Selection And Preventive Maintenance Of Motors In Pulp and Paper Mills

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An electric motor, when properly selected and installed requires little attention later on to keep it working properly. The various factors leading to proper selection of A.C. and D.C. motors in pulp and Paper Mills havc been discussed. The importance of preventive maintenance and history cards have been described. The trouble shooting methods have been tabulated for induction motors, synchronous motors and D.C. Motors.

An electric motor, when properly selected and installed, requires little attention later on to keep it working properly. If the Motor is selected with proper attention paid to the duty cycle, degree of protection, class of insulation, torque-speed characteristics and if the Motor installed properly and maintained clean and dry, it will give trouble-free service whether in a pulp mill or in stock preparation section, whether inside the paper machine hall or for material handling or in the recovery furnace.

Duty Cycle

In case the motors are used for a high number of switching operations as in a travelling crane, it may attain a high temperature rise. The selection should be made with reference to the following :

(1) The no. of switching operations the motors have to undergo.

(2) The accelerating and running functions.

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IS 325 : 1970 specifies duty cycles S1-S8 as follows :

(a) Duty type S1 (Continuous duty)
(b) Duty type S2 (Short time duty)
(c) Duty type S3 (Intermittent periodic duty)
(d) Duty type S4 (Intermittent periodic duty with starting)
(e) Duty type S5 (Intermittent periodic duty with starting and electric braking)
(f) Duty type S6 (Continuous duty with intermittent periodic loading)
(g) Duty type S7 (Continuous duty with starting and electric braking)
(h) Duty type S8 (Continuous duty with periodic speed changes)

For duty type S2, the temperature rise reaches its maximum permissible limit within its operating period i.e. 10,30,60 or 90 mins. The rest period is of sufficient duration to re-establish the equality of temperature with the cooling medium. For duty type S3 and S6, according to this specifications, duration of duty cycles is 10 mins. unless otherwise specified. The duty cycle consists of a period of duration at constant load and a rest period. Duty cycle is equal to N+R, where N is the period of rest and R is the rest period. The duty factor or cylic duration factor can be defined as the ratio of working period to duty cycles.

Therefore, duty factor $= \frac{N}{N+R} \times 100$ (expressed as percentage). For duty type S4 and S5 the duty cycle per unit time is greater than S3. The most important factor is the number of switching operation per hour, as the temperature rise in the motor occurs during acceleration, braking and reversal.

Enclosure

The enclosure should offer protection against contact with live parts, detrimental effect of water, foreign bodies and dust etc. In pulp mills the atmosphere is usually dusty whereas in other places there may be excess of steam or corrosive gases such as chlorine. A designation system has been included in IS:4691. The standard describes an Ingress Protection Code which consists of the letter IP followed by two numerals, the first number designates the extent of protection of persons against contact and of the machines against ingress of solid foreign bodies like dust, while the second number designates the extent of protection to machines against harmful ingress of water.

Class of insultation—

Indian standards have very well considered the world-wide development in reducing weight and dimensions of electric motors. According to IS 325 and recommendations of International Electrotechnical Commission, the limits for temperature rise are 60° for class A, 75°C class E and 80°C for class B (by resistance method). Suitable insulating materials of a very high heat durability are available nowadays to withstand high temperatures so that the high surface temperature is no criterion of the quality of the motor.

Torque-speed characteristics—

The most important step in selecting a motor is to determine the load to be driven and its torque characteristics. The accelerating torque, usually expressed in percent of running torque is the torque required not only to overcome friction, windage but also to overcome the inertia of the machine. This is important for pumps and fans where the minimum accelerating torque capability of the driving motor must exceed the maximum accelerating torque required by the machine. The peak torque is the maximum momentary torque that a machine may require for its driving motor. The peak torque required by a load is directly related to the breakdown or pull out torque for its driving motor. This is important for chippers, hydrapulpers etc.

If proper care is taken at the time of selection, the requisite starting current and starting torque can be obtained by proper shape and size of the rotor slot as follows:

(1) Motors with normal starting current and normal starting torque :

For this a standard squirrel cage motor is sufficient.

(2) Motors with low starting current and sufficiently high starting torque :

Such motors eg. pumps, blowers should employ a deep bar motor.

1) Charging Operation :
2) Rest :
3) Cooking Operation :
4) Rest :
5) Discharging Operation :
6) Rest :

(3) Motors with normal starting current and high starting torque:

Such motors eg. compressor usually employ a double cage rotor.

(4) Motors requiring more than 200% starting torque : Such motors should be would rotor type.

other informations :

Informations are also required regarding ambient temperature, mounting, how the load is driven etc.

Appendix 5 gives a table showing the load characteristics of various machines used in pulp and paper mills, the meanings of the various symbols being stated in the table that follows.

Proper selection of motor not only reduces maintenance problems but may reduce that initial investment.

Example—

A Hydrapulper motor may be specified as of 200 KW rating. On analysing the process regarding the motor application, however it is seen that the motor would be suitable for the following duty cycle·

10 Minutes—200 KW load
40 Minutes
20 Minutes—130 KW load
60 Minutes
5 Minutes—120 KW load
130 Minutes.

Further on studying the inertia ratio and the torque-speed characteristics, it has been possible to accommodate the motor in a much lower frame size than usual thus making the motor more compact and reducing the cost of the motor resulting in saving of space and money.

Selection of DC drives

The application of DC motors in pulp and paper mills is essential when.

1. Wide speed range with essentially stepless variation in speed setting is required.
2. Either constant torque, constant Horsepower or a combination of both is needed.
3. Fine accuracy of speed control is required.
4. Regenerative braking torque is needed.

Particularly, in paper machine, DC motors find useful applications. The modern paper machine drive is usually one of the following types:

(a) Ward-Leonard Set.

(b) Autotransformer — Rectifier controlled drive.

(c) Thyristor controlled drive.

In olden days Steam engine driven line shaft was used which had innumerable maintenance problems and has therefore been discarded.

A Ward-Leonard set consists of a D.C. generator and a synchronous motor with tachogenerator feedback. The no. of moving machinery being more, the maintenance of ward-Leonard set consists of the maintenance of the D.C. generator and that of the synchronous motor.

With the development of Power rectifier and thyristors, the maintenance problems of the paper machine drive has been reduced. There being only one D C. machine in place of a motor-generator set, the no. of moving parts is less.

Autotransformer rectifier controlled D.C motors are in use in paper mills but they have the following limitations.

(1) Constant Horsepower operation not possible.

(2) Speed variation range more than 10:1 not possible.

(3) Speed regulation less than 2% not possible.

(4) Soft start circuit for protection against transients not satisfactory.

(5) Timed acceleration is not satisfactory.

Therefore thyristor controlled drive is recommended for paper machine although its initial cost is high. The long term benefits from reduced wear and tear, good speed regulation, provision of soft start circuits, timed acceleration, outweigh its high initial cost.

Whereas in smaller mills the power transmission is through line shaft connected to a single D.C. motor (thyristor controlled), larger mills usually opt for thyristor controlled' sectional drives using multi-motor control. Each D.C. motor is powered by its own separate thyristor convertor, the reference being derived from a common highly stable master source. Each motor convertor combination forms a closed loop system and the outputs of individual speed feed back are compared with the master reference voltage. Each section therefore is compared with a standard reference, which should be adjusted to obtain overall speed adjustment of the drive. Individual speed adjustment is usually achieved by means of section speed control potentiometer which adjusts the individual section speeds against the master control reference. The draw control potentiometer for individual sections is used to introduce speed differentiate between adjacent motors in the line.

For D.C. motor, the selection should take care of the operation required viz., constant torque, constant horse power or a combination of both. The motor under constant torque operation receives armature current feedback and acquires a suitable stability depending on the time constant of the circuit; although its output varies directly with the speed. On the other hand, there are places where a constant output is required where field control has to be used. Again at the selection time, one should specify the nature of field excitation, whether separately excited, series excited or if compound excitation is needed. Ordinarily, for a constant torque operation, a separately excited field should be specified.

Checks before commissioning

Several mechanical and electrical checks are required as per Indian standards for installation and maintenance of motors. It is necessary to ascertain that the installation, foundation, levelling and alignment is faultless. Further the air gaps, ball or roller bearings of motors need to be inspected and all connections, ratings of fuses and overload protective devices, main earth-wires should be checked. Before starting, the insulation resistance should be tested. The phase sequence available to the motor should also be checked to ensure that the motor does not rotate in the wrong direction.

Preventive Maintenance

The importance of preventive maintenance and history cards have been described in the Appendix 1 enclosed.

From maintenance point of view, trouble shooting methods should be made available to the maintenance staff.

Appendix 2 describes trouble-shooting of induction motors.

Appendix 3 that of synchronous D.C. motors, and Appendix 4 that of D. C. motors. From the same, depending on the symptom developed, the electrical engineer in a pulp and paper mill can locate the trouble, the cause of the trouble and should apply suitable remedy.

Only if all the remedies fail to improve the performance, he should doubt the selection of the motor and should select a better motor in place of the defective motor.

Appendix-1

Preventive Maintenance Schedule

Preventive maintenance has long been recognised as extremely important in the reduction of overall maintenance cost and improvement of equipment reliability. A well-designed preventive maintenance programme will yield benefits far in excess of its costs. This can be done as per IS : 900. If the preventive maintenance programme is well planned and properly executed, the factory can benefit in the following ways.

a) Less production interruption and down-time.

b) Less overtime pay to maintenance personnel for carrying out routine check up and maintenance.

c) Less breakdowns and costly maintenance.

d) Less rejects of the product due to bad quality.

e) Minimum inventory of spare parts and less capital outlay for standby equipments.

f) Greater safety to workmen.

g) Lower unit cost of production.

h) The work being pre-planned, the follow up can be done by supervisory staff and the executive can devote more time to the develepment activities of the organisation.

The notes enclosed on preventive maintenance procedures and trouble shooting for various electrical equipments are based on experiences common in most pulp and paper mills.

(a) **Maintenance of Machines in SPDP enclosure** :

Monthly Servicing :

1. Blow out dust from the windings directing portable blower through openings in the body.
2. Clean the interiors of terminal box, slipring covers.
3. Clean the commutator.
4. Check brush holders. Brushes should move freely in the holder, check brush tension and adjust.
5. Check whether grounding is intact.

6. Ensure that the protective cover (if provided) is kept back in position.

(b) **Maintenance of rotary machines including machines in TEFC enclosures :**

Six Monthly Servicing :

1. Carvy out monthly servicing for SP/DP machine.
2. Run the machine, observe noise and grease the bearings with ball bearing grease. If no improvement is noted even after greasing, the bearings will have to be replaced.

Note : Care should be taken not to mix different types of grease.

3. Test the insulation resistance of windings. If less than 1 Megohm, windings may have to be dried, revarnished and tested.
4. Clean motor terminals, cable lugs, inspect the leads for any damages to the insulation, clean the terminal black with carbon tetrachloride or white petrol.
5. Tighten the connections.
6. Check the sliprings for excessive wear and scoring, slipring and commutator brushes for free movement, wear and tension. Replace the brushes and sliprings if necessary.
7. Check for possibilities of brush tails earthing with the frame and short circuiting.
8. Check the slipring short circuiting gear and brush lifting device for correct operation and adjust if necessary.
9. In case of AC Commutator motors, check brush rocker mechanism for free movement; clean and lubricate.

Two Yearly Servicing :

1. Carry out six monthly servicing.
2. If the motor is in service for 24 hours, replace the bearings, Otherwise, thorough cleaning and inspection of bearings and renewal of grease will be sufficient.
3. Check the end shield fixing stud bolt and bearing cover screws for wear, corrosion and cracks and replace if necessary.
4. If rubber gasketing is provided for the terminal box and end shields, check for deterioration and replace.

   Note : In some constructions, the rubber gasketing provided on the end shields serve as load distributing surfaces and if deteriorated and left unattended, the machine will vibrate excessively and the end shields will be damaged.

5. Check rotor and stator leads, reinsulate or replace and ensure that the lashings are satisfactory.
6. If a squirrel cage induction motor is employed for rigorous starting duties, check the rotor thoroughly for cracks in the rotor bars near end rings and erosion of rotor core above the slots. Defects in rotor core above the slots. can be repaired with advantage.
7. Remove oil paint with wire brush and repaint.

   Note : If any of the symptom as mentioned in the trouble shoothing chart for different types of rotary machines is observed, suitable remedial actions should be taken at the earliest opportunity to prevent further deterioration.

Records or history cards

In each section of the mill, a register should be maintained giving one or more pages for each motor and all important inspections and maintenance works carried out from time to time be recorded, therein. These records show past performance, normal insulation level, air gap measurements, nature of repairs, and time between previous repairs and other important informations which would be of help for good performance and maintenance.

Trouble Shooting-Induction Motors

Sl. No.	Symptom	Troubles	Cause	Remedy
1.	Bearing too hot to touch or smoking.	a) Bearing dry.	a) Not sufficient oil/grease oil rings not working.	a) Refill with clean oil after working bearings with kerosene.
		b) Bearing dirty.	b) Dust or dirt in oil.	b) Refill with clean oil after working bearings with kerosene.
		c) Bearing tight	c) Causes a and b or particles of metal sheared off and deposited at other parts	c) Scrape bearing and shaft or replace bearing.
		d) Oil rings not working	d) Rings out of slots	d) Replace rings, making sure that no metal adheres to sides of slots. If rings stick or run slowly, bevel at either top or bottom with a fine file.
		e) Bearings binding	e) Shaft out of true	e) Plane shaft in lathe true, renew bearings.
		f) Bearings out of true	f) Too much strain on pulley	f) Bearings should be shimmed with thin pieces of tin as a temporary measure or replace by a new one.
		g) Loose bearing	g) Vibrations	g) Tighten set screws holding bearing in journal.
2.	Bearing too hot but not hotter than other parts of motor.	Heat transferred from starter or rotor of motor	Overload on motor	Decrease load to normal.
3.	Smoke issues from windings Part of windings hot while remainder cool.	Displaced air gap or motor not centred in stator.	Bearing worn on one side	If noticed before coils are damaged realigning the bearing and inserting new wedges will correct the fault otherwise coils will need to be replaced.
4.	Every Third group in a 3 phase motor hotter than adjacent groups	One phase grounded or few coils in a phase short circuited.	Dampness or damage by foreign materials or conductor insulation failure.	Replace short circuited coils or jump the coils as a temporary expedient remove ground by reinsulating or rewinding.
5.	Motor runs hot	Motor running single phase	One fuse blown or open circuit in the incoming system.	Take ammeter reading of each phase, check and replace fuse or locate the open ckt. & rectify.
6.	Motor runs hot and explosions accompanied sometime by fire occuring in winding.	Temporary ground or short circuit.	Due to the dampness which causes circulating currents between coils.	Bake motor until dampness disappears and varnish. Punctured coils should be replaced. If motor

Sl. No.	Symptom	Troubles	Cause	Remedy
				is needed at once, the punctured coils can be cut out, if not too many as a temporary measure.
7.	Motor does not start but hum.	a) Single phasing	a) One fuse blown or one o/l relay out of order.	a) Replace fuse or adjust relay.
		b) Air gap displaced.	b) Bearings out of true	b) Shim bearing or replace with new one.
		c) Open circuit in starter windings.	c) Caused either from short circuit or from rough handling.	c) Insert new coil or jump the damaged one.
8.	Motor starts up and runs but rotor heats up while stator is cool.	Abnormal currents in rotor	Rotor bars loose or grounded.	Solder or weld the rotor bars and remove grounds. This trouble is seldom encountered in modern construction of sq cage motors.
9.	Motor issues a peculiar sound when running light as if a heavy load is thrown on periodically with a slight slackening of speed at these intervals.	One coil in one phase reversed.	Due to wrong connection when being repaired or reconnected.	Connect coil to its proper groups and in proper polarity.
10.	Motor issues buzzing sound when fully loaded.	Loose connection rotor bars	Overheated bars or rings.	Solder or weld the loose bars.
11.	Wound rotor motor runs at half speed.	Open ckt. in rotor connections	Broken connection between windings and collector ring or one brush not touching.	Repair break or replace worn brush spring, if motor is fully loaded it might not start. A trouble of this kind has the effect of doubling the no. of plates.
12.	Wound rotor motor sparking.	a) Sparking at slipring	a 1) Overloading of motor.	a 1) Reduce the load.
			a 2) Brushes may not be of correct quality and may be sticking in the holders.	a 2) Use brushes of the grade recommended.
			a 3) Brush pressure may be too light or too much.	a 3) Adjust brush pressure correctly.
			a 4) Sliprings may be rough, dirty or oily.	a 4) Clean the sliprings and maintain them smooth glossy and free from oil and dirt.

Trouble Shooting of Synchronous Motors

S. No.	Symptom	Troubles	Cause	Remedy
1.	Motor fails to start	a) Insufficient torque	a) Voltage too low	a) Increase the line voltage if possible. Raise the compensator taps on motor started by reduced voltage, since the torque varies as the square of the voltage.
		b) Open ckt. in stator winding.	b) Due to short circuit, rough handling etc.	b) Repair, break or replace the damaged coil.
		c) Friction	c) Bearings too tight	c) Loosen bearing caps and if the trouble persists scrap the bearings.
		d) Overload	d) Mechanical load too great.	d) Remove part of the load or install a clutch coupling between motor & load
		e) Wrong connection in, compensator.	e) Mistake in diagram or carelessness.	e) Test out & make proper connections.
		f) Motor trying to start single.phase.	f) One line open–contact on citcuit breaker burnt off.	f) Test out line or repair circuit breaker
2.	Motor starts but fails to come upto speed.	Insufficient torque.	a) Mechanical load too great.	a) 1. Open discharge resistances. 2. Raise the line voltage. 3. Increase squirrel cage winding on the rotor. 4. Install clutch between motor and load.
			b) Rotor field in circuit with excitor,owingto discharge switches's being in wrong position. This creates a separate flux which opposes the alternating flux in the stator windings.	Open the circuit between the excitor and the motor field windings.
			c) Not enough bars in sq. cage winding.	Same as for (a)
3.	(a) Motor comes upto near synchronous speed. (b) Motor fails to synchronise. (c) Circuit breaker trips out when line voltage is impressed on motor.	Trouble in excitor circuit.	a) Open circuit on rotor & field.	a) Test out with low voltage or magneto and repair.
			b) Open circuit in excitor field.	b) Test out with low voltage or megneto and repair.
			c) Open circuit between excitor and motor field.	c) Test out with low voltage or megneto and repair

Trouble Sheoting of Synchronous Motors

Sl. No.	Symptom	Troubles	Cause	Remedy
			d) Open circuit in excitor armature.	d) Bridge the open circuit by connecting the commutator bars each side of break.
			e) Faulty brushes on excitor causing the same trouble as above.	e) Adjust brushes if out of line renew if broken or worn-out.
			f) Open circuit in motor field rheostat.	f) Test with magneto and repair break.
			g) Open circuit in excitor field rheostat.	g) Test with magneto and repair break.
			h) Short circuit in one or more field coils.	h) Test with low voltage and compare and reverse connections of coil causing the trouble.
	Stator winding hot in all parts.	a) Mechanical Overload.	a) Mech. overload	a) Remove part of load or increase size of motor.
		b) Low power factor	b) Over excitation of field coils.	b) Adujst field excitation to the normal rated value or until the stator current reaches a value where further adjustment will increase its value.
	Motor issues a peculiar humming sound which increases in volume at certain. intervals.	Motor hunting	a) Supply frequency fluctuations.	a) If frequency can't be maintained damper winding of the motor should be improved.
			b) High resistance in excessively long transmission line.	b) If frequency can't be maintained damper winding of the motor should be improved.
			c) Excitor failed or Insufficient.	c) Check and currect.

S. No.	Symptom	Trouble	Cause	Remedy
6.	Motor issues a harsh buzzing sound which remains constant in value.	a) Short circuit coil on group.	a) Mechanical injury or insulation failure.	a) Repair or replace the coils.
		b) Open circuit	b) Mechanical injury or insulation failure.	b) Repair or replace the coils.
		c) Grounds	c) Dampness or as above.	c) Reinsulate & varnish.
		d) Revised coil or group.	d) Due to wrong connection during repairs.	d) Test with low voltage direct current and compass and change the connections on the reversed coil or group.
7.	One collector ring and the brushes show excessive signs of wear.	a) Flow of D.C. is always in one direction.	a) Negative brushes & collector rings always wear faster than the positive.	a) Change the loads to collector rings at least once enery six months or after.
8.	Motor trips its circuit breaker and shuts down, although the induction motors on same system remains running.	a) Single on line	a) Supply system transients	a) No remedy
		b) Low voltage	b) Supply system transients	b) No remedy.
		c) Executation ceases while carrying a heavy mechanical load.	c) Open circuit between excitor & motor fields.	c) Test out and repair.
			c1) Exciter not operating.	c1) Test out and repair.
9.	Motor issues a load growing sound, easily distinguished from other noises, under normal supply conditions.	Rotor out of stator magnetic center	a) Motor not level.	a) Level the motor bed plate.
			b) Shaft collars shifted too great end play of shaft.	b) Adjust collars for proper end play.

Appendix-4—Trouble Shooting Of D.C. Motors/Generators

S.No.	Symptom	Troubles	Cause	Remedy
1.	Hot bearings	as per	induction	motors
2.	Arcing of brushes	a) Brushes not diametrically opposite.	a) Brush holder studs loose or not set properly.	a) Adjust ~~the~~ settings.
		b) Brushes not set on neutral point in relation to the field.	b) Set screw holding rocker arm may have become loose or shifted through carelessness.	b) Shift rocker arm and brushes anead in the direction of rotation for a generator and backward or against the direction of rotation for a motor.
		c) One or more brushes in contact with wrong no. of commutator bars.	c) One or more brushes thicker than others.	c) Trim all brushes to the same thickness.
		d) Brushes cover too many bars.	d) Brushes too thick for the design.	d) Use proper brushes.
		e) Brushes out of line.	e) Brush holders not set properly on studs.	e) Adjust holders so that they line up Properly.
		f) Brushes too short.	f) Wear	f) Replace with new ones.
		g) Poor contact between brush and commutators.	g) 1. Oil and grit on commutator. 2. Flint or other hard substances in brush. 3. Brushes not trimmed properly.	g) 1. Clean commutator with a dry rag. 2. Wipe the brush with sand paper to remove foreign matter keeping it in the shape of the commutator. 3. Place a piece of sand paper under brush with smooth side flat in Commutator & work back and forth until the brush fits the commutator at all points.
3.	Brushes arcing	h) Rough commutator.	h) 1. Vibrations 2. Uneven brushes 3. Different quality of bars. 4. Uneven ridges where brushes do not touch commutator.	h) If taken in time, the commutator may be tried by using a commutator stone or by a piece of sand paper in a hollowed wooden block. Clean all copper dust from Commutator before putting it back in service.
		i) High Commutator bars.	i) Jam nuts and cones holding segments into place loose.	i) Carefully drive high bars back into place and tighten cones & jam nuts. Smoothes the commutator.

Sl. No.	Symptom	Troubles	Cause	Remedy
		j) Low bars.	j) Rough handling or wearing away due to soft bars or from a short circuited coil.	j) Loosen jam nuts & cones, lift bars even with others if possible and turn the commutator.
		k) Loose bars.	k) Clamping cones and jam nuts loose.	k) Tighten cone and jam nuts and true commutator.
		l) High mica	l) Copper wears faster than mica.	l) Under cut mica below surface of bars. Remove all dust before putting back into service.
		m) Weak magnetic field	m) 1. Open ckt. in field. 2. Short ckt. in field.	m) Repair or rewind.
		n) Excessive armature current	n) Too much load on machine.	n) Reduce load.
		o) Ground on machine line.	o) Defective insulation.	o) Repair.
		p) Short ckt. in armature.	p) Same as above.	p) Repair.
		q) Voltage too high.	q) Armature speed too great.	q) 1. Reduce speed of prime mover, 2. Cut more resistance in field ckt.
		r) Commutator bars short ckted, mica worn or eaten away, causing deep pits between bars.	r) 1. Copper or carbon or melted solder between bars. 2. Insulation between brushes and holders broken down	r) 1. Remove foreign matter from Commutator. 2. Repair insulation.
		s) Open ckted armature.	s) 1. Conductor burnt by short circuit. 2. Connections at commutator bars loose.	s) 1. Bridge the open circuit by connecting the commutator bars adjacent to the break or stagger the brushes if possible in all brushes holders in order to cover the break. 2. Re-solder.
		t) Reversed armature coil.	t) Cross connection to wrong commutator bars.	t) Test polarity and connect properly.
		u) Interpole field reversed.	u) Wrongly connected.	u) Reverse interpole field only.
4.	Rings of fire follow the brushes around the commutator.	a) Short circuited armature.	a) Defective insulation.	Repair
		b) Open circuited armature coil.	b) Same as (S) Sympton (3).	Same as (S) symptom (3)
5.	Flashing or excessive arcing from brush to brush.	a) Excessive voltage impressed on motor.	a) High voltage on line.	a) Reduce voltage.
		b) Short circuit in generator line.	b) Usual short ckt. causes.	b) Remove the cause.

S. No.	Symptom	Troubles	Cause	Remedy
6.	Singing of brushes	a) Brush pressure too great.	a) Brush holders not properly adjusted.	a) Remove part of the tension of the brush holder springs Admissible pressure is 200 gm/cm^2.
		b) Brushes too hard.	b) —	b) Replace by softer grade of brush. Note: A small quantity of vaseline tubbed evenly on the commutator will help reduce singing.
7.	Chattering of brushes	a) High bars.		Remedies as outlined earlier.
		b) Low bars. c) High mica. d) Loose bars.	Same as Causes in Symptom (3)	
		e) Brushes set at improper angle for direction of rotation.	Wrong direction of rotation.	1. Reverse angle of brush setting or change polarity of generator and reverse the prime mover. 2. Motor brushes are usually set for rotation in either direction.
		f) Improper end play.	f) Shaft collars not properly set.	f) Rest.
		g) High ridges on commutator.	g) Not enough end play.	g) Rest. Remove ridges with a commutator stone.
8.	Blackening of commutator at certain spots.	a) Short circuit in armature. b) Open circuit in armature.	Usual causes.	Remedies suggested in p & s.

Appendix-5—Load Characteristics Of Various Machines

S. No.	Load Description	Peak Running Load Torque % Full load Drive Torque	Inertia Ratio	Environment	Mounting	How Driven ?	Remarks
1	Agitators :						
	a) Liquid	100	2	J	RV	B	Can be direct connected.
	b) Slurry	100	2	DJ	RV	B	Settling of solids when idle may cause difficult restarting.
2	Beaters						
	a) Standard	100	4	DJ	R	B	—
	b) Breaker	120	4	DJ	R	B	—
3	Blower, Centrifugal	100	3	DJ	R	BLT	Some applications would require constant speed.
4	Compressors, reciproeating start unloaded.	100	10	DJ	R	BL	—
5	Conveyors, belt	100	4	DJ	R	B	Inertia depends on load.
6	Conveyors, screw	100	1	DJ	R	B	—
7	Cranes, travelling						
	a) Bridge motion	100	4	DJ	R	L	Drives must be suited to duty cycle and service.
	b) Trolley motion	100	4	DJ	R	L	
	c) Hoist motion	100	–	DJ	R	L	Hoisting inertia depends on load.
8	Cutters	150	–	DJ	R	B	Inertia depends on load.
9	Fans, Centrifugal	175	–	DJ	R	B	Inertia depends on load.
10	Fans, propeller, axial flow	100	–	DJ	R	BT	Inertia depends on load.
11	Feeders, screw, dry	100	1	DJ	R	B	Starting loaded.
12	Feeders, table	100	2	DJ	R	L	Starting loaded.
13	Feeders, vibrating, magnetic	100	–	DJ	R	L	Starting loaded No rotating member.
14	Feeders, vibrating, motor driven	100	4	DJ	R	L	Starting loaded.
15	Brinders, metal	100	2	D	RV	LB	Starting unloaded.
16	Hydropulpers	150	1	—	R	L	
17	Mixers, slurry	100	1	DJ	RV	B	
18	Pumps, centrifugal.	100	1	J	RV	T	Starting loaded.

S. No.	Load Description	Peak Running Load Torque % Full Load Drive Torque	Inertia Rated	Environ-ment	Moun-ting	How Driven	Remarks
19	Pumps, slurry handling.	100	1	D	R	B	
20	Pumps, turbine, centrifugal deep-well	100	2	–	RV	L	
21	Pumps, vacuum (Paper mill service)	150	4	–	RV	L	
22	Screens, Vibrating.	70	60	DJ.	I	B	

Notes :

Inertia ratio : Load inertia compared with normal capability of its drive motor.

Enviror ment :

- D "Dirty" or atmosphere containing abrasive dusts.
- J Atmospheres containing quantities of Chemical dusts which may be corrosive or gummy after exposure to humidity.

Mounting :

- R Bolted or securely fastened to a metallic base so that whatever vibration is generated by the driven machine is transmitted directly to the motor.
- I Mounting provides some degree of vibrational isolation between driven machine and motor.
- V Vertical mounting can be required.

How driven :

- B Usually belted to motor
- L Usually direct—connected to motor.
- T Direct-connected with axial thrust placed on motor bearings.

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