ANJUMAN-I-ISLAM'S KALSEKAR TECHNICAL CAMPUS

Department of Electrical Engineering

SCHOOL OF ENGINEERING & TECHNOLOGY

Plot No.23, Sector-16, Near Thana Naka,
Khandagaon, New Panvel-410206

A Report on

AN OVERVIEW OF MAINTENANCE OF 485KW TRACTION MOTOR: A CASE STUDY

DEPARTMENT OF
ELECTRICAL ENGINEERING

UNDER THE GUIDANCE OF
PROF.YAKUB KHAN

2020-2021

AFFILIATED TO

UNIVERSITY OF MUMBAI

A PROJECT REPORT
ON
"AN OVERVIEW OF MAINTENANCE OF 485KW TRACTION MOTOR:A CASE STUDY"

Submitted to

DEPARTMENT OF ELECTRICAL ENGINEERING

In partial Fulfilment of the Requirement for the Award of

BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING BY

PRAWEJ ALAM	17EE33
KHAN MD AKIL	17EE12
MOHAMMAD SADIQUE	17EE22
SATOPAY MOHD SADIQUE	17EE35

UNDER THE GUIDANCE OF
PROF.YAKUB KHAN

DEPARTMENT OF ELECTRICAL ENGINEERING

Anjuman-I-Islam's Kalsekar Technical Campus
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Department of Electrical Engineering
SCHOOL OF ENGINEERING & TECHNOLOGY
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Khandagaon, New Panvel-410206

CERTIFICATE

This is to certify that the project entitled

"AN OVERVIEW OF MAINTENANCE OF 485KW TRACTION MOTOR: A CASE STUDY"

Submitted By

KHAN MD AKIL 17EE12
MOHAMMAD SADIQUE 17EE22
PRAWEJ ALAM 17EE33
SATOPAY MOHD SADIQUE 17EE35

Is a record of bonafide work carried out by them, in the partial fulfilment of the requirement for the award of Degree of Bachelor of Engineering (Electrical Engineering) at ***Anjuman-I-Islam' Kalsekar Technical Campus, New Panvel*** under the University of MUMBAI. This work is done during year 2020-2021, under our guidance.

Date: / /

(PROF.YAKUB KHAN)
Project Supervisor

(Prof. RIZWAN FARADE)
HOD, Electrical Department

DR. ABDUL RAZAK HONNUTAGI
Director A.I.K.T.C.

External Examiner

Forwarding Letter

Anjuman-I-Islam's Kalsekar Technical Campus,
New Panvel,
Navi Mumbai, 410206

Dear Reader

We the students of "Bachelor of Electrical Engineering" assigned with the below mentioned group code are submitting the report entitled

"MAINTENANCE OF 485KW TRACTION MOTOR A CASE STUDY".

This report encompasses various aspects of analytical mechanisms with its key impact and various benefits for the Human being as a travelling issues

Yours Sincerely,

KHAN MD AKIL 17EE12

MOHAMMAD SADIQUE 17EE22

PRAWEJ ALAM 17EE33

SATOPAY MOHD SADIQUE 17EE35

Abstract

Traction motors play one of the most important roles in the rail industry it is essential they are well maintained and kept in good working order to prevent underperformance or unexpected breakdowns.

Various companies has many years' experience in the rail industry, but where we studied at Saini heavy electrical Engg. Pvt. Ltd. offering emergency repairs, fault finding services, rewinds and maintenance on all types of AC and DC traction motors, generators and associated equipment.

Here we are talking about various objectives and parameters of traction motors, like constructon of traction motor, stator of traction motor, rotor of traction motor ,dismantling, assembling of traction motor,mechanical equipments of traction motor,electrical equipments of traction motor,various testings before and after of dismentaling ad assembling of traction motor,sizing of mechanical and electrical equipments, etc.

Declaration

We declare that this written submission represents our ideas in our own words and where others ideas or words have been included; we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

KHAN MD AKIL	**17EE12**
MOHAMMAD SADIQUE	**17EE22**
PRAWEJ ALAM	**17EE33**
SATOPAY MOHD SADIQUE	**17EE35**

ACKNOWLEDGEMENT

We have a great pleasure in presenting our project on

" MAINTENANCE OF 485KW TRACTION MOTOR A CASE STUDY"

I sincerely thank with deep sense of gratitude to PROF.YAKUB KHAN **my guide for him kind co-ordination forthe fulfilment of this project.**

We would also like to thank our seniors, librarians who sincerely helped me getting this information and, last but not the least my college for the big reason that I am here in front of you in presenting this project.

KHAN MD AKIL 17EE12

MOHAMMAD SADIQUE 17EE22

PRAWEJ ALAM 17EE33

SATOPAY MOHD SADIQUE 17EE35

Contents

Chapter 1: Introduction

1.1 Historical Background

A **traction motor** is an Electric motor used for propulsion of a vehicle, such as locomotives, eectric or hydrogen vehicles or electric multiple units.

Traction motors are used in electrically powered rail vehicles (electric multiple units) and other electric vehicles including electric milk floats, elevator,rolers , and trolleybuses, as well as vehicles with electrical transmission systems (Diesel electric locomotives, electric hybrid vehicles), and battery electric vehicles.

In 1824, the French physicist François Arago formulated the existence of rotating magnetic fields, termed Arago's rotations By manually turning switches on and off, walter baily demonstrated this in 1879, effectively the first primitive induction motor The first commutator-free single-phase AC induction motor was invented by Hungarian engineer Ottó Bláthy; he used the single-phase motor to propel his invention, the electricity meter
The first AC commutator-free three-phase induction motors were independently invented by Galileo Ferraris and Nikola Tesla, a working motor model having been demonstrated by the former in 1885 and by the latter in 1887. . Tesla applied for US patents in October and November 1887 and was granted some of these patents in May 1888. In April 1888, the *Royal Academy of Science of Turin* published Ferraris's research on his AC polyphase motor detailing the foundations of motor operation. In May 1888 Tesla presented the technical paper *A New System for Alternating Current Motors and Transformers* to the *American Institute of Electrical Engineers* (AIEE) describing three four-stator-pole motor types: one with a four-pole rotor forming a non-self-starting reluctance motor, another with a wound rotor forming a self-starting induction motor, and the third a true synchronous motor with separately excited DC supply to rotor winding. George Westinghouse, who was developing an alternating current power system at that time, licensed Tesla's patents in 1888 and purchased a US patent option on Ferraris' induction motor concept.
An Induction motor or Asynchronous motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding.

An induction motor can therefore be made without electrical connections to the rotor. An induction motor's rotor can be either wound type or squirrel-cage type.

❖ Problems & Its advantages that make it powerful and efficient

- The size of 3phase traction motor for the same output power is much less compared to DC motor. Resulting in low power to weight ratio.
- These motors are very robust. Consequently reliability of a 3-phase locomotive is higher.
- Full power is available up to the maximum speed.
- Overload capabilities are more liberal.
- Regenerative braking is possible in 3 phase locomotives from the full speed till
- dead stop. Resulting in energy saving and higher operational efficiency.
- A much improved adhesion is available due to superior drop characteristics of
- speed Vs torque and motor speed is limited by the synchronous speed.
- It operates at near unity power factor throughout the speed range except at very
- low speeds.
- Due to lesser weight of traction motor, the unsprung masses are low. This reduces
- the track forces and consequently minimizes wear on rails and disturbance to track
- geometry

1.2 Traction motor's Recent Research & Projects

Previous studies showed that along with the improvement of the existing Control Systems (CS) through the introduction of microprocessor-based units, international companies are working on creating new system types through the usage of promising electric motors to increase the reliability and speed, and achieve a high-dynamic performance [1 - 4].

At present, synchronous (SM) and asynchronous (AM) electric motors are widely used as traction motors. The frequency converter with a scalar or vector CS is commonly used as the control element [1, 5, 6]. However, it is necessary to create complex multiloop CSs and to generate a multiphase sine wave signal to achieve high-control performance. Moreover, any ripple in the sine wave of supply voltage leads to additional losses in the motor and high - frequency noise in the power supply line. The frequency converter is a complex device consisting of several components such as rectifier, filter, inverter, sensor system, and master controller, which reduce its reliability in general [5].

In addition to the stator windings, which are common to all electric motors, SM and AM motors also have a rotor winding in the form of stacked conductors or cast "short-circuited", respectively. These machines are much more reliable and smarter than DC machines, but are less cost-efficient than the switched reluctance motors (SRM) [2].

The SRM CS, similar to other high-precision systems, is a multiloop microprocessor-based unit, but its power unit is much simpler than that of the frequency converter. Instead of the inverter generating a sine wave of the given amplitude and frequency, the pulse-width converter is used [7, 8]. This type of converter is simpler and cheaper.

Thus, the development of a simple and effective CS for traction SRM is necessary as these machines have evident efficiency and manufacturability; however, there are no simple control methods and systems that would provide the necessary control performance. The aim of this research is to develop a laboratory model of the traction electric drive based on SRM and to perform tests with this model.

MATERIALS AND METHODS

To obtain the results regarding the operation of the SRM drive, the following tasks were set:

- selection of the SRM for the model;
- description of the CS structure and implementation methods;
- description of different modes and their characteristics;
- obtaining the waveforms of phase voltage and current of the motor;
  and taking the waveforms of the start-up transient of the constructed electric drive using various speed controllers

Selection of the SRM for the model

Electromechanical power converters are an integral element in the power conversion system of the rolling stock. The type and operating conditions determine the traction electric drive structure,

equipment configuration, and rolling stock composition. However, nowadays, it is difficult to conduct pilot studies on the SRM due to the lack of such machines with geometric dimensions and parameters that would correspond to the traction motors used in the existing rolling stock.
Therefore, the four-phase SRM was chosen as the control object. Its basic specifications are given in Table.1 and its configuration is shown in Fig. 1.

A general view of the model including an electric motor together with a gearbox and wheelset is presented in Fig. 2.

Basic SRM specifications

Sr.no	Parameter	Value
01	Rated phase voltage, V	220
02	Maximum phase current, A	10
03	Rated speed, rpm	10,000
04	Rotor diameter, mm	57.4
05	Rotor active length,mm	60
06	Stator outer diameter,mm	106
07	Stator tooth width, mm	11
08	Rotor tooth width, mm	12.2
10	Number of phase winding turns	60
11	Rotor moment of inertia,kg·m²	21.6e+06
12	Phase DC resistance, Ohm	0.34
13	Rated torque, Nm	0.2
14	Stator core length, mm	120

The proposed functional circuit of the CS for this SRM is shown in Fig. 3. It consists of a control unit, microcontroller, high-side and low-side drivers, electronic switch, and current sensors. The dsPIC30F3011 microchip microcontroller that is specifically designed to accomplish this kind of tasks and digital signal processing was used for SRM control. The controller core was built on the modified Harvard architecture with an expanded instruction set. The architecture is a novel development and not a modification of the conventional 8-bit cores.
The dsPIC30 microcontroller supports the execution of

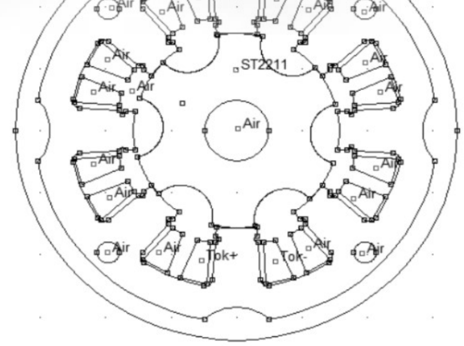


fig. 1. Four-phase SRM configuration

instructions (multiply-accumulate) specific to digital signal processing algorithms and special addressing methods .

dsPIC30 has a vector priority interrupt system and the ability to display a part of the program memory in the RAM area, which is unrealized on the chip, and it also has the ability of symbolic computation with integers and fixed-point numbers. The instruction set of the core has two classes, namely microcontroller instructions and digital signal processing commands. Both of these classes are equally integrated into the controller architecture and are controlled by the same core. The 16-bit arithmetic logic unit allows the performance of the following operations per one instruction cycle: addition, subtraction, bit shift, and bitwise logical operations including inversion. Many elements such as analog-to-digital conversion (ADC), pulse-width modulation (PWM) control module with six outputs (pulse distributor), and quadrature encoder module (pulse counter) are already included in the microcontroller, whereby the major tasks solved with software were passed to the hardware. This development helped to reduce CPU usage and allocate the remaining time for the implementation of different control methods including the usage of complex mathematical computations.

The SRM circuit diagram has an essential advantage over the induction motor circuit diagram as it is able to prevent short-circuit currents, while opening the high-side and low-side power switches on one side. Short-circuit current may lead to the failure of the Ud power supply, as well as the failure of the transistors and their controllers. The electronic switch circuit diagram, showed in Fig. 4, is used to power the motor. The normal operation of these transistors was ensured in the temperature range of –55 to+150°C, rated voltage of 1,000 V, and rated current of 16 A. Low stray inductance provides a high quality of transients in the transistor switching modes and has the ability to operate at high PWM frequencies. During the phase operation when the high-side switch was closed "single" switching was performed. The current was closed through the free - wheeling Schottky diode (STTH6012). The features of such diodes are as follows: low forward drop, high speed, and virtual absence of recovered charge. Preference is given to the use of Schottky diodes in high-power converters at high switching frequencies. The most common method to control field-effect transistors in bridge circuits is through the combined use of low-side and high-side drivers. Thus, both high - side and low-side drivers were used in this research due to the specifications of the electronic switch and switch control. When using such switching circuit, as shown in Fig. 4, two high - side and four low-side switches are necessary. Therefore, we used two high - side and two low-side drivers. The most common chips drivers in such cases are IRS21850 (high-side driver) and IR4426 (low-side driver). The microcontroller - generated PWM is transmitted to the switching circuit by the considered types of drivers (Fig. 4).

To control the rotor position, as well as speed and direction, the SRM -built-in-HEDS-4190 optical incremental encoder, which allows receiving 360 pulses per shaft revolution and coupled directly to the quadrature microcontroller encoder, was used. The encoder is a disc that is placed on the motor shaft and on a detector module that determines the disc position. The encoder has three outputs: phase A, phase B, and index output, wherein the data gathered from are decoded to obtain the information on shaft rotation. The machine rotation direction is determined by means of the encoder phases that prioritize pulsing on these outputs. The index output provides controller reset after each shaft revolution, thereby preventing error accumulation during rotation

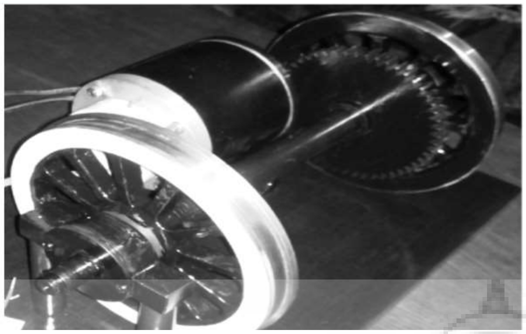


Fig. 2. Four-phase SRM traction drive model

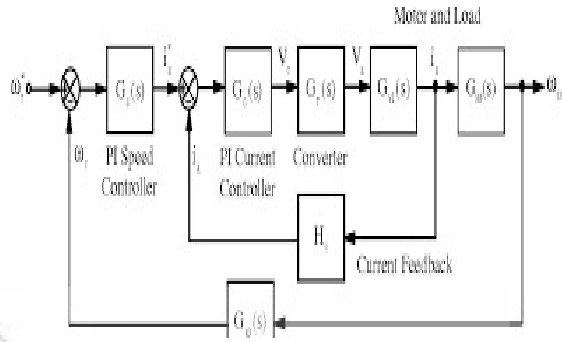


Fig. 3. SRM CS block diagram

The current sensors used are ACS711 chips, which function through the Hall-effect principle; and its voltage is measured by the ADC. The advantages of these sensors include high reliability and durability, small size, and the shortcoming of constant power consumption, rather than high cost. The data on the SRM - winding temperature are taken by the TMR36 sensor.

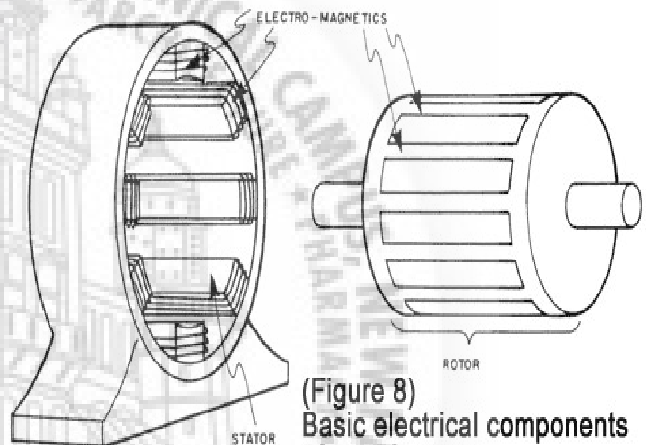
Chapter 2: Construction's traction motor

2.1 Traction motor & its Specifications

The electric motor consists of a stator and a rotor. A rotating magnetic field in the stator acts on the rotor winding and the induction current floods in it, so a rotating moment arises, which leads to the movement of the rotor. The electric energy supplies to the motor windings is converting into mechanical energy of rotation

The traction motor is an asynchronous 4pole squirrel cage rotor motor which operates by a three phase supply fed by 3phase converter. It is forced air cooled through a vent in the non-drive end housing. The traction motor blower supplies filtered air to cool the traction motor. The flexible bellows connect the traction motor vent and the air outlet of the blowers on the locomotive under

The rotational force from the traction motor is Transmitted to the gear box by a drive coupling. The opposite end of rotor shaft is enclosed by end plate.



(Figure 8)
Basic electrical components of an AC motor

2.2 Stator & its components

The stator is constructed from a stack of laminated plates secured together by wrap-around rings and traction rails welded to the end plates. The stator winding is insulated under vacuum conditions with a solvent free silicon resin using the ABB 200 class "Veridur" insulating system. Temperature probes are provided in the stator stack, which monitor the temperature of the stator winding during operation and thus stator windings are protected from thermal overloads.

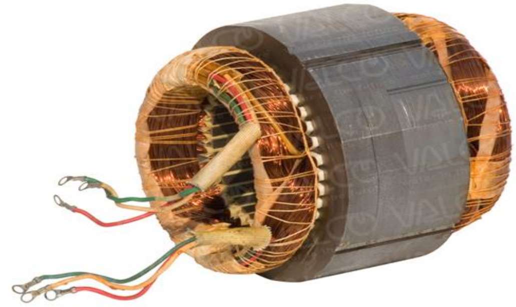
The stator is the stationary component of electromagnetic circuits in motors. In different configurations, stators may act as field magnets that interact with the rotor to create motion, or as armatures that work with moving field coils on the rotor. They are generally permanent magnets or electromagnets that maintain field alignment, with the latter being a field coil or winding.

The stator in an AC motor consists of a core of thin, steel laminations and coils of insulated wire inserted into it, which are called field windings and are connected directly to the power source. When current is applied, the two together become an electromagnet. In DC motors, the stator carries both the field windings and the poles, which constitute the magnetic circuit with the rotor.

Field windings in that case may be either windings or permanent magnets on the stator; the poles house the field winding, with the number determined by voltage and current.

i. Components

1.Stator Laminantion
2.Slots
3.Windings
4.Copper matterials
5.Insulations
6.Varnish insulation



2.3 Rotor & its Componenets:

A **squirrel-cage rotor** is the rotating part of the common squirrel-cage induction motor It consists of a cylinder of steel laminations, with aluminum or copper conductors embedded in its surface. In operation, the non-rotating *stator* winding is connected to an alternatinating current power source; the alternating current in the stator produces a rotating magnetic field. The rotor winding has current induced in it by the stator field, like a transformer except that the current in the rotor is varying at the stator field rotation rate minus the physical rotation rate. The interaction of the magnetic fields of currents in the stator and rotor produce a torque on the rotor.

By adjusting the shape of the bars in the rotor, the speed-torque characteristics of the motor can be changed, to minimize starting current or to maximize low-speed torque, for example.

Squirrel-cage induction motors are very prevalent in industry, in sizes from below 1 kilowatt (1.3 hp) up to tens of megawatts (tens-of-thousand horsepower). They are simple, rugged, and self-starting, and maintain a reasonably constant speed from light load to full load, set by the frequency of the power supply and the number of poles of the stator winding. Commonly used motors in industry are usually IEC or NEMA standard frame sizes, which are interchangeable between manufacturers. This simplifies application and replacement of these motors

ii. Components

1. Rotor Bars
2. End Rings
3. Skewing
4. Laminatio

2.4 Specifictions of traction motor

2.4.1 Motor's mechanical data

Sr/no	Data's Names	Values
01	Self-ventilatin	0.25m$^{3\backslash s}$
02	Rotor Diameter	322mm
03	Stator bore Diameter	325mm
04	Length of core assembly	350mm
05	Air gap	1.5mm

2.4.2 Motor's Electrical data

Sr/no	Data's Names	Values
01	Rated voltage	930
02	Rated current	200A
03	Rated power	240KW
04	Rated speed	2000RPM
05	Rated frequency	101.5HZ
06	Thermal class	200
07	Rated insulation voltage	2300V
08	Maximum current	277A
09	Maximum voltage	1403V
10	Maximum speed	3562RPM
11	Cicuit	Y
12	Supply cable	1x35 m^2/phase
13	Specification	IEC60349-2

2.4.3 Motor Weight

Sr/no	Data's Names	Values
01	Motor, complete	1120KG
02	Rotor complete(balancing unit)	294KG
03	Stator complete (winding+frame)	695KG
04	Length of core assembly	350mm

2.4.4 Motor Bearing

Sr/no	Data's Names	Values
01	Bearing (D-End) :	cyllendrical roller bearing f809035.01.NU-j2AA,FAG (oil lubricated/electrical insulated)
02	Bearing(N-End):	Deep-groove ball bearing Din-43283-6316.808916J20AA,FAG(grease lubricated, Electrical insulated)
03	Rolling-contact bearing grease:	Shell Retinax LX2
04	Initial grease quantity, bearing(N-End)	0.15KG
	Regreasing quantity, bearing (N-End)	26KG

2.4.5 Gears

Sr/no	Data's Names	Values
01	Weight bull gear/pinion	204/18KG
02	Gear ratio	(97/17),5,71

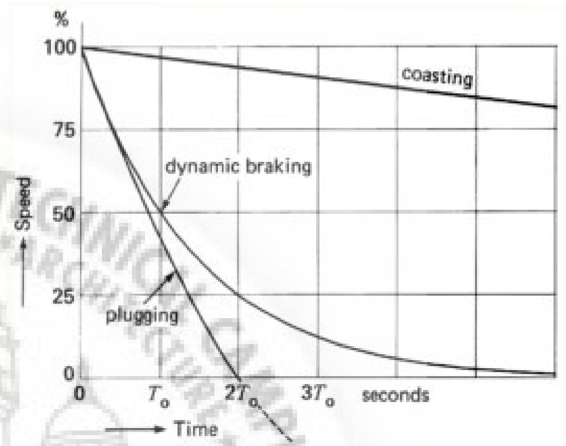
2.4.6 Dtetailed Specifications for Staor & Rotor

Sr.no	Data's Names	Values
	Types of Winding	3phase double layer
	No of pole	6Pole
	No of Phase	3Phase
	No of Slots for Stator	54 Slots
	No of Slots for rotor	42 Slots
	No of turns per coil	6Turns
	No of Slots per pole per phase	54/(3*6)=3
	Serial connected pole	3
	No of turns (windings) per phase	3*3*6=54
	Pole pitch,coil Pitch,Pitch factor,DF,WF	9,7,7/9=0.78,0.955,0.89
	Speed Factor	0.655
	Size of Stator conductor/bar insulated	7.5*2.26/7.30*2.43

Chapter 3: Braking methods of traction motor

There are generally three types of electrical braking for motors: regenerative braking, dynamic braking and plugging. Of the three methods, plugging provides the fastest stop, but it can be harsh on both the electrical and mechanical components. Because of this, it's the least commonly used method of braking,

3.1 Plugging Braking & its Specifications



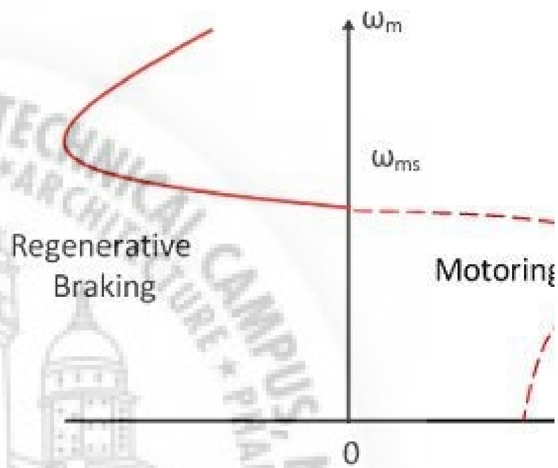
Plugging can be more harsh on electrical and mechanical components, but it provides a faster stop than dynamic braking methods. Plugging can be more harsh on electrical and mechanical components, but it provides a faster stop than dynamic braking methods.
Plugging sometimes referred to as "reverse current braking" is possible on both DC motors and AC induction motors. For DC motors, plugging is achieved by reversing the polarity of the armature voltage. When this happens, the back EMF voltage no longer opposes the supply voltage. Instead, the back EMF and the supply voltage work in the same direction, opposing the motor's rotation and causing it to come to a near-instant stop. The reverse current produced by the combined supply voltage and back EMF is extremely high, so resistance is placed in the circuit to limit the current.
For AC induction motors, the stator voltage is reversed by interchanging any two of the supply leads. The field then rotates in the opposite direction and the motor's slip (the difference between the speed of the stator's rotating magnetic field and the speed of the rotor) becomes greater than unity ($s > 1$). In other words, the rotor spins faster than the rotating magnetic field in the stator. Torque is developed in the opposite direction of the motor's rotation, which produces a strong braking effect.
When the motor speed reaches zero, if it is not disconnected from the supply, it will begin to reverse, or rotate in the opposite direction. In some applications, reversal of the motor's direction is the goal. But when plugging is used to *brake* the motor, a zero-speed switch or plugging contactor is used to disconnect the motor from the supply when its speed reaches zero.
One of the potential problems with plugging as a braking method (especially when the braking time is short) is that it can be difficult to brake the motor at exactly zero speed. Another drawback to plugging is that it can induce high mechanical shock loads on the motor and connected equipment, due to the abrupt stop that it causes. Plugging is also a very inefficient method of stopping and, therefore, generates significant heat.

3.2 Regenerative braking & ita characteristicss

The input power of the induction motor drive is given by the formula shown below

$$P_{in} = 3VI_s cos$$

Where φ_s is the phase angle between stator phase voltage and the stator phase current I_s. For motoring operation, the phase angle is always less than the 90º. If the rotor speed becomes greater than synchronous speed, then the relative speed between the rotor conductor and air gap rotating field reverse.



This reverse the rotor induces emf, rotor current and component of stator current which balances the rotor ampere turns. When the φ_s is greater than the 90º, then the power flow to reverse and gives the regenerative braking. The magnetising current produced the air gap flux.

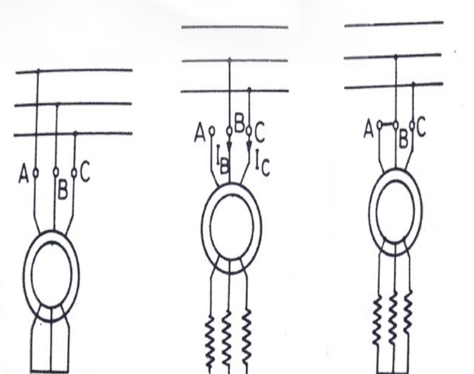
The nature of the speed torque curve is shown in the figure above. When the supply frequency is fixed, the regenerative braking is possible only for speeds greater than synchronous speed. With a variable frequency speed, it cannot be obtained for speed below synchronous speed.

The main advantage of regenerative braking is that the generated power is fully used. Andthe main drawback is that when fed from a constant frequency source the motor can not employ below synchronous speed.

3.3 Rheostatic Braking & its characteristics

AC Dynamic Braking-

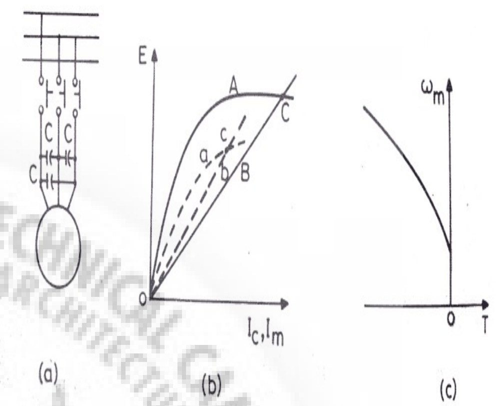
This type of induction motor braking is obtained when the motor is made to run on a single phase supply by disconnecting any one of the three phase from the source, and it is either left open or it is connected with another phase. When the disconnected phase is left open, it is called two lead connection and when the disconnected phase is connected to another machine phase it is known as three load connection.



(a) Motoring (b) Two lead connection (c) Three lead connection

The braking operation can be understood easily. When the motor is running on 1-phase supply, the motor is fed by positive and negative sequence,

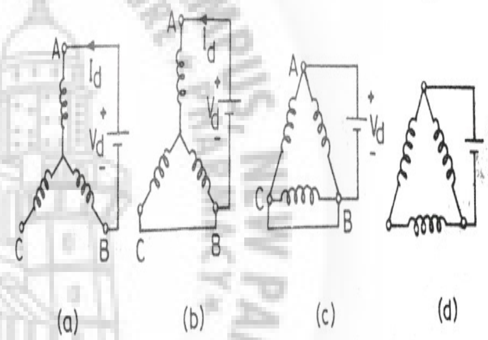
net torque produced by the machine at that point of time is sum of torques due to positive and negative sequence voltage. At high resistance the net torque is found to be negative and braking occurs. From the figure below the two and three load connections can be understood.



The figures above shows the circuit diagram and various characteristics of self excited braking using capacitors. As we can see from the figure, in this method there capacitors are kept permanently connected across the source terminals of the motor. The value of the capacitors are chosen depending upon their capability to deliver enough reactive current to excite the motor and make it work as a generator. So, that when the motor terminals are disconnected from the source the motor works as a self excited generator and the produced orque and field is in the opposite direction and the induction motor braking operation occurs. In the figure (b) the curve A represents the no load magnetization curve and line B is the current through capacitors, which is given by

Here, E is the stator induced voltage per phase

The speed torque characteristics under self excited braking is shown in the figure (c). To increase the braking torque and to utilize the generated energy sometimes external electrical resistance are connected across the stator terminals.

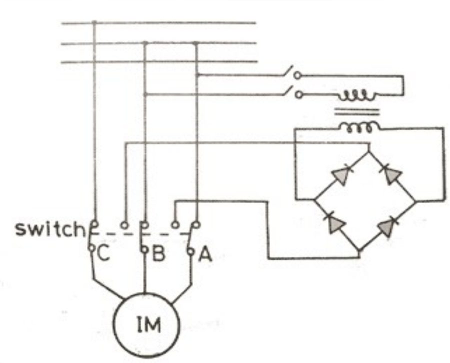


Various stator connections for dc dynamic braking (a) and (d) are two lead connections and (b) and (c) are three lead connection

DC Dynamic Braking

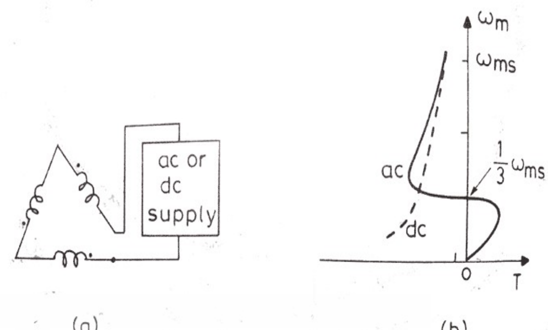
To obtain this type of braking the stator of a running induction motor is connected to a DC supply. Two and three load connections are the two common type of connections for star and delta connected stators.

Another diagram is shown below to illustrate how by diode bridge two load coonection can be obtained within a circuit.



Two Loads DC Dynamic Braking Operation

Now coming to the method of operation, the moment when AC supply is disconnected and DC supply is introduced across the terminals of the induction motor, there is a stationery magnetic field generated due to the DC current flow and as the rotor of the motor rotates in that field, there is a field induces in the rotor winding, and as a result the machine works as a generator and the generated energy dissipates in the rotor circuit resistance and **dynamic braking of induction motor** occurs.



Zero Sequence Braking

<u>Zero Sequence Braking</u>

In this type of braking all the three stator phases are connected in series and single phase AC or DC is connected across them (as shown in the figure). This type of connection is called zero-sequence connection, because current in all the stator windings are co-phasal. When the connected supply is AC, resultant field is stationery in space and pulsates at the frequency of supply, when the supply is DC, resultant field is stationery and is of constant magnitude. The main advantage of this induction motor braking is that all the stator phases are uniformly loaded. It does not require large rotor resistance like AC dynamic braking, it does not require large rotor resistance. The circuit diagram and the speed torque characteristics As shown below

Chapter 4:Maintanance of Traction motor

Periodical maintenance is essential to ensure safety, reliability and continuous operation of traction motors over long time periods.
Following maintenance schedules shall be followed for traction motors type IM4507BZ

Schedule	**Freight locomotives** IM4507BZ	**Pass./ Mail/ Exp. Locomotives** IM4507BZ
TI	Every 45 days	3000 kms. or one trip whichever is latter
IA	90 days	90 days
IB	180 days	180 days
IC	270 days	270 days
AOH	After 18 months	After 18 months

Work to be carried under each maintenance schedule is given below:

4.1 <u>TI SCHEDULE</u>

- Examine all traction motors for signs of damage caused by ballast. Check air outlets are not obstructed in any way.
- Check traction power cables, speed sensor and temperature sensor cables are not chafed or damaged in any way.
- Check the condition of bearing by seeing the grease, which comes out from grease inlet. Check the condition of grease too.
- Check the condition of spheriblocks. Replace if required.
- Measure inductance at TM power cable terminals of SR-1 and SR-2.
- Check end shield bolts tightness.
- Visually check TM support plate lugs for any damage/ crack.
- Attend logbook/ PPIO bookings if any

2.4 <u>IA / IB SCHEDULE</u>

In addition to TI Schedule carry out the following activities:

- Open TM junction box at body side and check the tightness of connections.
- Check the intactness of junction box cover and bolts.
- Check the condition of bellows and replace if required.
- Check grease nipple on DE & NDE sides.

- Check for oil falling on traction motor from under frame.
- Check for proper tightness of cable with Din Rail for cable connection and tie up with cotton tape for additional protection.
- Check rubber grommets of power cables, earthing connection with traction motor body and earthing screw.
- Check and tighten NDE cover bolts.
- Measure resistance of speed sensor at SR electronics.

4.3 IC SCHEDULE

In addition to IA/IB Schedule carry out the following activities:

- Before greasing, open NDE speed sensor cover. Take grease sample for checking ferrous content.
- Check the condition of speed pulse generator unit on traction motor (NDE) for any grease ingress.
- Lubricate TM bearing with specified grease (Kluber Isoflex Topaz L 152) DE- 50 storke (150 gms), NDE- 25 storkes (75 gms)
- Check the suspension tube bearing grease (NDE) and do the greasing.
- Open TM junction box at TM side and check the tightness of connection and water ingress.
- Check the condition of DE side stator winding for any abnormality from DE side net.

4.4 AOH SCHEDULE

In addition to IC Schedule carry out the following activities:

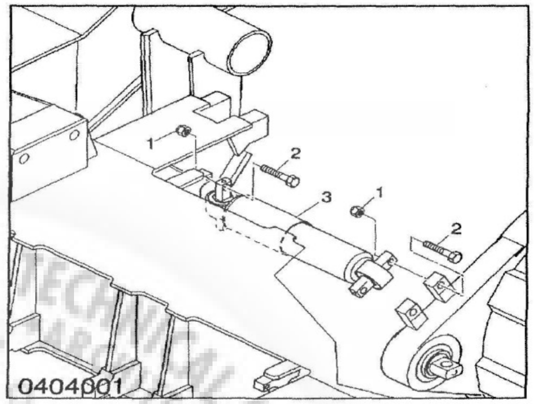
- Measure the resistance of traction motor temperature sensor, speed sensor, winding inductance and IR value.
- Check the condition of bearing grease sample.
- Chec k base tangent of pinion and conduct UST.
- Change DE side ‘O’ ring.
- Check tightness of PGR and NDE lock bolts.

- Check and ensure temperature sensor modification as per RDSO/MS/350 or latest.
- Check tapping of traction motor bellow plate holes.
- Check terminal connection of traction motor by opening terminal box.
- Check traction motor temperature sensor and speed sensor wiring crimping.
- Replace the gasket of temperature sensor.

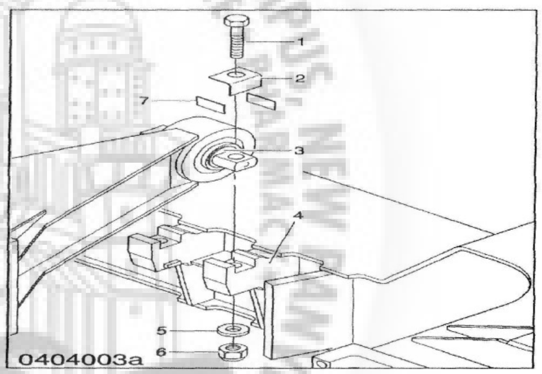
Chapter 5: Disassembling of traction motor

5.1.1 Removal of traction motor

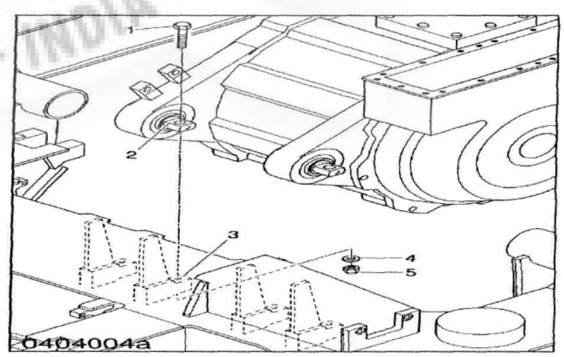
- Attach suitable lifting equipment to the lifting eyes on the traction motor.
- Raise the equipment slightly to support the
- Remove the bolts (2) and nuts (1) securing the traction motor damper (3)
- between the motor and bogie frame.
- Disconnect the drive coup between the motor and gear box.



- Remove bolts (1), nuts (6), washers (5) and locking plates (2) securing the traction motor support arm spheriblock (3) to the bogie frame mounting tugs (4).
- Carefully remove the compensating plates (7) from between the mounting lug (4) and spheriblock (3) cross-pin.

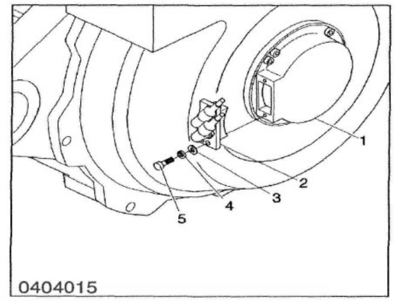


- Remove the bolts (1), washers (4) and nuts (5) securing the traction motor spheriblocks (2) to the centre transom mounting lugs (3).
- Raise the traction motor slightly and ensure nothing is entangled.
- Lift the traction motor from the bogie frame



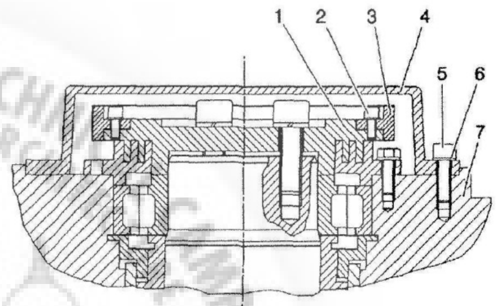
- and position on a suitable stand.

5.1.2 Removal of Rotary Speed Transmitter Cartridge

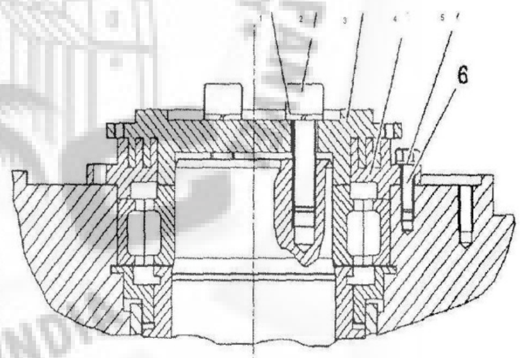


- Remove screws (5), washers (3) and spring washers (4) securing the speed transmitter cartridge (2) to the non drive end bearing cover (1).
- Remove the speed transmitter cartridge (2)

5.1.3 Removal of Non-Drive End Bearing Cover

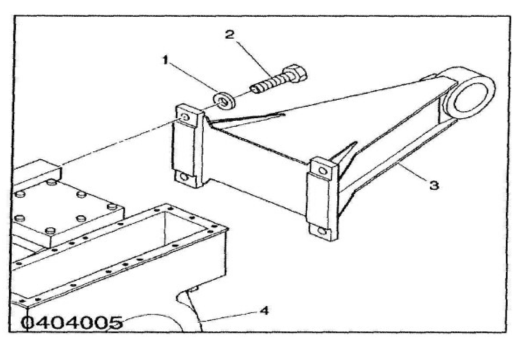


- Remove screws (5) and spring washers (6) securing the non-drive end bearing cover (4) to the traction motor (7).
- Remove the bearing cover (4). Pay attention to the pulse transmitter ring (3).
- Remove screws (2) securing the pulse transmitter ring (3) to the support (1).



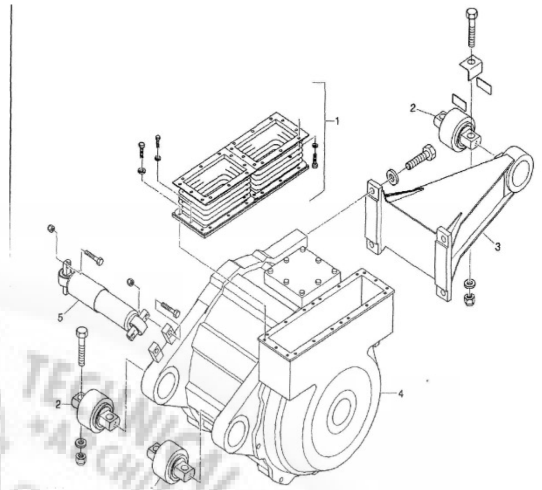
- Remove the pulse transmitter ring (3)
- Remove the screws (2) and spring washers (1) securing the pulse transmitter ring support (3).
- Remove the pulse transmitter ring support (3).
- Remove the screws (6) and spring washers (5) securing the thrust collar (4).
- Remove the thrust collar (4).

5.1.4 Removal of Support Arm



- Take the weight of the arm (3) using suitable lifting equipment.
- Remove the four bolts (2) and washers
  (1) securing the support arm (3) to the
  (2) traction motor (4).
- Separate the arm (3) from the traction motor (4)

5.2 Pre-inspection



- Inspect the condition of the traction motor mounting points on the bogie frame.
- Inspect the condition of all cables. Ensure all cables and cable insulation is in good condition and free from wear, cracks or other damag necessary,replace any damaged or suspect cabling.
- Ensure all cable tangs, plugs and sockets are in good condition and free from oxidation, wear, cracks or other damage.
- Inspect the condition of the traction motor.
- Visually inspect the support arm for cracks or damage. Pay particular attention to the eye and traction motor mounting flange.
- Measure the inside diameter of the eye bore (x). If greater than the specified, replace the support arm.
- Remove any burrs from the eye or mounting flange using a suitable honing stone.
- Test the support arm for damage using a non-destructive method and replace if required.

5.3 COMING TESTING

- Bring motor to the testing place.
- Check the insulation resistance between each phase and earth with 2.5 kV megger. It should be min. 2.18 M Ohms.
- Carry out continuity test between phase to phase with 500V megger
  Phase U &V
  Phase V & W
  Phase U &W
- Run the motor at 100 V 3 phase AC 50 Hz for 5 minutes and measure the current in each phase.
- Carry out run test of the motor by raising voltage gradually to 400 V AC for 2 Hrs.

Then measure & record the following:

a. Current in each phase

b. Bearing noise (DE & NDE side)

c. Vibration

d. Check the bearing temperature on both end shields and record temperature rise.

e. Record speed of the motor with the help of tachometer.

5.4 DISASSEMBLY OF PINION

- Check the distance between shaft face and pinion teeth back face (Advancement).
- Clean pinion inside hole by Kerosene oil.
- Provide a wooden lever across the pinion teeth and secure the lever against turning.
- Connect the SKF pressure pump and fit the special plug ¼" into the pinion.
- Screw the special screw M24 into the shaft by using the pressure bearing. A clearance of approx. 0.5 mm is required between pressure bearing and pinion face.
- Increase the pressure of the pressure pump up to 130 MPa and maintain it for 15 minutes.
- Increase the pressure further to 150 MPa and maintain it for 15 minutes
- Increase the pressure further to 180 MPa and wait until a ring of oil is visible at the pinion shaft end towards the teeth. Now the pinion is free.
- This pressure can be increased up to 200 MPa, if necessary.
- Increase the pressure steadily and loosing the screw M24 at same time, until the pressure collapsed and the pinion is totally released.
- Disconnect the special plug ¼" and remove the wooden lever.
- Remove the pinion.

5.5 DISASSEMBLY OF TRACTION MOTOR

- Remove speed probe & its housing.
- Remove bearing deflector (outer labyrinth) from the shaft with the help of press out tool.
- Fit the dummy pinion.
- Remove speed sensor ring, locking plate and thrust collar.
- Keep motor vertical (equal level) on wooden block (pinion top side).
- Unscrew M 20 x 55 screws (8 nos.) and remove drive end cover.
- Fit the coupler on dummy pinion and lift the rotor carefully and place on the wooden block.

- Keep motor horizontal and remove NDE cover by unscrewing M 20 x 55 screws (08 nos).
- Remove temp sensor.
- Open terminal box cover and open cable connections. Preserve the coupler of speed and temp sensor

5.5.1 Checks after Dismantling of Motor

- Check the insulation resistance between phase and earth with 2.5 kV megger. It should be min. 2.18 M Ohms.
- Check visually the stator body, core and windings for any damage and flashing.
- Check the tightness of each phase cable connection in terminal box.

Chapter 6: Overhauling of Traction motor

6.1 OVERHAULING OF STATOR

6.1.1 Dry Cleaning of Stator

- Clean the stator frame by wire brush and scraper.
- Clean the stator from in side by nylon brush.
- Clean difficult portion of stator by wedges of fiber glass.
- Blow the stator thoroughly with dry compressed air to remove dust/ dirt.
- Heat the stator in oven at 120°C for 2 Hrs. and remove loose dust by vacuum cleaner.
- Check the insulation resistance between phase and earth with 2.5kV megger after dry cleaning of stator. It should be min. 6.36 M ohm for 6FRA 6068 & 3.18 M ohm for 6FXA 7059.

6.1.2 Solvent cleaning of stator

- Check visually the winding for any damage after cleaning.
- Spray liquid Xylol on stator inside out side, coil, core and terminal box etc. and allow it to act for 5 to 10 minutes.
- Again spray liquid Xylol.
- Clean inside by nylon brush and outside by wire brush.
- Blow the stator thoroughly with dry compressed air from inside and out side.
- Repeat the cleaning process, if required.
- Wipe the stator by calico cloth inside and out side.

6.1.3 Checking & Repairing of Stator

- Check the winding resistance between phases with Wheatstone bridge
- multimeter at room temperature.

a. Phase U and V

b. Phase V and V

c. Phase U and W

- If any repairing is done on stator coils, measure the diameter at core portion.
- Check broken bolt in stator body and act accordingly.

- Visually check for any crack on lug housing, lifting hook etc..
- Bake the stator in oven at 120 deg C for 24 hrs.
- Check the winding resistance between phases with Wheatstone bridge or multimeter at 120 deg C.

a. Phase U and V

b. Phase V and W

c. Phase U and W

- Cool the stator at room temperature.
- After baking of stator, do varnishing with SI 620 resin varnish and allow drying in air for minimum 12 hrs at room temperature.
- Check the insulation resistance between phase & earth after baking and varnishing with 2.5 kV megger. It should be min 63.6 M ohm for 6FRA 6068 & 31.8 M ohm for 6FXA 7059.

<u>Clean and check the following for any damage</u>:

a. Pulse generator ring

b. Pulse pick up unit and speed sensors

c. Couplers of speed and temperature sensors

d. Cables of speed and temperature sensors

- Check the resistances of speed and temperature sensors at room temperature

a. Speed sensor 93.2A between terminals A & B, terminals C & D

b. Speed sensor 93.2B between terminals A & B terminals C & D

c. Temperature sensor 98A between terminals A & B terminals C & D

- Check and clean terminal box cover cleat & clip hardware.
- Check the terminal box connection lead & support visually. If any crack is there, replace the lead support.
- Clean all hardware by 'K' oil

6.2 OVERHAULING OF ROTOR

6.2.1 Dry Cleaning of Rotor

- Remove the old grease from racers on both ends.
- Clean the out side case portion cavities, shrink ring and in side hole cage by nylon brush.
- Blow the rotor thoroughly with dry compressed air to remove dust/ dirt.

6.2.2 Solvent Cleaning of Rotor

- Spray the liquid Xylol by air or by brush to out side rotor cage and in side hole etc. Allow it to act for 5 to 10 minutes.
- Clean racers by petrol.
- Rub the nylon brush on cavities & holes. Blow the rotor thoroughly with dry compressed air to remove dust/ dirt from core & holes.
- Repeat the cleaning process, if required.
- Wipe the rotor & racer by calico cloth.

6.2.3 Checking & Repairing of Rotor

- Check the condition of rotor bars
- Check the condition of rotor stamping for any deformation, crack, looseness, overheating mark etc.
- Perform ultrasonic testing of rotor shaft.
- Perform Grawler testing of rotor to detect crack in rotor bars.
- Check the diameter of rotor, if repaired.
- Bake the rotor in oven at 120 deg C for 24 hrs.
- Allow to cool the rotor at room temperature.
- After baking of rotor, do varnishing with SI 620 resin varnish and allow drying in air for minimum 12 hrs at room temperature.
- Remove the both side inner racers.
- Check the shaft diameter on racer seat both side & record it.
- Perform dynamic balancing the rotor.
- Fit the new set of inner racer by Induction heater & allow to cool at room temperature.
- Cover the rotor by suitable means.

6.3 OVERHAULING OF END COVERS & BEARINGS

6.3.1 Cleaning

- Remove the bearing caps.
- Remove grease by hand.
- Rub the wire brush on covers to remove dirt/ dust.
- Clean by dry compressed air.
- Apply petrol on the covers and bearings and clean after 10 minutes by dry compressed air.
- Wipe covers and bearings by clean cloth.
- Clean all part like labyrinth & hardware by ‘K’ oil.

6.3.2 Checking & Repairing

- Check diameter of inner/ outer labyrinth.
- Remove the bearings.
- Check cover visually for any damage.
- Weld the air net on DE end cover.
- Repair mechanically as per requirement.
- Check end shield bearing housing diameter & record it.
- Heat up the both end covers in oven for 2 hrs. at 150°C.
- Fit inner labyrinth in both end covers with matching slot of labyrinth with grease hole.
- Fit the new bearing set on cover housing.
- Cool the cover by fan at room temperature.
- Paint the covers and protect them by suitable means.

6.3.(i) ASSEMBLY OF TRACTION MOTOR

- Put stator on wooden block.
- Apply RTV compound on stator body at NDE side surface.
- Fit NDE side cover on stator. Apply ANR-124 compound on M 20 x 55 (08 nos.) screws and tighten them with specified torque.
- Fill up the specified quantity of approved grease in NDE bearing & DE bearings.
- Keep the stator in vertical position (NDE side bottom) on wooden base.
- Fit dummy pinion on rotor.

- Fit coupler on rotor. Lift rotor by crane and put it into stator slowly by taking care of its centre.
- After full lowering of rotor in NDE racer.
- Revolve the rotor in stator
- Apply RTV on stator at DE side.
- Lift DE cover & place on TM keeping grease nipple bottom side.
- Fit DE side cover on stator. Apply ANR-124 compound on M 20 x 55 (08 nos.) screws and tighten them with specified torque.
- Keep TM horizontal on wooden block.
- Remove coupler & dummy pinion.
- Check bearing clearances at both NDE & DE side.
- Fit locking plate by M16 screw (3 nos) at NDE side.
- Fit speed indicator ring on locking plate.
- Fit speed probe housing cover by M 8 x 12 screws.
- Fit speed sensor on housing cover.
- Fit speed & temperature sensor cables in cleat and provide protection pipe.
- Fit the cables after providing protection sheet.

6.3.(ii) <u>ASSEMBLY OF PINION</u>

- Clean the conical shaft of the pinion and bore hole of the rotor shaft carefully.
- Insert the conical shaft of the pinion into the bore hole of the rotor shaft. Measure the distance a between the shaft and the end of the pinion.
- Apply glycerine on pinion shaft and inside bore hole of the rotor shaft.
- Insert the pinion shaft carefully into the bore hole of the rotor shaft by applying slight pressure.
- Position the pressure bearing.
- Locate and secure special screw into the rotor shaft.
- Fit the special plug for SKF pressure pump into the pinion shaft.
- Secure the wooden lever against the pinion turning clockwise.
- Tighten the special screw with preload.
- increase the pressure of the pressure pump up to approximate 170- 190 MPa. Ensure that under no circumstances this pressure exceeds 200 MPa. At the same time tighten the special screw steadily until the pinion has come to its final position. Thereby a maximum torque of 600 Nm should be applied.
- Decrease the pump pressure and disconnect the special plug.

6.3.(iv) RUN TEST

- Connect 3phase, 440V 50 Hz AC supply to the traction motor.
- Start the plant and increase the voltage gradually 0 – 100V for 5 minutes & measure the following:
  i. Bearing noise at DE & NDE.
  ii. Current in every phase by Tong tester.
- Increase the voltage gradually up to 400 volts & run the motor for 2 hrs.
- Measure and record the following:
  i. Current in each phase
  ii. Bearing noise at DE & NDE.
  iii. Vibration
  iv. Temperature rise at DE & NDE.
  v. Speed in RPM.
- Ensure tightness of all bolts and screws with proper torque value as per torque table given below:
  M6 - 9.5 Nm
  M8 - 23 Nm
  M10 - 46 Nm
  M12 - 80 Nm
  M14 - 125 Nm
  M16 - 195 Nm
  M18 - 270 Nm
  M20 - 380 Nm
- Paint the traction motor with recommended quality of pain

Chapter 7: Conclusion, Recommendations and Future Work

The AC segment is expected to be the largest contributor to the market, by type, during the forecast period

The report segments the electric traction motor market based on type into AC and DC. The AC segment is projected to be the largest market for electric traction motors, by type, during the forecast period. Earlier, DC motors were preferred for railway applications; however, AC motors are now increasingly being used due to modern power electronics. Compared to DC motors, AC motors are more efficient and easier to control.

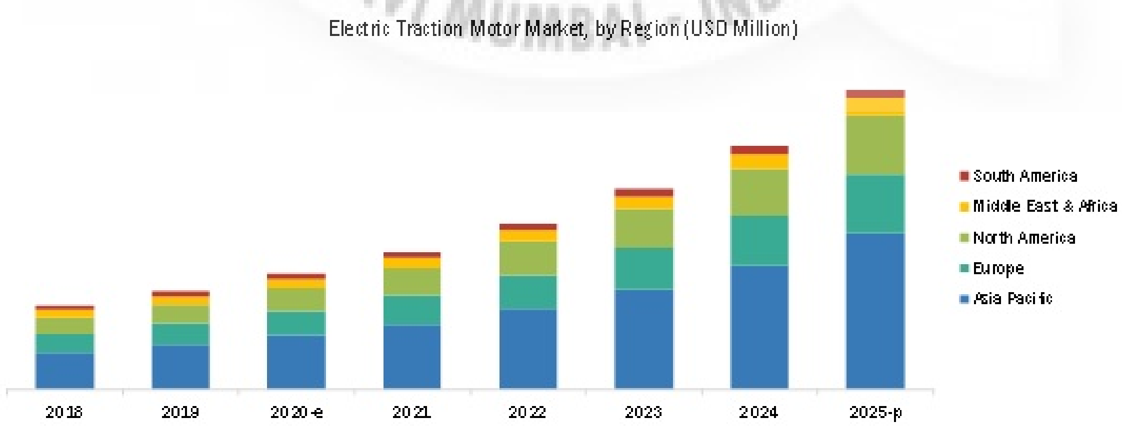
The below 200 kW segment is expected to be the largest market, by power rating during the forecast period

The report segments the electric traction motor market based on power rating into below 200 kW, 200-400 kW, and above 400 kW. The below 200 kW segment is expected to hold the largest size of the electric traction motor market, by power rating during the forecast period. The large share of this segment can mainly be attributed to the extensive use of below 200 kW power rated motors in electric vehicles and light rail transit vehicles, which is expected to grow at a faster pace in the coming years.

The railways segment is expected to be the largest contributor to the electric traction motor market, by application, during the forecast period

The railway segment is expected to hold the largest size of the electric traction motor market, by application, during the forecast period. Electric traction motors are an essential part of railway trains. The railways segment is likely to dominate the market in the coming years due to the increased reliance of the railway industry on electric traction motors for enhanced speed control and high start-up torque.

Here is done Traction motor case study by group work with Refering the hand books of Indian Railways and the industrial analysis and



e- Estimated; p- Projected

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