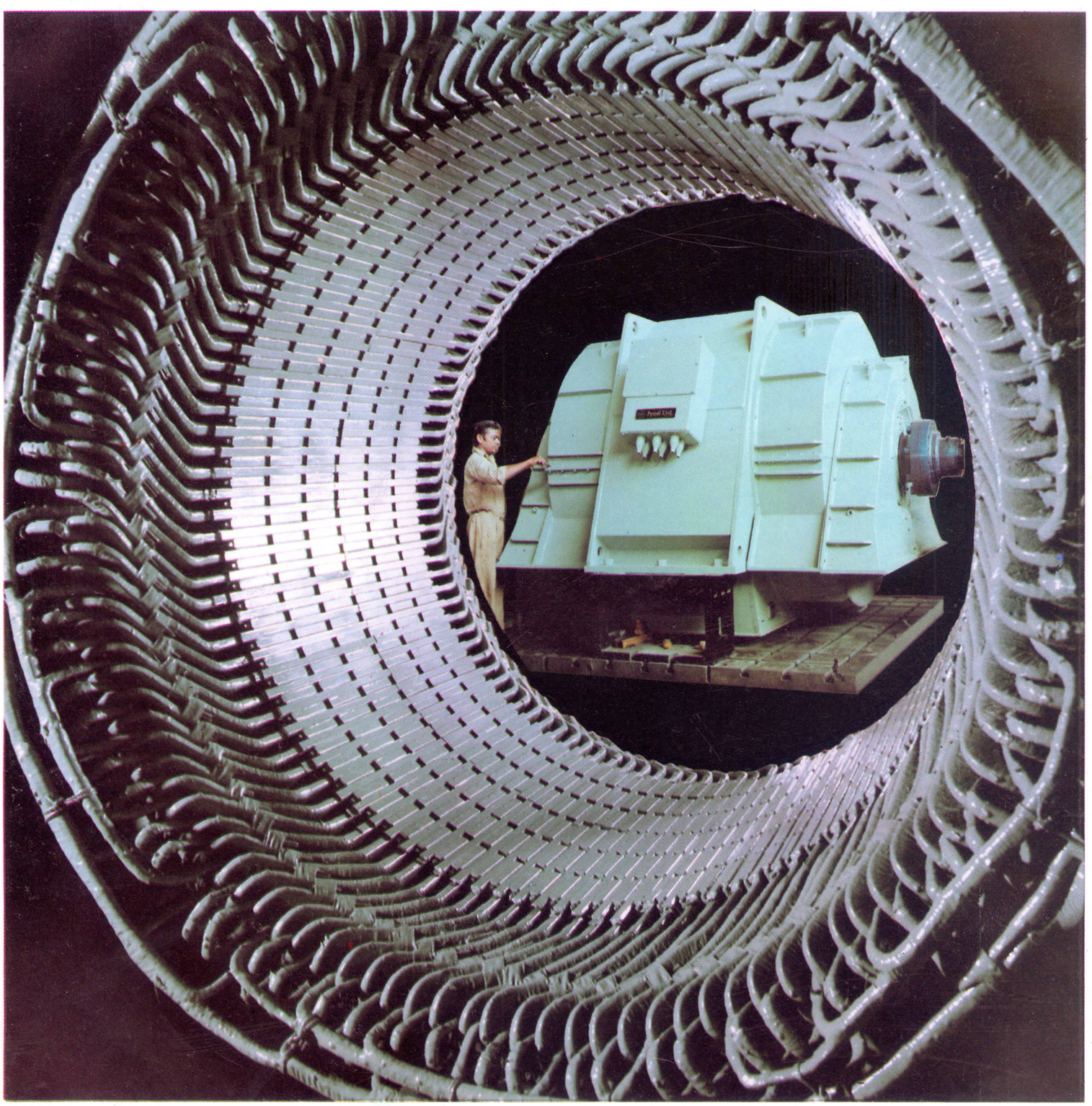
TÜV CERT
EN ISO 9001
RWTÜV

Jyoti Ltd.

50 YEARS OF ENGINEERING EXCELLENCE

'Jyoti' High Voltage Synchronous Generators

Indigenously Developed for Indian Operating Conditions



AN EXPERTISE BUILT OVER EXPERIENCE

Jyoti is well known for its wide range of Rotating Electrical Machines which have been indigenously developed and are giving excellent service for more than 40 years. Jyoti has been the pioneer in the development of alternators (AC Generators) to supply electricity for captive power requirements, project sites, micro-hydel stations, etc. These generators are driven by different prime movers like Diesel Engines, Steam Turbines and Hydraulic Turbines. The range of generators has been continuously extended to cover higher ratings and sizes to meet varied customer requirements. The performance of 'Jyoti' Generator is comparable to that of other leading manufacturers in India and abroad.

The 'Jyoti' High Voltage Synchronous generators have been developed to cater to generating sets for meeting the power requirements of industry supplying reliable power, particularly in the present power shortage situation in India with the demand far outstripping the supply of electricity. It is also possible to employ these generators for paralleling with the grid supply systems to supply excess power to the grid.

While developing these generators, Jyoti has given maximum attention to use the best available materials, closely controlled processes and latest quality control techniques. This has resulted into highly reliable generators designed and manufactured to suit the varied performance requirements of the customers, particularly in Indian environment. This relates to motor starting capabilities, ability to take non-linear loads, and to operate satisfactorily with wide grid voltage variations, etc.

RANGE OF OUTPUTS

The generators are available in different voltage ratings, speed, construction and enclosures to cater to industries like sugar, cement, chemicals, paper, steel, etc. The Output Speed Chart is shown in Figure :1

While the above range is given as standard, it is possible to design and supply special generators to meet specific customer requirements against request.

Reference Standard : IS 4722/IEC 34

MECHANICAL DESIGN

Construction

The generators are normally offered in horizontal foot-mounted construction in either IM 1001, i.e. horizontal foot-mounted or IM 1101 horizontally mounted with raised feet construction. The generators are normally supplied with 2 bearings in the end shields for small ratings upto 1500 KVA and pedestal mounted journal bearings for larger ratings. In special cases, single bearing construction on the NDE end and a bare shaft extension with a coupling flange at the driving end can be provided.

Normally the generator with two pedestal bearings is provided with a free shaft extension and a suitable base plate for mounting on the foundation.

Generators in vertical construction can be offered on request.

Bearings

Anti-friction Ball and Roller Bearings are provided upto 1500 KVA rating. For higher ratings, Jyoti has developed its own Tilting Pad journal and thrust Bearings which are mounted on pedestals. For normal applications, no thrust bearing is provided but for proper centering, thrust collar with locating pads on either side is provided. In case, there is a requirement to take the thrust load from the prime mover (as in the case of hydro-electric generators), special thrust bearings can be provided.

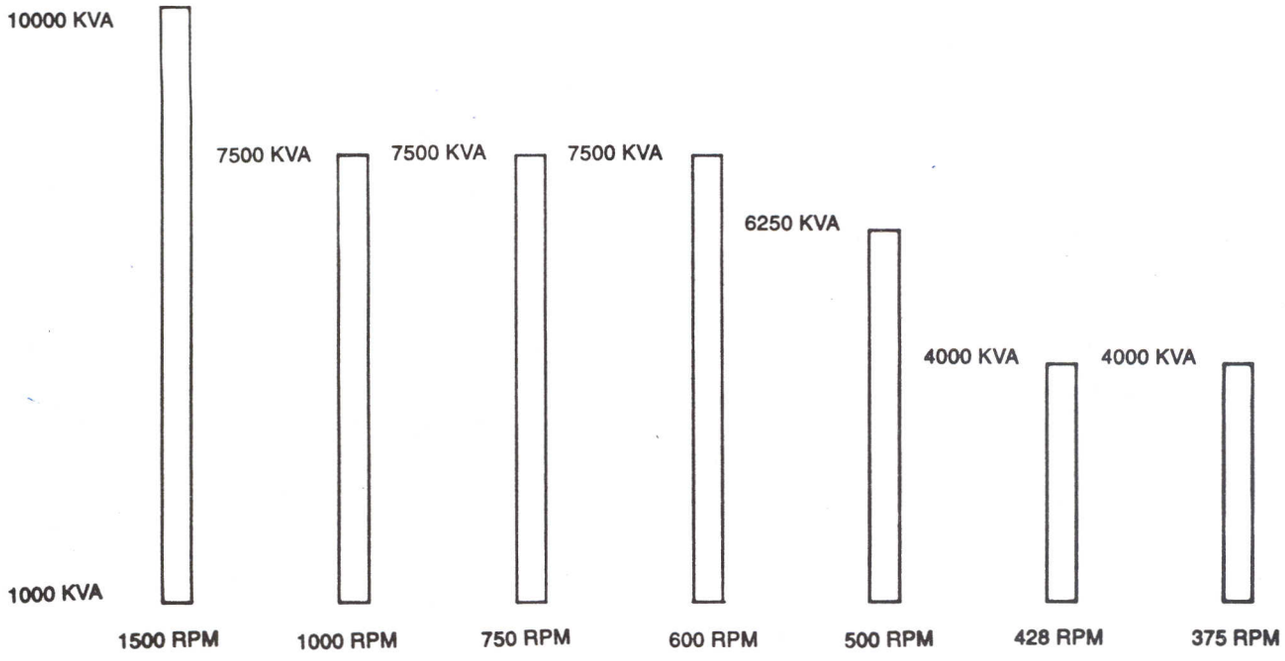


FIG. 1:- OUTPUT - SPEED CHART OF GENERATORS

Enclosure

The generator enclosures are of the following types:

1. IP 21/23 with inlet filters for diesel generator applications.

2. IP 44/54 with air to water heat exchangers for steam turbine applications (CACW mode). Here, the internal air is kept clean and is cooled by the water of the heat exchanger. Hence,the windings are well protected from dust present in the surroundings of the industry.

The location of air to water heat exchangers can either be by the sides or in the pit or on the top of the generators as per customer's choice.

In special cases, air-to-air heat exchangers (CACA)can be provided, but considerable derating of the generator will have to be carried out which will increase the price of the generator.

Frame

The frame of the generator is of rugged, welded, steel construction to withstand stresses during normal operation and extreme stresses due to short circuits. This is achieved by using computer - aided design techniques. The frame ensures low vibration during running. The end shields are made up of fabricated construction.

Rotor

Rotors are of the salient pole construction with either laminated pole stacks bolted to the spider or fitted through dovetails for high run-away speed requirements.

In the case of 4 pole generator, forged steel pole shoes are bolted on the spiders for ratings above 1875 KVA.

As a standard practice all rotors are dynamically balanced and tested at 20 % overspeed.

Cooling - system Design

Standard ambient temperature of the cooling air is regarded as 40°C. For higher ambient temperatures, suitable derating can be considered as given in Figure : 2

Standard altitude is upto 1000 M above Mean Sea Level. For higher altitudes, suitable derating can be considered as given in Figure : 3

In order to cool the generator, either one centrifugal fan or two centrifugal / axial fans are mounted on either side of the rotor.

Adequate inlet and outlet passages are provided at the inlet and outlet of the machine. For diesel generators, washable filters are provided at the inlet.

ELECTRICAL DESIGN :

The stator stack is made up of stampings from low loss, high grade silicon steel sheets. These are insulated on both sides by core plate insulating varnish to reduce losses. Special stacking fixture is used to accurately locate the stack.

FIG.2

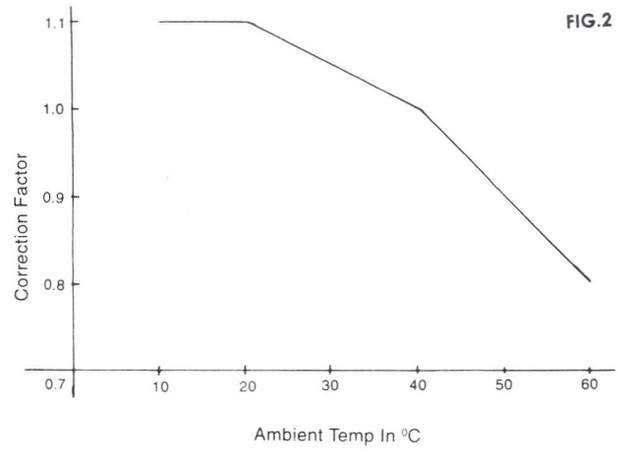


FIG.3

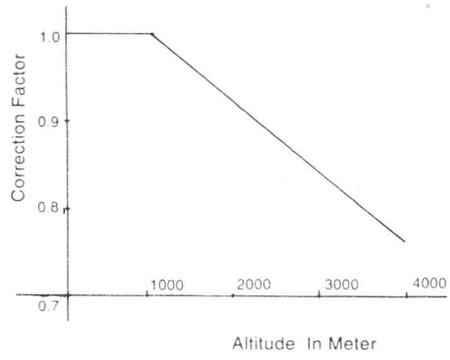


Fig. 2 -3 **OUTPUT CORRECTION AS A FUNCTION OF ALTITUDE AND AMBIENT TEMPERATURE**

Enamelled and fibreglass insulated rectangular copper strips are used to manufacture the high voltage coils. The coils are insulated by high quality mica epoxy glass tapes and are perfectly cured in the special press under controlled pressure and temperature. All coils are subjected to high voltage, loss angle and surge withstand tests as per VDE and IEC standards. The coils are provided with suitable corona protection.

The wound stator is impregnated in varnish under vacuum and pressure conditions to remove all the air voids and to consolidate the windings to the stack.

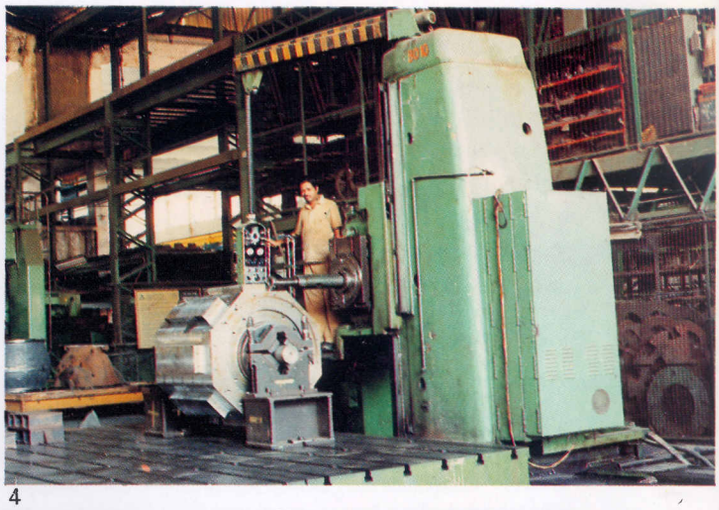
The winding is properly supported and adequately braced at the overhangs to withstand short circuit forces and is given special gel coat treatment.

The wound stack is inserted into the body.

For all new designs, sample coils are tested for impulse strength as per IEC standards.

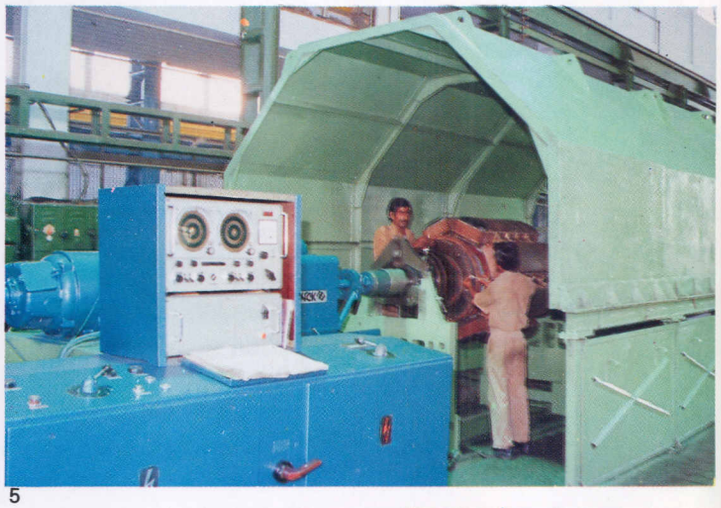
The main field windings are made up of insulated rectangular copper strips for small ratings and single layer, bare copper strips with suitable epoxy insulation for larger ratings. Pole coils are supported suitably against the centrifugal forces caused by rotation. The field windings are fed by shaft mounted AC exciter through a rotating diode wheel to convert AC into DC. The excitation power to the AC Exciter is supplied to the poles on the exciter stator by

1

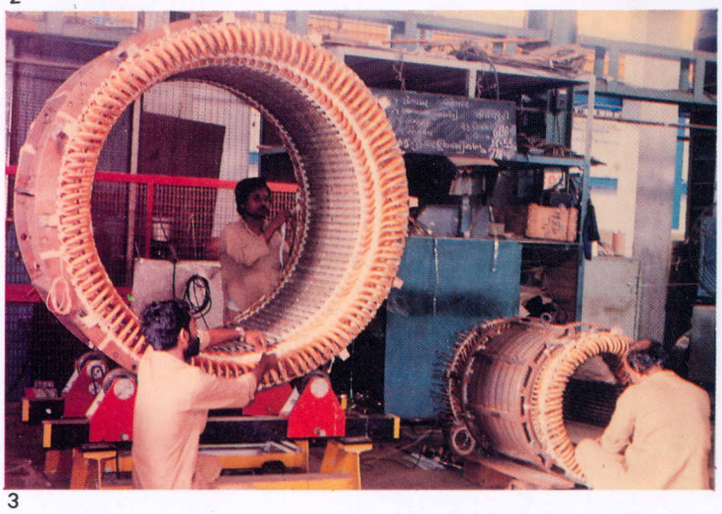


4

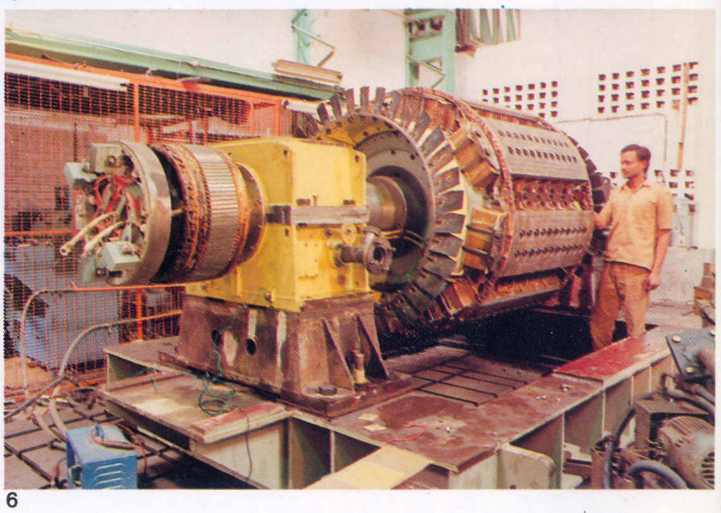
2



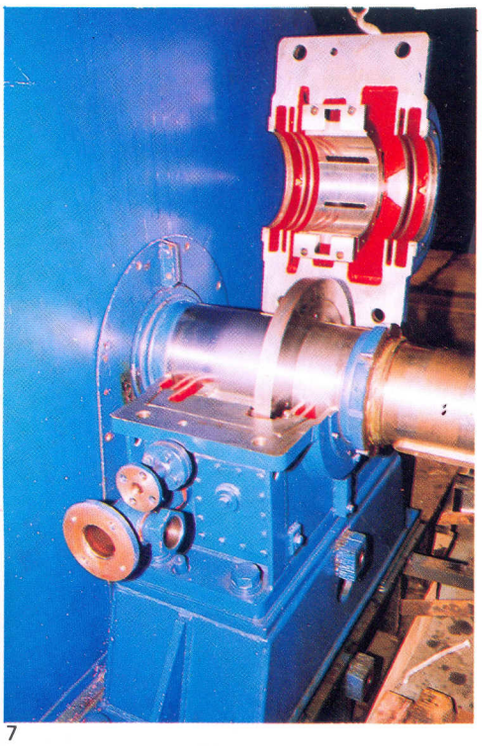
5



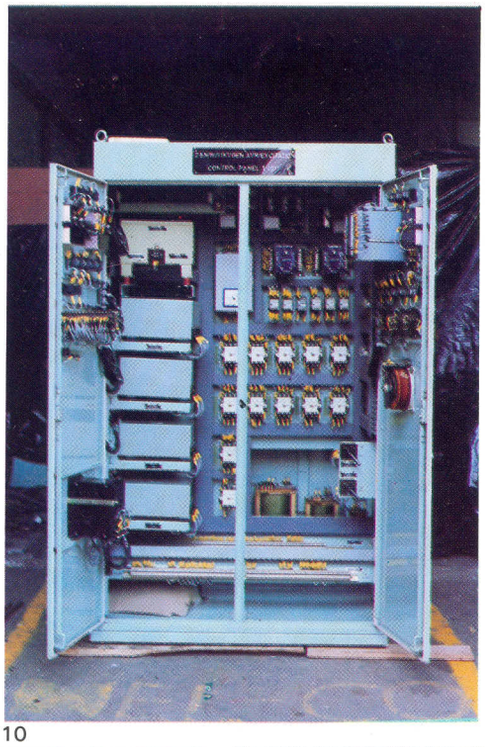
3



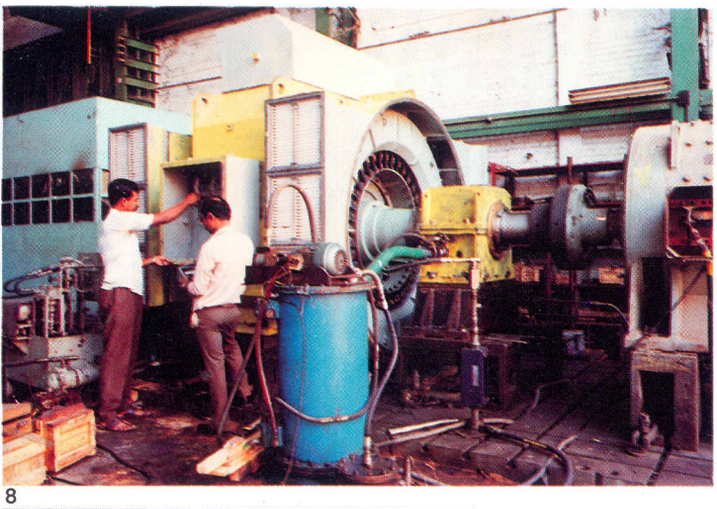
6



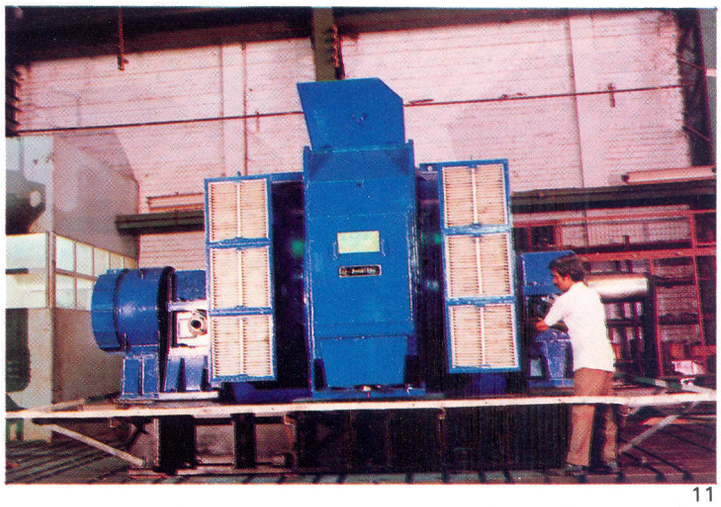
7



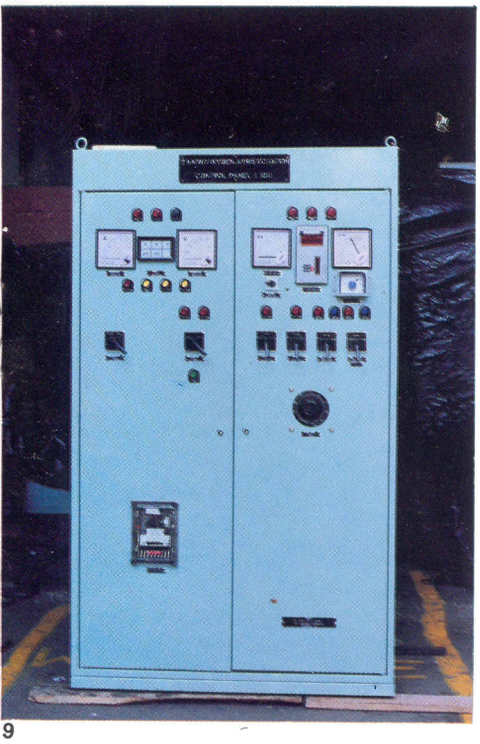
10



8



11



9

1. Stator Frame for a Large Alternator being made for insertion of stack.
2. Stacking of Stator Core for Alternator
3. Stator Winding for a High Voltage Alternator in progress
4. Machining of rotor spider of an Alternator
5. Dynamic Balancing of the rotor of an Alternator
6. Rotor Assembly with Bolted field poles of 5000 KVA, 6.6 KV, 750 RPM Brushless Alternator for D.G.Set being prepared for overspeed test overhung A.C. Excitor and Diode bridge are seen.
7. 250mm Dia Horizontal Tilting Pad Journal and Location Bearing with circulating oil cooling system fitted to a 3 MW, 750 RPM Alternator (Open View).
8. `Jyoti' 4000 KW, 11 KV, 750 RPM Brushless Alternator for Diesel Set undergoing final testing.
9. AVR and Excitation Panel for a 2500 KW ,11KV,1000 RPM Alternator.
10. Open view of AVR and Excitation Panel for a 2500 KW, 11 KV, 1000 RPM Brushless Alternator.
11. `Jyoti' 4000 KW,11 KV 750 RPM Brushless Alternator,

electronic Automatic Voltage Regulator (AVR). Hence there is no contact between stator and the rotor of the generator. (Brushless design.)

A connected damper winding is provided in the pole - faces to damp the oscilations and ensure satisfactory performance during parallel operation.

The insulation provided for the stator windings conforms to thermal Class F with the temperature rise normally limited to Class B limits.

For large generators, 6 terminals are brought out, 3 on the line side and 3 on the neutral side. The terminal execution can be either on the 2 sides of the stator body or on the top of the machine or in the lower side as per requirement. Phase segregated terminal boxes can be provided to conform to the fault withstand capability of the supply system.

Overload Capacity

Generators are designed for continuous operation at rated load (S1 duty). Diesel Generators are suitable for 10% overload for 1 hour at intervals of 12 hours.

Accessories

For proper monitoring and control purposes, following accessories are provided on the generators as standard.

1. 6 nos. RTDs for stator windings (Two per phase)
2. 2 nos. RTDs for bearings (One per bearing)
3. 2 nos. Dial Temperature Indicators / RTDs for Cooling Air Circuit (At inlet and outlet)
4. Anti-condensation heaters to maintain slightly higher ambient temperature inside the machine during storage to drive away the moisture.

AUTOMATIC VOLTAGE REGULATOR (AVR) AND EXCITATION SYSTEM :

Excitation power to the AC Exciter is supplied through Electronic AVR to maintain the terminal voltage of the generator constant from no-load to full load within $\pm$ 1%. The AVR draws the power from a step-down transformer located in the switchgear panel. The voltage and current sensing are also obtained through PTs and CTs located at suitable places in the panels.

The AVR is normally housed in AVR and Excitation Panel alongwith other control modules, change-over switches, meters, indicating lamps, etc. The Figure : 4 shows the typical schematic diagram of the AVR and excitation system of the generator.

Being Static, the AVR and excitation system ensure fast response for sudden load changes, motor starting operation, etc. The initial voltage dip during motor starting depends upon the starting KVA of the motor and its power factor. As a normal standard, starting KVA of 60% of the rated KVA produces a transient voltage dip of around 15%. For larger starting KVA of the motor, voltage dips will be higher. Voltage is restored to within 97% of the rated value in 0.5 seconds from the application of the load.

PARALLEL OPERATION

The generators are suitable for parallel operation with other generators in the power house. For this purpose, a quadrature droop CT is normally provided.

The generators are also suitable for parallel operation with grid supply system. A power factor regulator is usually provided in the excitation system to facilitate smooth performance of the generator even when wide grid voltage variations take place.

Looking to the special requirements of the control and protection of the generator as per customer requirements, following modules/features can be incorporated in the AVR and Excitation system.

- Motor operated Potentiometer
- Voltage/Frequency Module
- Short Circuit Supporting Arrangement
- Max./Min. Excitation Limiter
- Stator Current Limiter
- Manual Voltage Control Module
- Auto/Manual automatic changeover
- AVR Fault Detector
- Diode Failure Detector
- Loss of Field Control
- Field Failure Relay
- Over Voltage Relay
- Permanent magnet Generator (PMG)

The above modules and the control arrangement is generally finalised with the customer/consultant at the time of finalising the order for the generator.

TESTING

Jyoti has exhaustive testing facilities to ensure that the generator meets the performance requirements as per design. Tests are divided into:

1. Routine Tests performed on all generators and
2. Type Tests performed on one generator of a typical design.

ROUTINE TESTS

- Air Gap Measurement
- Insulation Resistance Measurement
- Resistance Measurement
- Terminal Markings
- Vibration Measurement
- Testing of AVR
- Open Circuit Characteristics
- Short Circuit Characteristics
- High Voltage Test
- Over-Speed Test

TYPE TESTS

In addition to above tests, following tests are performed:

- Inertia Measurement
- Heat Run Tests on OCC and SCC

- Measurement of Loss and Efficiency
- Measurement of Reactances and Time Constants
- Waveform Distortion
- Shaft Voltage

Additional tests are performed on request when facilities are available.

QUALITY PLAN

The generators follow the rigorous Quality Plan which has been evolved based on long experience in the manufacture of generators. The Quality Plan covers the following steps :

- Inspection of incoming materials
- In-Process inspection
- Testing of the final product

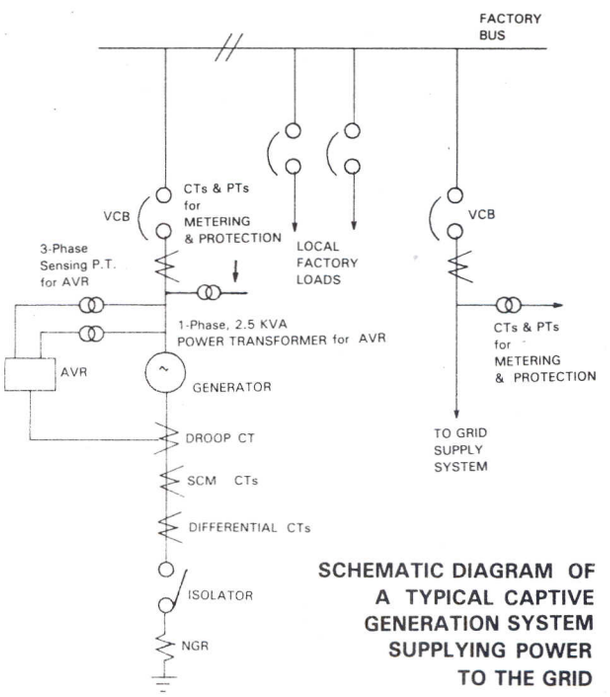
For ensuring proper quality of materials, a Vendor Approval Procedure evolved jointly by R&D, Quality Control and Purchase Departments is followed.

Record of various inspection and testing of materials, in-process checks and final testing of generator are maintained. If the customer requires, special Quality Plan can be agreed upon at the time of placing the order.

If required by the customer, Jyoti is willing to engage an external Inspection Agency (like Lloyds) to carry out the inspection work during manufacture of the generator.

CUSTOMER SERVICE

Jyoti has a team of experienced engineers at its Head Office as well as at its Zonal Offices at the metropolitan Cities to provide prompt service during the installation, commissioning and after-sales service to the generators at various sites.



SCHEMATIC DIAGRAM OF A TYPICAL CAPTIVE GENERATION SYSTEM SUPPLYING POWER TO THE GRID

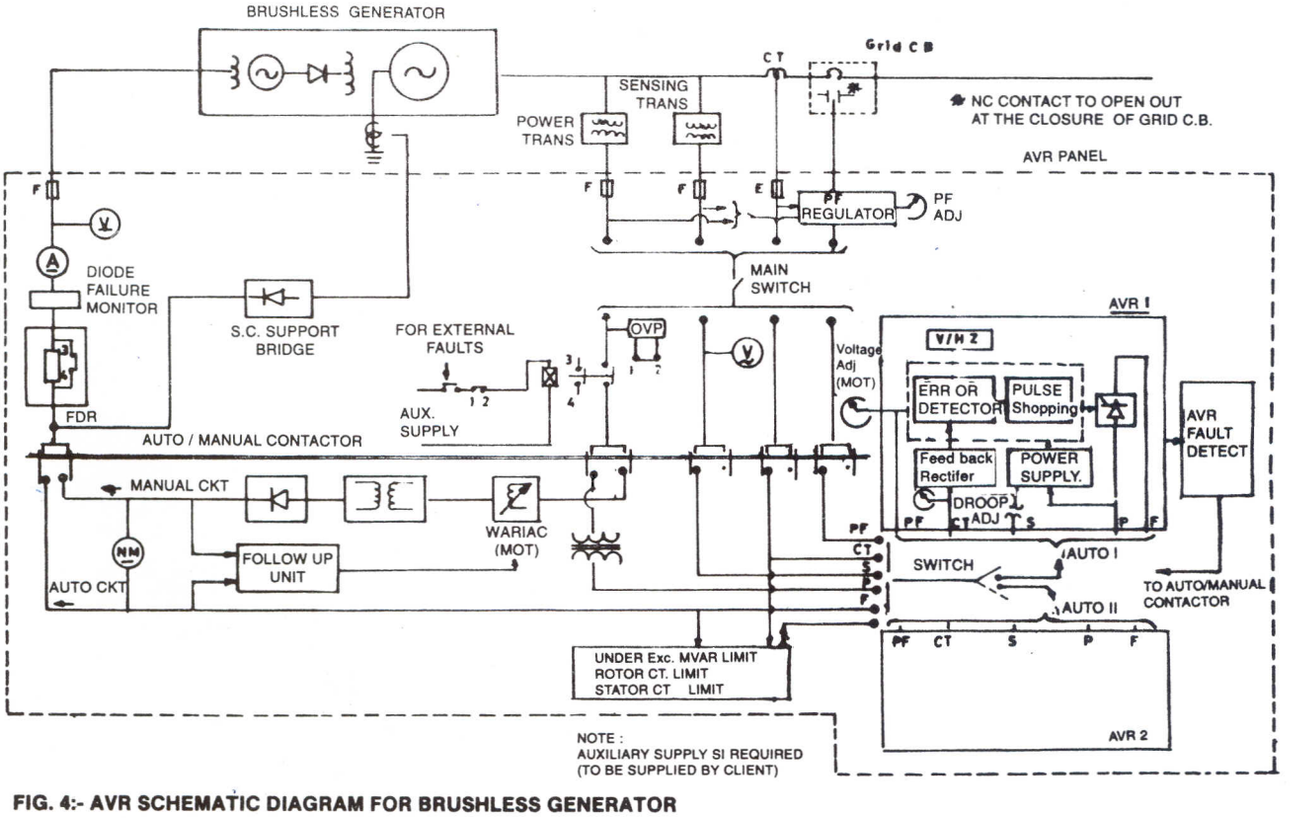
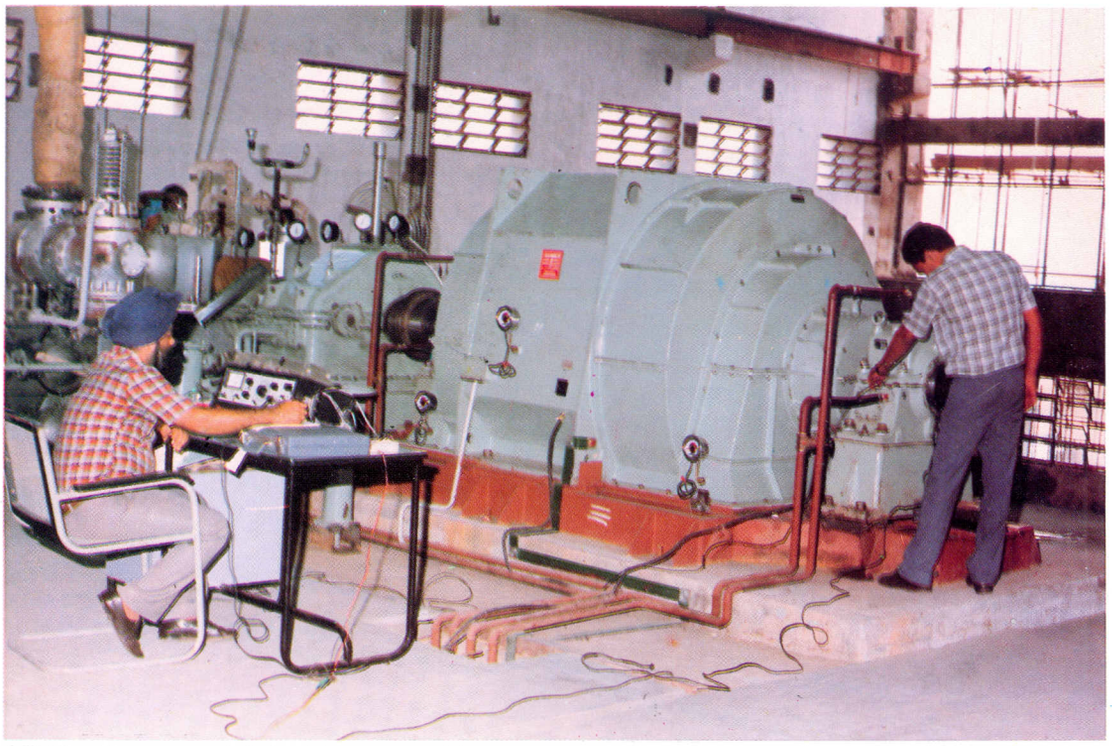


FIG. 4:- AVR SCHEMATIC DIAGRAM FOR BRUSHLESS GENERATOR



Vibration Measurements being taken at one of the sites where a Large Generator is in operation.

Jyoti Ltd. VADODARA (INDIA)

50 Years of Engineering Excellence

FOR FURTHER ENQUIRIES PLEASE CONTACT

Rotating Electrical Machines Division
Nanubhai Amin Marg, Industrial Area,
P.O. Chemical Industries,
Vadodara 390 003.

Phones : 280633, 280648
282059
Fax : +91-265-281871
Grams : PROJYOTI
E Mail : rnd.jyoti@sm3.sril.in
Website : http://www.jyoti.com

ZONAL AND BRANCH OFFICES

• **Bangalore** : 85, (New No. 26/1), 9th Cross, 1st Floor, Opp. Sadshivnagar Post Office, Rajmahal Vilas Extension, Bangalore-560 080. Fax : 080-3349250 E-Mail : kar.jyoti@ sm3.sril.in • **Chennai** : VEE DEE YEM Complex, 270, Ground Floor, Lloyds Road (Avvai Shanmugham Salai) Royapettah, Chennai 600014, Fax : 044-8275140, E-Mail : mad. jyoti@sm3.sril.in • **Kolkata** : 45, Jhowtalla Road, Syed Amir Ali Avenue, Calcutta-700 019, Fax : 033-2475267 E-Mail : cal.jyoti@sm3. sril.in • **Mumbai** : 103, Kakad Chambers,132, Dr. Annie Besant Road, Worli, Mumbai-400 018. Fax : 022-4964468, E-Mail : bby.jyoti@sm3.sril.in • **New Delhi** : 406, Chiranjiv Towers, 43, Nehru Place, New Delhi-110 019, Fax : 011-6426225, E-Mail : del.jyoti@sm3.sril.in • **Pune** : 'Sushrut' Clinic, Dr. Kanitkar's Bungalow, Bombay-Pune Road, Chinchwad, Pune-411 019, Fax : 020-7473077 E-Mail : pun.jyoti@sm3.sril.in • **Secunderabad** : Gr. Floor, 5-4-187/7, Karbala Maidan, M.G.Road, Secunderabad - 500 003. Fax : 040-7543673, E-Mail : sec.jyoti@sm3.sril.in

In Keeping with the technological strides the world is making in the engineering field, we introduce changes in the design of our products. Hence, the products as actually supplied might have features varying herefrom.

Bulletin No. : D-01-34 (R) 1000/04/2001