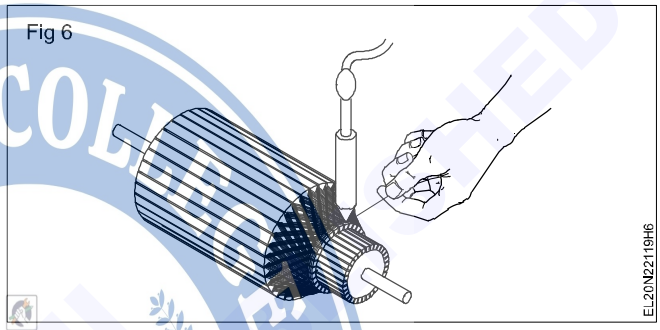
9 Clean by using the sandpaper/sand cloth to give fine finish to the commutator surface.

After finishing, check again for raised mica if necessary undercut the mica.

Badly damaged commutator needs to be replaced by a new one having the same specification.

10 Check the commutator connections in the raisers. If necessary, resolder the suspected soldering spots. (Fig 6)

Fig 6



11 Clean away the dust, dirt and carbon deposits from the brush holder and assembly using Carbon Tetra Chloride. (CTC)

12 Check the length of the brushes using scale.

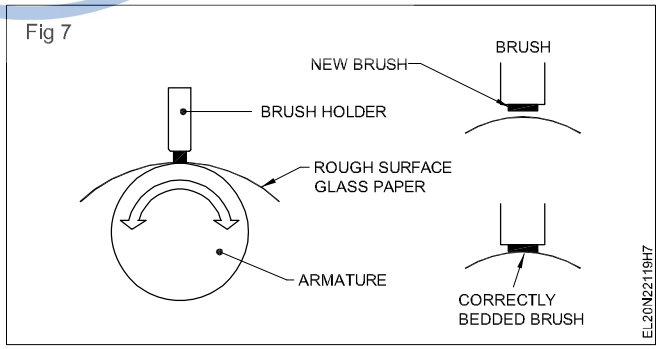
If the length of the brush is reduced to 1/3rd of the original length, the brush should be replaced.

In case a new brush is to be replaced in place of the old one, the new brush should have the specification as recommended by the manufacturer.

13 Check new brush whether it slides freely in the holder without undue side play. If necessary fit with a smooth file. Keeping the brush sides parallel.

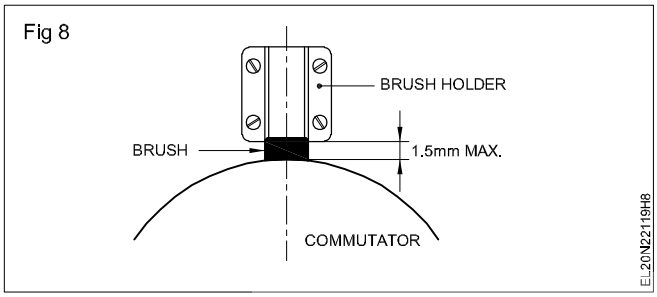
14 Insert the new brush and shape the end of the curve of the commutator, using glass-paper wrapped around the commutator and light pressure in the brush. (Fig 7)

Fig 7



15 Assemble the brush in the brush holder check that the brush holders are not more than 1.5 mm (1/16 in.) away from the commutator surface. If necessary adjust, keeping them square to the commutator. (Fig 8)

Fig 8

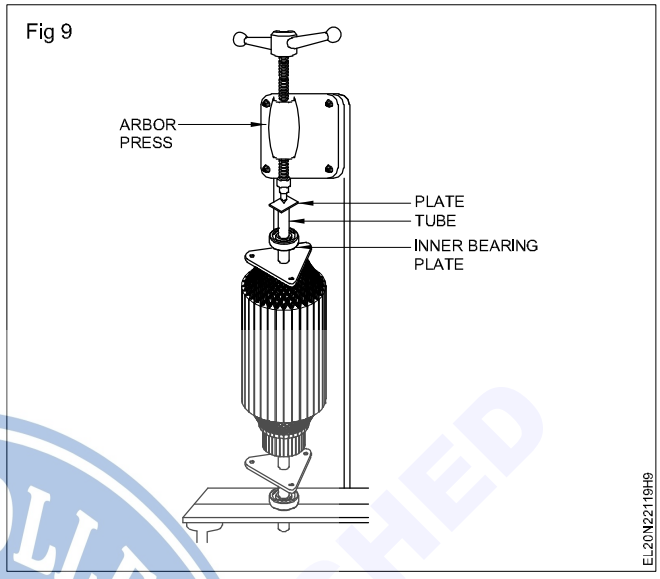


16 Check the spring tension. If it is adjustable, set it to the minimum pressure that will prevent sparking or follow the directions given by the manufacturer.

17 Identify the bearing which is found defective, remove the defective one with the help of a bearing puller and replace it with a bearing having the same specification.

18 Refit the inner bearing plate and then press the bearing on to the shaft in an arbor press, using a tube and a plate to apply pressure to the inner ring of the bearing. (Fig 9)

Fig 9



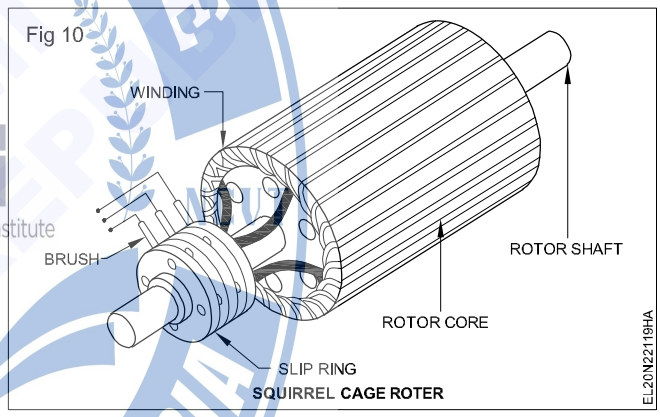
TASK 2: **Practice maintenance of slip rings**

1 Wipe the slip rings with the rag to get ride of any dirt.

2 To get rid of the residue wipe the rings with denatured alcohol.

3 This procedure will completely, clean the dust and debris off of the electrical slip rings. (Fig 1)

Fig 10



Perform speed control of DC motors field and armature control method

Objectives: At the end of this Exercise you shall be able to
- **vary the speed of a DC motor using the shunt field control regulator, and find the relationship between the field current and speed**
- **vary the speed of a DC motor using armature circuit resistance and find the relationship between armature voltage and speed.**

Requirements

Tools/Instruments

- Insulated cutting pliers 200mm - 1 No.
- Screwdriver 200mm - 1 No.
- Electrician's knife (100 mm) - 1 No.
- M.C. ammeter 0-1A - 1 No.
- M.C. voltmeter 0-300V - 1 No.
- Tachometer 300-3000 r.p.m. - 1 No.
- Megger - 500V - 1 No.
- Test lamp - 1 No.
- M.C. ammeter 0 to 15A - 1 No.

Equipment/Machines

- DC shunt motor 220V 3HP - 1 No.
- Rheostat 220 ohms 1 amp - 1 No.
- 4-point starter 15A 220V - 1 No.
- Rheostat 20 ohms 15 amps - 1 No.
- 3 point starter 15A 220V - 1 No.

Materials

- P.V.C. Insulated multi-strand copper cable 2.5 sq mm 600V grade - 10 m
- Fuse wire 15 Amps - as reqd.

PROCEDURE

TASK 1: **Control the speed of a DC shunt motor by the field control method**

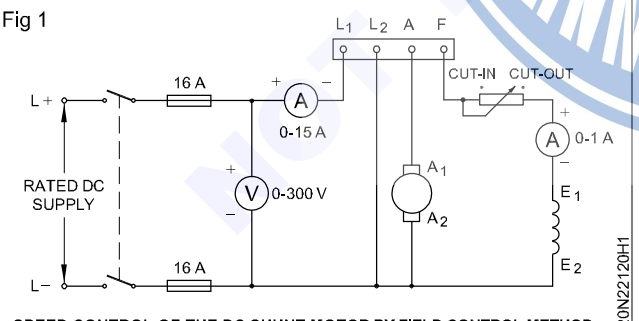
1 Note the name-plate details of the given DC shunt motor and record then in your note book.

2 Identify the terminals of the given DC shunt motor and test for insulation and ground.

3 Select a suitable range of rheostat, ammeter, voltmeter, switch and fuse according to the specification of the given DC shunt motor.

4 Make the connections as per the circuit diagram. (Fig 1) .

Fig 1



SPEED CONTROL OF THE DC SHUNT MOTOR BY FIELD CONTROL METHOD

5 Keep the field rheostat in the cut out position to have minimum resistance in the shunt field circuit.

The rheostat position must be in the cut out position at the time of starting to have a low starting speed.

6 Apply the rated supply voltage through the switch and start the motor by the 4-point starter.

7 Measure the speed, field current, voltage and enter them in Table 1.

8 Decrease the field current by increasing the field control resistance in steps.

Calculate 130% of the speed value from the name-plate details. The speed should not be more than 30% of the rated value.

9 Measure the speed, field current and the applied voltage for each step and enter these values in Table 2.

10 Switch OFF the supply of motor.

11 Draw the speed versus field current curve in a graph sheet, keeping the field current in the X-axis and the speed in the Y-axis.

12 Write your observation highlighting the relation between speed, field current and field flux.

Observation

Table 1

Sl.No.	Voltage	Line current (I_L)	Field current (I_{SL})	Speed rpm
1				
2				

— — — — — — — —

TASK 2: **Control the speed of a DC shunt motor by the armature resistance method**

1 Note the name-plate details of the given shunt motor and record it.

2 Identify the terminals of the given DC shunt motor and test for insulation and ground.

3 Select the 3-point starter, rheostat, ammeter and voltmeter according to the rating of the given DC shunt motor.

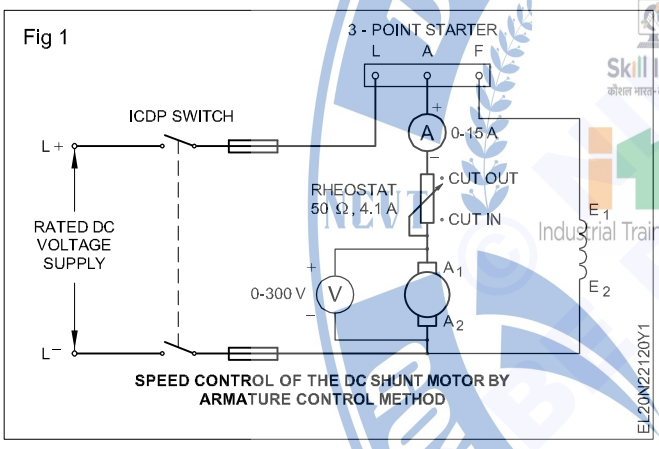
4 Make the connections as per the circuit diagram. (Fig 1)

5 Keep the armature circuit rheostat in the cut out position.

6 Apply the rated voltage and start the motor by using the 3- point starter.

7 Measure the speed, armature current & voltage across the armature and enter them in Table 2.

Fig 1



8 Increase the armature circuit resistance gradually and check the speed and corresponding armature current and voltage across the armature.

9 Repeat step No 7 for each variation .

10 Switch `OFF' the supply to the motor.

11 Draw the speed and armature voltage characteristic curve in the graph sheet, keeping voltage in the X-axis and speed in the Y-axis.

12 Write your conclusion highlighting the relationship between the voltage across the armature and speed.

Note: Back emf =

E_b = Applied voltage – Total armature circuit voltage drop

$= E - I_a R_T$

$= E - I_a (R_a + R_{ar})$

E_b = Applied voltage – (Internal armature resistance drop + External armature rheostat drop)

Assuming the internal armature resistance drop is negligible, we can also assume voltage across the armature = back emf E_b.

Conclusion

Table 2

S.No.	Armature current (I_a)	Voltage across armature	Speed r.p.m.	Remarks

— — — — — — — —

For this Exercise Refer Exercise No : 2.1.115

Perform DC machine winding by developing connecting diagram, test on growler and assemble

Objectives: At the end of this Exercise you shall be able to
- **dismantle the armature from the body**
- **collect and record the armature datas**
- **perform winding of armature**
- **test the armature for short in the coil with an external growler**
- **test the armature for open in the coil with an external growler.**

Requirements

Tools/Instruments

• Electrician tool kit	- 1 Set
• Insulated cutting pliers 200mm	- 1 No.
• Scissors 150 mm	- 1 No.
• Mallet hardwood 0.5kg	- 1 No.
• Soldering iron 25W, 125W, 240 V	- 1 No.
• Tray 200 mm x 200 mm x 50 mm	- 1 No.
• Scale with weights 1 to 450 g	- 1 No.
• Outside micrometer 0-25mm	- 1 No.
• Tweezer 100mm	- 1 No.
• Stand winder for armature	- 1 No.
• Power hack saw blade used	- 1 No.
• Centre punch 150mm	- 1 No.

Equipment/Machines

• Growler external with hacksaw blade	- 1 No.
• Burnt out armature	- 1 No.
• Rotor balancing machine for small armature	- 1 No.
• Multimeter 0 1000 ohm 2.5 to 500V	- 1 No.

Materials

• 7 Mill millinex paper	- as reqd.
• 30 SWG super-enamelled copper wire	- 300 g
• Empire sleeve 1mm, 2mm	- 1 m each
• Cotton tape 20mm	- 1 m
• Binding/hemp thread	- 1 roll
• Hylam/fibre wedge 2mm thick	- as reqd.
• 10 milli triplex paper	- as reqd.
• V-32 insulation varnish	- 1/2 litre
• Thinner	- 1/2 litre
• Resin core solder 60/40	- 20 g
• Resin flux (power type)	- 10 g
• Air dry varnish	- 1/2 litre
• Used hack saw blade	- 1 No.
• Soldering paste	- 10 g

PROCEDURE

TASK 1: **Dismantle of armature from the body**

Assumption: To facilitate easy approach, the procedural steps are for a mixer similar to Sumeet make. However NIMI does not take any responsibility for the correctness of the specification given in this information as the specifications are bound to change by the manufacturer from time to time.

1 Note the name-plate details of the given mixer in Table 1.

2 By turning the mixer upside down, make the position of the closing cover.

3 Dismantle the rubber bush and unscrew the fixing screw from the closing cover.

4 Trace the main supply lead and its connection to the internal parts.

5 Trace the internal connection from the field, armature, speed selector switch and draw the connection diagram.

Fig 1 is given for your guidance.

Fig 1

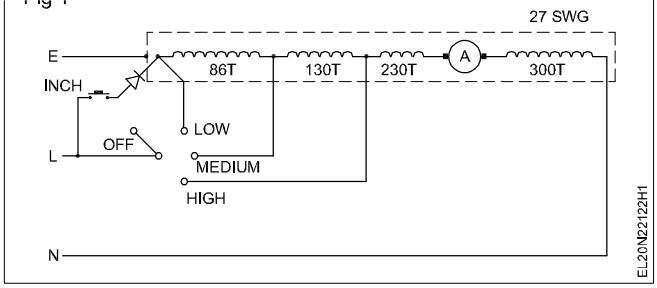


Table 1

Data Sheet

Make ..... Type.....

KW..... Volt ..... Amp..... No. of poles.....

R.p.m..... Frame..... Model.....

Rotor	Size of wire	No. of Turns	Coil Pitch	Coils/Slot	Wt. of one coil	Wt. of the winding	No. of slots	No. of commutator	Remarks

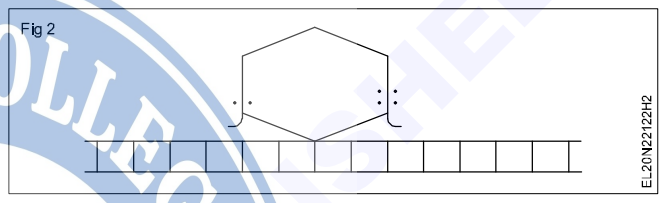
Centre of slots.

to

Centre of bars

Centre of mica

Fig 2



Commutator

Pitch

Lap Wave

6 Remove the top cover screw which is fitted in the inner side of the body of the mixer.

7 Remove the top cover of the mixer.

8 Remove the coupling pulley

9 Disconnect the main supply lead and inner leads from the speed selector swich terminals.

10 Remove the motor from the plastic cover assembly.

11 Remove the carbon brushes.

12 Mark the position of the bottom cover and the body for the mixer with the help of a centre punch.

13 Loose the through machine screw and remove the bottom cover.

14 Remove the fan blade from the armature shaft.

15 Remove the armature out of the stator

TASK 2: **Collect and record the armature data's**

1 Check visually the armature for fault symptoms and then by an external growler.

2 Note down your findings in Tables 1 under symptoms of defects

3 Place the armature in the winding stand. Count the number of slots, number of segments and record in Table 1.

4 Draw the developed diagram with the help of the data obtained.

To give proper guidance to the trainees a particular make mixer (similar to sumeet mixer) is considered here.

The connection diagram is shown in Fig 1, the ring diagram is shown in Fig 2 and the developed diagram is shown in Fig 3.

5 Identify one slot and mark a dot each on the side of slot with the help of a centre punch. (Fig 4)

6 Trace the end connection from the slot to the commutator segment.

Fig 1

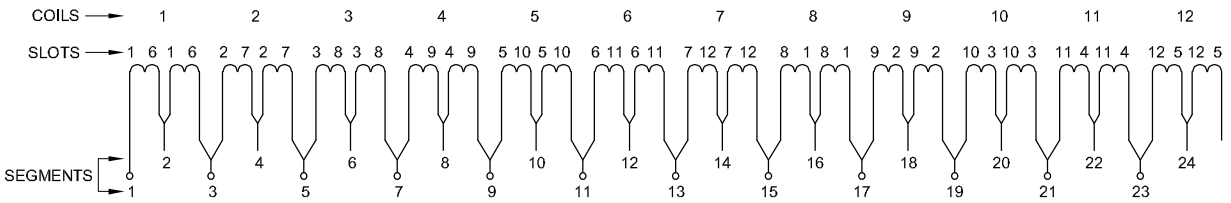


Fig 2

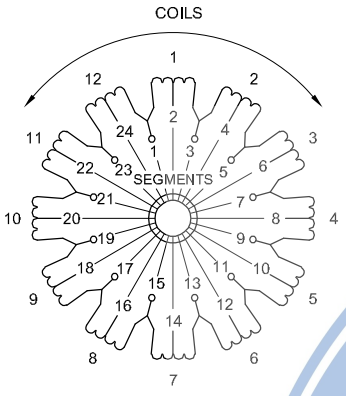


Fig 4

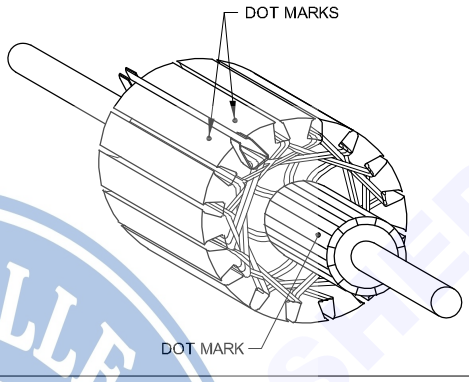
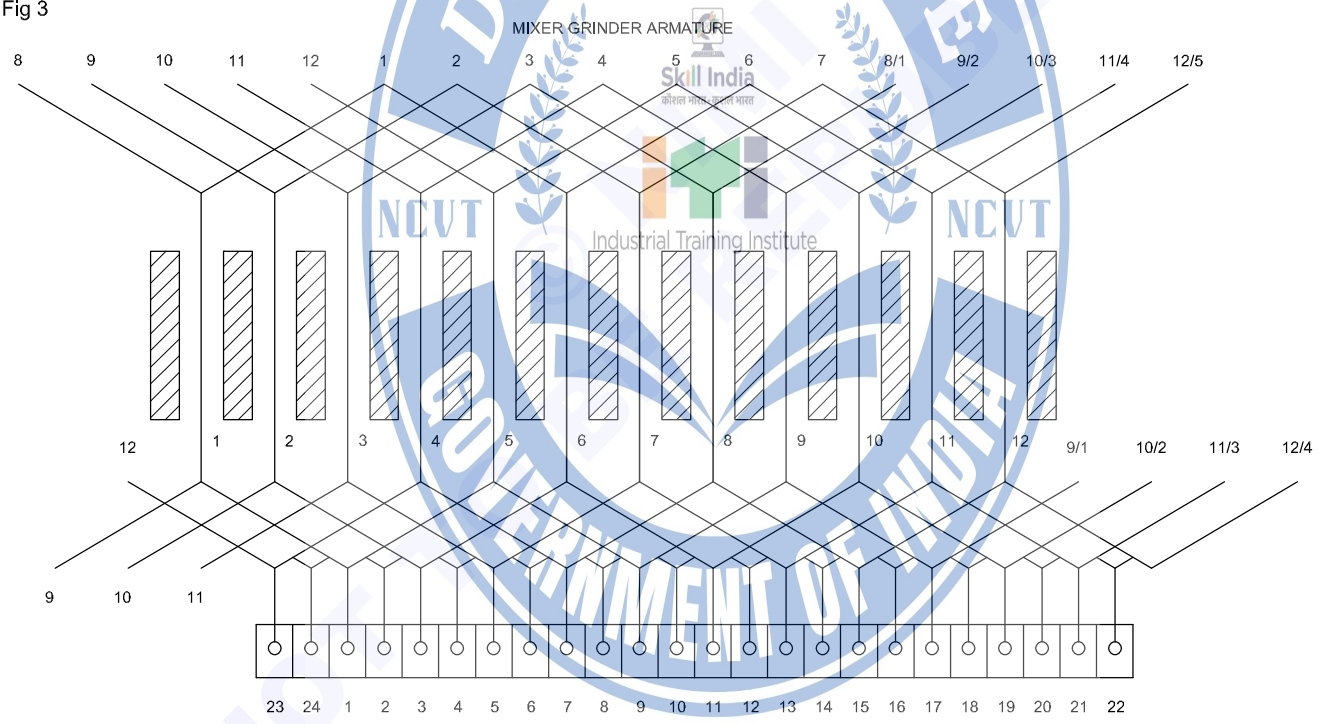


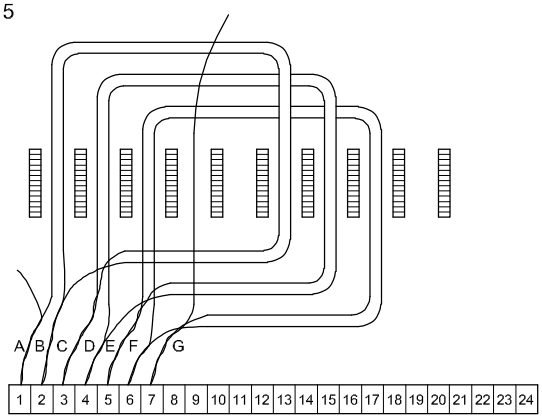
Fig 3



7 Mark one dot on the lightly ends of the identified commutator segment by using a centre punch. (Fig 4)

Fig 5 shows the lead swing as found in the mixer taken as the example

Fig 5



8 Record the findings in Table. 1

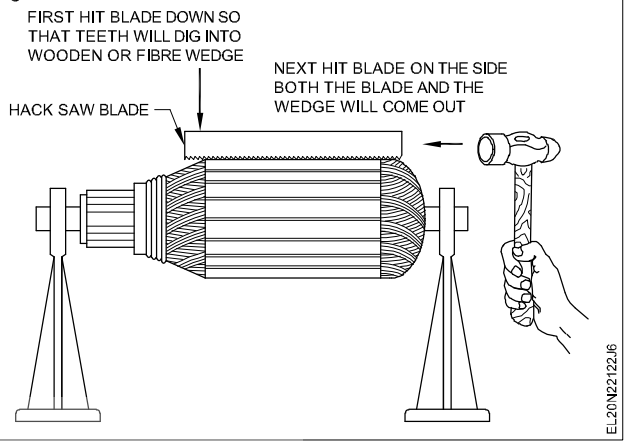
9 Cut the armature leads from the commutator raisers.

10 Apply a thinner to the armature slots and winding.

11 Remove the fibre/Hylam wedges from the armature slots (Fig 6).

12 Count the coil pitch and record it in Table. 1

Fig 6



13 Remove the armature coil one by one from the slots

14 Count the number of turns, size of winding wires weight of each coil, weight of whole winding and type of slot insulation. Record them in Table 1.

15 Practice the Exercise for three or four times with different armature assemblies.

16 Keep all the parts safely for using at the next Exercise.

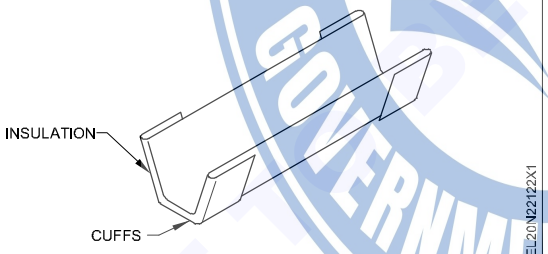
TASK 3: **Perform winding of armature**

1 Select the winding wire according to the original winding and mount the spool on a stand.

For sumeet mixer use winding wire of size 30SWG.

2 Insert a guide paper in the identified slots in which the coil is to be placed. (Fig 1)

Fig 1



For the sumeet mixer, taken as an example, we have

Total number of slots	**= 12**
Segments	**= 24**
Winding wire	**= 30 SWG**
Number of coil sides in each slot	**= 4**

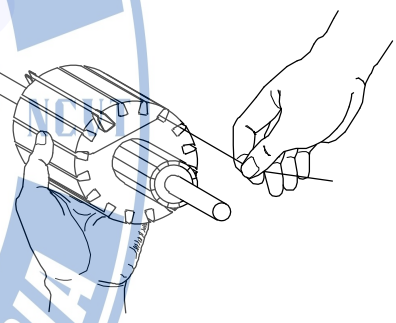
(2 coil sides are looped together and the loops are connected to the segments)

Number of turns in each coil = 36 turns identified slot pitch 1-6.

3 Place a guide paper in slots 1 and 6. (Fig 1)

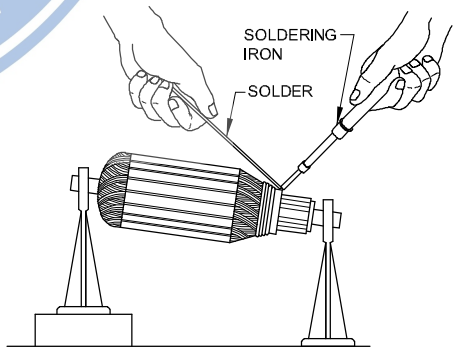
4 Hold the armature in hand. (Fig 2)

Fig 2



Large size armatures are to be supported by stands (horses during winding). (Fig 3)

Fig 3



5 Wind the armature by hand placing one end of the coil side in slot No.1 and the other in slot No.6

6 Count 36 tons and then make a longer loop.

Do not make mistakes in counting. Wrong number of turns will result in unbalanced armature.

7 Make another 36 turns in the same slots (1 and 6) by holding the loop with your fingers of the hand.

8 Make a short loop at the end of the second coil and start winding the next coil in slot numbers 2 and 7.

9 Make a long loop at the end of 36 turns and wind the same number (36) of turns in the same slots (2 and 7).

— — — — — — — —

TASK 4: **Solder the armature after rewinding**

1 Measure the lead swing length so as to reach the identified commutator raisers.

2 Remove the insulation of the winding wire loops at the connection points to the raisers.

3 Place the end connection wires in the risers in proper sequence and tie a rubber band on the commutator so as to hold the extended wire connections from the raisers in position.

4 Solder the end connections with the raisers properly (Fig 3 from Task 3).

5 Remove the excess solder from the raisers.

6 Check the connections and then bind the end connections with the armature. (Fig 1)

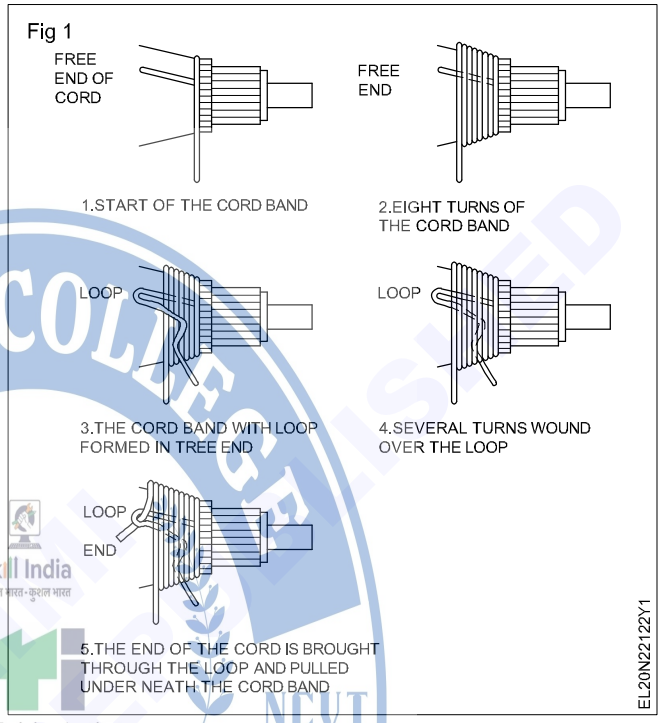
7 Test the armature with an external growler for shorts, open and grounding.

8 Varnish the armature after no fault in armature.

9 Remove the excess varnish after drying and check the rotor for balance in a dynamic balancing machine.

10 Assemble the mixer/liquidizer and test run the mixer with load.

Fig 1



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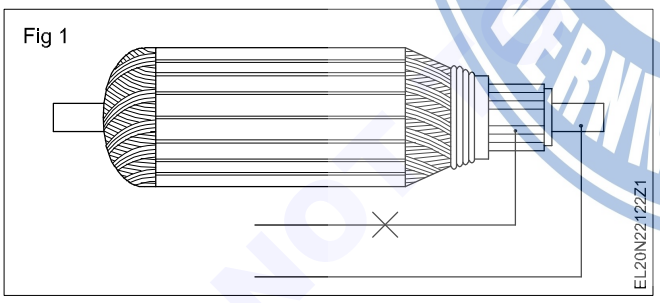
TASK 5: **Test the armature**

1 Test the armature winding for ground with a test lamp between the commutator segments and shaft. (Fig 1)

Fig 1



In case of grounding, trace the grounding by sequential de-soldering of the commutator connections and remove the grounding.

2 Place the armature on the external growler. (Fig 2)

3 Switch 'ON' the growler.

4 Hold the hacksaw blade over the top of the slot and along the length of it. (Fig 3)

Fig 2

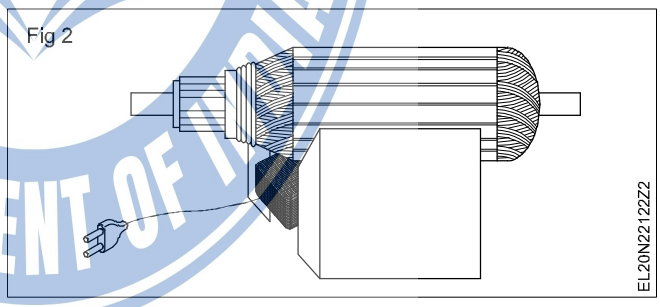
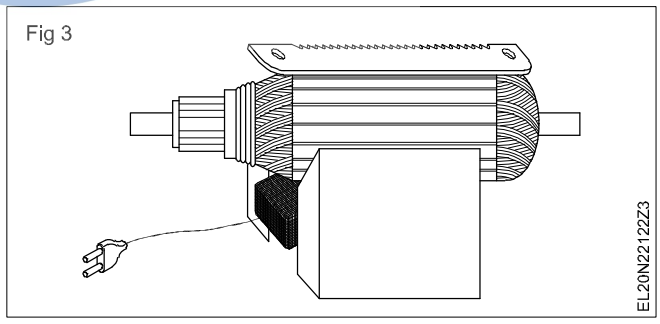


Fig 3



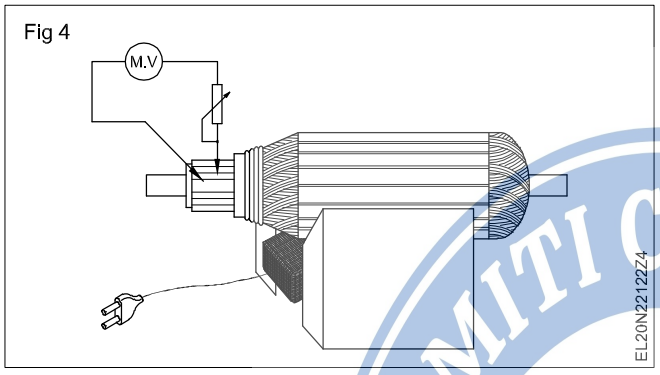
5 Rotate the armature slowly and observe the hacksaw blade vibration and the growling noise.

- The blade does not vibrate-it is an indication of 'NO' short in the armature coils.
- Vibration of the blade and a growling noise indicate short in the coil.

In case of a fault, rectify the same.

6 Connect the AC milli-volmeter/ammeter (normally provided with the growler) leads to the top two adjacent segments (Fig 4) by keeping the growler switches 'ON'.

Fig 4



7 Rotate the armature and continue testing all the adjacent bars.

While rotating the armature, the geometrical position of the test-leads should not be changed for subsequent testing's.

- Equal meter reading show correctness of winding.
- Any higher value of reading shows open in-between the armature coil/coils

8 Consult the instructor in case of fault in the armature winding.

9 Pre-heat and varnish the armature.

Care should be taken while varnishing the armature to ensure that the commutator is not exposed to the varnish.

10 Repeat the Exercise for four or five armatures.