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Research on Insulation Problem of Million-kilowatt Hydropower Unit

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ABSTRACT

China's power demand has promoted the rapid development of China's hydropower industry. Correspondingly, China's turbines and their auxiliary facilities manufacturing industries are developing rapidly and leading the world. Since the reform and opening up, China's hydropower workers have designed and built large-scale hydropower stations independently. By the end of 2017, China's hydropower installed capacity reached 341 million kilowatts. Meanwhile,The large-capacity, large-size, and high-reliability hydropower units are gradually being applied. At present, the million-kilowatt-class hydropower units are recognized and agreed on by the advantages of unit cost and bottom cost. This paper focuses on the analysis of the insulation problem of a million kilowatt hydropower unit, and proposes new insulation requirements for the high value of the unit itself, the large abnormal shutdown loss and its protection, design and operation.

Keywords: hydropower industry?insulation problem?million kilowatt?insulation materials?turbine?electrical properties.

THE FEASIBILITY OF A MILLIONHYDROPOWER UNITS.

Nowadays, China has mastered the design, manufacture and core technology of large-scale Francis turbine generator sets. Its operation is not only stable but also compact. At the same time, the high partial load pressure pulsation is eliminated in the entire operating area, which makes its even efficiency improved sharply. At the same time, the water cooling method is adopted in the new turbine technology of the turbine, and the water cooling device is installed on the thrust bearing chamber of the generator, and the copper tube of the bearing chamber is ô14 on the outer edge of the bearing. Because the copper tube coil at the outer edge makes the contact area small and the thermal conductivity low; and the thermal grease is added to the outer edge of the copper tube and the bearing, that the cooling effect is more remarkable. Ten years ago, the 700MW-class large-scale all-air-cooled water-wheel generator with the largest single-unit capacity, the largest structural size and the largest thrust load independently developed, designed and manufactured by Harbin Electric Machinery Co., Ltd. created the world's largest single-capacity capacity. A new era of operation of air-cooled water turbine generator sets. Recently, the construction of the world's largest hydropower project - Baihetan Hydropower Station in Jinsha River came to the news: China Electric Power Construction Group Subsidiary Hydropower Bureau won the bid for the installation and commissioning of mechanical and electrical equipment for the left bank power station. The world's largest hydropower station with the second largest installed capacity in the world uses 16 single-million-kilowatt hydropower units. It is currently the largest single-unit hydropower unit, bringing world hydropower into the "millions of single generations". In the hydropower construction in western China, a large number of super-large capacity units of millions of kilowatts are still needed. The state vigorously advocates independent design and innovation to overcome the key technologies of the million-kilowatt hydropower unit based on the research of the Three Gorges unit. Not only that, but also accelerates the research and development of new technologies, new structures and new materials, the selection of voltage levels, the cooling method of generators, The structural design of the unit and the insulation problem of the generator set are extremely critical for this project, and the hydropower unit will inevitably develop towards large capacity, large size and high reliability in the future.

SELECTION OF INSULATION MATERIALS FOR MILLIONS OF HYDROPOWER UNITS.

The advantages and disadvantages of a million kilowatt-class hydropower unit are outstanding. Although its unit cost and power generation cost are low, it is of high value to the unit. If the special situation causes downtime, the loss is huge. In terms of equipment protection, unit design, computer monitoring, etc. There are also many new problems, so people have put forward higher standards for the insulation capacity of the unit. Therefore, the insulation capacity of the unit has been put forward to a higher standard. Therefore, the insulation capacity of the unit has been put forward to a higher standard.

2.1 Main insulation materials in China and abroad

The stator of a large generator is an important part of the generator and the starter. The insulation of the synchronous motor includes the inter-strand, the gate, the row, and the interlayer insulation. The insulation part mainly acts as an isolated electric machine because the motor runs for a long time. not only will be electric, thermal impact, mechanical action and also to withstand ambient conditions of thermal cycling thermal stress occurs when starting and stopping, or a strong electromagnetic force generated by the short circuit accident circuit occurs, and therefore the stator coil insulation must Good electrical and mechanical properties ensure efficient and stable operation of the generator. Accordingly, the stator main insulation is the most important part of the insulation system of the high-voltage motor. It not only directly affects the overall technical indicators of the motor, but also determines the reliability and service life of the motor to a large extent.

At present, the main insulating materials of high-voltage motor stators are generally divided into two types, one is continuous insulation method for vacuum rubber impregnation (VPI) with less rubber powder mica, and the other is epoxy multi-powder mica tape molding (or hydraulic). Continuous insulation. Domestically, it is mainly a multi-adhesive epoxy mica insulation system with a mica content of 80g/m2. The main insulating materials used in foreign motors, regardless of the multi-glue or less-glue system, generally have a mica content of about 160 g/m2. The purpose is to ensure that the generator has good mechanical and electrical properties under long-term operating conditions, especially anti-aging properties.

2.2 Study on main insulation materials

2.2.1 multi-rubber molded insulation system

The main insulation material of the rubber molding main insulation system is a multi-rubber mica tape. Mica is a nonmetallic material with excellent flexibility and rationality. Its dielectric energy is very high, corona resistance and spark resistance are higher than those of organic insulation materials. Mica is hydroaluminosilicate and has a layered structure. Although new insulating materials emerge one after another, there is no insulating material to replace mica. Since the development and application of TOA epoxy mica powder insulation in China in the 1960s, great efforts have been devoted to the study of main insulation in the past decades, which has led to the application of multi-adhesive mica in domestic advanced large-scale power generation equipment.

Multi-adhesive raw materials include mica, mica paper, adhesive, reinforcing materials, etc. They must have sufficient electrical, thermal and mechanical properties.

1) Mica.

Piece mica is formed by peeling and cracking pieces of mica, and is divided into nine specifications such as, and the like according to area. According to their thickness, they were divided into groups I, II and III. According to the surface quality is divided into a, b, c three grades. As insulation materials, muscovite and phlogopite are the most widely used materials. In contrast, muscovite has higher breakdown strength and lower dielectric loss than phlogopite. Phlogopite has high heat resistance and good flexibility and bending resistance.

2) Mica paper.

At present, the basic types of mica paper are raw paper, cooked paper and mixed paper. After the industrial raw materials we need are mined from mica ore, most of the remaining mica fragments are used to make mica paper. It has uniform thickness, small fluctuation range of dielectric strength, high and stable corona initial voltage, high electrical strength and can weaken the thickness of electrical main insulation material. In addition, due to the good uniformity of mica paper and no overlapping phenomenon of mica sheets, the glue is easy to soak

and the residual gap is small, which can greatly improve the insulation reliability. Correspondingly, its mechanical strength is poor, which needs to be made up by selecting appropriate adhesive and reinforcing materials. Therefore, we still need to develop mica paper with high performance, high permeability, high standard and multi-tape with high mica content and good stability.

The performance of various mica papers is shown in the following figure.

Table1

Type	Nominal value, g/m2	Maximum deviation (%) between individual values of thickness and average values of all values	Permeability(s/100ml)	Penetration time (non-mesh)	Conduc ti-vity of water extract (s/m)	Tensile strength (N/M)
MPM 1	68	±10	3200-6500	100	70	8.0
	82		3800-7300	120		9.8
	100		4700-8500	120		9.8
	115		≧6000	130		9.8
	130		≧6000	130		11.0
	145		≧6000	150		11.0
	160		≧6000	150		11.0
MPM 2	80	±10	1400-2300	50	20	6.2
	100		1600-2600	70		7.0
	115		1700-2900	90		7.5
	125		1850-3150	110		8.0
	150		2200-3700	160		9.0

3) Viscose.

Viscose plays an important role in mica tape. It is responsible for bonding mica paper and reinforcing materials. The main insulation material for high-voltage motors must have excellent dielectric properties, thermal stability, storage stability, moisture resistance, water resistance and chemical stability. Epoxy resin material has good process performance, and can be cured by curing system. The cured product has excellent electrical insulation performance, good adhesion and mechanical strength, small solid shrinkage rate, good moisture resistance, corrosion resistance and low dielectric loss. Therefore, all companies use epoxy resin as the adhesive for main insulating mica tape.

There are many kinds of main adhesives, including asphalt adhesive, alkyd adhesive, unsaturated polyester imine resin, epoxy adhesive, etc., among which the main adhesive systems are:

(1) Epoxy tung oil anhydride system adhesive is mainly used for 5438-1B grade epoxy glass mica tape (TOA tape), because its molecule contains cyclic structure, double bond, ether bond and ester group, which makes it strong in adhesion, good in toughness of cured product, excellent in dielectric property, mechanical property and good in moisture resistance. However, due to the long chain in its structure, the cured product of tung oil anhydride adhesive is poor in rigidity, low in thermal deformation, poor in thermal mechanical property and short in storage period, which is not conducive to long-term storage. Bismaleimide is used to modify the weakness of TOA belt (tung-ma belt). Up to now, the large generator with tung-ma insulation has exceeded 10 billion MW. It maintains the advantages of TOA belt, and at the same time improves the heat-resistant grade and high-temperature mechanical strength, but the range is not large. Therefore, many domestic manufacturers are developing new multi-adhesive systems to further improve the flexibility of the belt, improve the binding process, extend the storage period, and the cured electrical properties are equivalent to tung-ma belt. Its mechanical properties, especially the shock wave strength and thermal bending strength, are significantly improved

compared with tung-ma belt, and the heat-resistant grade is F grade.

(2) Boron amine cured epoxy adhesive. It is prepared from latent boron amine complex, bisphenol A epoxy and phenolic epoxy. The most prominent feature of its cured product is its high thermal deformation temperature and thermal mechanical properties. It is stable in storage at normal temperature and can be cured quickly when the required curing temperature is reached. The heat resistance grade is F.

(3) Epoxy adhesive cured by organic carboxylate. It is prepared from organic carboxylate and bisphenol A epoxy resin or bisphenol A epoxy resin and phenolic epoxy resin. The adhesive has excellent dielectric properties, high thermal deformation temperature and thermal mechanical properties, and heat resistance grade is B-F grade.

(4) Polyester epoxy adhesive. Made of polyester and epoxy resin dissolved in solvent. The adhesive has good flexibility, adhesiveness and storability, but the medium loss is large. The heat resistance grade is grade B.

4) Reinforcing materials

The mica tape composed of reinforcing material, mica paper and adhesive plays a role in enhancing mechanical strength. The performance of the master tape is closely related to the type and performance of reinforcing material.

Reinforcing materials are divided into natural reinforcing materials and synthetic reinforcing materials , and are divided into organic reinforcing materials and inorganic reinforcing materials according to structure. Organic reinforcing materials include wood, cotton and synthetic fiber. Inorganic reinforcing materials are divided into glass fibers and asbestos. At present, the reinforcing material widely used in mica tape is alkali-free glass cloth.

After comparing the insulation level of our country's F-grade multi-rubber mica with that of foreign countries, our country's multi-rubber mica insulation electrical performance is equivalent to that of the international advanced manufacturers (see Table 2). In terms of heat resistance, it can still maintain good performance despite two cycles of cold and heat cycle tests.The impact strength is close to that of foreign countries. The normal bending strength is slightly lower than that of foreign advanced manufacturers, while the bending strength at 155 ! is higher than that of foreign manufacturers. It is worth noting that the holding capacity of bending strength at 100 ! is only 20% ~ 25%, which is obviously lower than the level of foreign products. Relevant experts believe that this is an important indicator of foreign products. Only more than D602 adhesive tapes in China meet this requirement. Experts suggest that bending strength of insulation system at 100 ! should be listed as an indicator for future evaluation of insulation performance.

Table 2

	Factory D 5440-1	Factory B 440-1	China less glue VPI insulation GBMP	AmericaGE Micapall	Switzerland BBC Micadur
normal	1.20	<1.0	<1.0	1.6	<2
thermal state	6.0 (155 degrees)	4.0 (155 degrees)	5.0 (155 degrees)	5.8 (100 degrees)	5.8 (130 degrees)
Thermal state after thermal stability experiment	2.5 (155 degrees)	3.0 (155 degrees)	4.0 (150 degrees)	-	-
Lateral bending length（MPa）	123 100 degrees 155 degrees	184 155 degrees	230 100 degrees 155 degrees	25% higher than Micapall 2 times higher than Micapall	190 120 degrees -
Normal impact length	26	-	26	4.8 times higher than Micapall	20

2.2.2 Less Glue VPI Insulation System

Vacuum pressure impregnation (VPI) is a better insulation treatment technology today. There is no air gap in the rubber-less insulation structure after vacuum pressure impregnation of golden rudder, which improves mica content and thermal conductivity of insulation, at the same time helps to improve electrical performance and service life of insulation system, thus improving technical index and reliability of motor, greatly simplifying manufacturing process of insulation system, improving productivity and reducing cost.

VPI insulation technology was applied to generator stator insulation in the 1940s, to main insulation of medium and large high voltage motors in the 1970s, and to insulation treatment of motors and electrical appliances in the 1990s. In recent decades, companies and institutions have continuously improved and perfected VPI insulation technology to a very high level.

Mica tape with less rubber powder and impregnating resin are two important components in VPI insulation system. The adhesive content in mica tape with less rubber powder is very small, and the final curing performance of mica tape with less rubber powder mainly depends on impregnating resin. The performance of mica tape with little rubber powder and its compatibility with impregnating resin have great influence on the insulation performance and electrical aging performance of VPI.

(1) Unsaturated polyester imine resin VPI insulation. The impregnating resin is based on the solvent-free paint, optimizes its molecular structure, reduces active groups, simplifies the main chain structure, and adopts a capping technique to control the curing reaction and achieve low temperature rapid curing under the premise of ensuring storage stability. According to the principle of similar dissolution, the structure similar to the impregnating resin paint base insulated by unsaturated polyester imine resin VPI is selected as the adhesive of the low-rubber-powder mica tape, and the softening point and bonding strength of the adhesive resin of the low-rubber-powder mica tape are controlled, so that the softness of the low-rubber-powder mica tape is ensured on the premise that the special raw mica paper has good bonding property with glass cloth.

Immersion resins for whole dipping are generally solvent-free resins prepared from epoxy resins, curing agents, diluents, accelerators, etc. Abroad, they can be generally divided into two types, one is modified epoxy resins, liquid anhydrides, styrene systems, and the other is pure epoxy resins and anhydride curing agents systems. Both systems have good performance. The requirements for impregnated resin are low viscosity to facilitate overall impregnation, short gelling time to reduce resin loss during baking, and long storage period as much as possible, with excellent mechanical properties, heat resistance and electrical properties after curing. Westinghouse believes that the technical requirements for impregnating resin are: '$ viscosity at 25 ! should be 120 d; (3) curing by dipping curing agent in tan ´ resin at 150 ! for 150 ! gelling time. Therefore, the matching and compatibility between impregnated resin and mica tape with less glue are especially important. The main problems of impregnating resin in China are unstable storage period and users are too risky to use it safely. Some have high low volatility, some have poor compatibility, and the loss increment Ätan ä is high.

(2) Epoxy VPI insulation The structure of the impregnating resin in this insulation system is similar to that of the impregnating resin in Westinghouse's Thermalastic insulation. The impregnating resin uses epoxy anhydride styrene resin, maleic anhydride and epoxy resin generate epoxy ester compound under the catalysis. The epoxy resin relies on the introduction of maleic anhydride double bond, methylnadic anhydride and styrene for crosslinking reaction. In order to improve the curing crosslinking density of the composite, a high-temperature accelerator is added to improve the high-temperature medium loss characteristics. The mica tape with less rubber powder mainly consists of epoxy resin adhesive, relatively dense raw mica paper and glass cloth. In the previous VPI insulation system, the index of permeability of mica paper with less rubber powder is very important, and

relatively dense mica powder paper will affect this index. However, the actual application shows that the impregnated resin mainly enters the insulation from the gap between the half-packs under the action of pressure. The impregnated resin in the insulation system has good compatibility with mica tape with less rubber powder, stable quality and good dielectric property, and normal electrical aging and thermoelectric aging have reached a very high level.

COMPOSITION OF MAIN INSULATION FOR MILLION KILOWATT HYDROPOWER UNITS

3.1 Main Insulation of Stator Bar

The mica content of the F-grade epoxy multi-rubber powder mica tape with high mica content suitable for the multi-rubber molding system of large generators reaches 160g/m2, while those who have mastered the F-grade heat resistance include ABB and SIEMENS represented by Westinghouse Electric Company of the United States. The VPI process with less adhesive tape is adopted, i.e. after wrapping with less adhesive mica tape, the resin is vacuumized and pressurized in the tank. The storage period of the mica tape with less glue is longer. After dipping a batch of bars, they are taken out and then put into an oven for heating to solidify the insulation. The production efficiency is higher. There are also ALSTOM and Russian power plants represented by GE, which adopt multi-adhesive tape hydraulic or molding process, i.e. after wrapping with multi-adhesive mica tape containing resin and curing agent, a batch of wire bars are put into tank hydraulic process, asphalt is used as medium for heating and pressurizing to solidify insulation, or wire bars are put into mold for heating and pressurizing to solidify insulation into a solid whole.

1) Developed F-grade epoxy multi-rubber powder mica tape with high mica content suitable for multi-rubber molding system for large generators. Its mica content reaches 160 g/m2. Its conventional mechanical and electrical properties meet the requirements of domestic quality grading standards and reach or approach the international advanced level. The thermodynamic properties such as dynamic modulus, mechanical loss, dynamic viscosity, thermal conductivity and creep properties of the main insulation material are tested.
2) The electric heating aging test of stator bar insulation is carried out by using the electric heating aging test system which can truly simulate the operating conditions of stator bar. The electric heating aging life is more than 2,000 h, which greatly exceeds the standard requirement of 500 h, indicating that the insulation structure and anti-corona structure of the bar are designed reasonably and should be able to meet the requirements of the insulation structure of the generator with working field strength.
3) After 500 cold and hot cycle tests, the stator bar insulation still meets the standard requirements, the bar section size is slightly increased, the creep characteristics of the insulation are good, and the main insulation still has good dielectric properties.
4) The application of the main insulation material on the stator bar of the hydro-generator unit shows that the 160 g/m2 thick mica powder belt can be used as the main insulation material for the insulation of the stator bar of the large-scale high-voltage generator.

3.2Anti-corona of Stator Bar

The development of anti-corona technology for stator bars and windings of large-scale electrical machines has been continuously improved with the improvement of the performance of main insulation materials and the increase of rated voltage. The insulation material of stator bars of large motors is asphalt mica, and the anti-corona treatment adopts paint type anti-corona structure. The material is asphalt semiconductor with iron-containing asbestos tape or glass ribbon. After that, with the application of TOA epoxy mica powder insulation, related enterprises in various countries began to develop alkyd semiconductor paint. In 1966, the anti-corona structure of 15.75kv stator bars was studied, and the anti-corona structure of alkyd high resistance semiconductor paint containing silicon carbide was developed. Specific criteria are as follows.

1) There should be corresponding internal voltage-sharing semiconductor paint, and the structure of semi-shielded internal voltage-sharing layer is selected according to the structure of stator bar.

2) The low-resistance semiconductor glass ribbon is selected for the slot of the bar, and the surface resistivity is within the required range of 1× 103 ~ 1× 105 ohms after being solidified and molded with the main insulation.
3) Through the combination of theoretical calculation and actual situation.Sustainability is a subset of CSR.

3.3 Stator core insulation

Generator stator core is formed by stacking tens of thousands of fan-shaped silicon steel sheets. The assembled stator core requires flat slot shape, flat slot wall and sufficient tightening force to ensure the rigidity of the core and avoid inter-slice vibration caused by electromagnetic force. Attention should also be paid to inter-slice insulation should not be damaged, ventilation ducts should be uniform and neat, and deformation should not occur. The thickness of punching sheet commonly used for large turbogenerators is 0. 35 mm or 0. 5 mm. Generator stator core may have poor quality due to manufacturing or maintenance, or due to thermal and mechanical forces during operation, inter-slice insulation may be damaged, resulting in short circuit and local overheating in the short circuit area, threatening the safe operation of the unit. Insulation damage between stator plates is the most common fault of iron core, which is caused by thermal damage, electrical deterioration, mechanical deterioration and manufacturing defects. When the inter-slice insulation of the iron core is short-circuited due to damage, the eddy current loss of the iron core at the fault position increases, which will cause the short-circuit point to heat up, further damage the inter-slice insulation at the adjacent position, and expand the fault flour.

After the expansion of the fault flour, the eddy current loss further increases and the heating phenomenon becomes more serious, thus forming a disgusting cycle. When eddy current increases to a certain extent, silicon steel sheets will melt. Hot spots will damage the main insulation of stator windings, accelerate the deterioration of stator insulation, and may lead to short-circuit grounding fault of stator windings to iron core in case of serious development. The stator core is made of high-quality cold rolled thin silicon steel sheets. In order to reduce eddy current loss, the sheets are coated with F-grade insulating paint. For silicon steel sheet paint, the requirements are higher in terms of Dielectric strength, heat resistance index, adhesion and hardness, longer storage period, lower curing temperature and shorter curing time.Voltatex Ell5lA silicon steel sheet paint and xiju133c semi-inorganic silicon steel sheet paint can be taken as representatives, and their properties are shown in the following table.

Table 3 Voltatex Ell5lA silicon steel sheet paint

dielectric strength	≥40MV/m
Resistance	Interlayer resistance 1500 Ω ·cm²/
Temperature tolerance grade	≥155
adhesion	Good
Curing conditions	300C/35s
shelf life	12 months

Table 4 Xijue 133C Semi-inorganic Silicon Steel Sheet Paint

Serial number	Name	Indicators
1	Viscosity, viscosity cup number 4	18 ~ 25s
2	Solid content, 105‡ 2‡, 2h	≥31%
3	Filler content	15% ~ 20%
4	Dielectric strength	≥50MV/m
5	Oil resistance, 120™ 2™, transformer oil 2h	No blistering, no shedding
6	Adhesion, finished punching sheet shall be tested by circle drawing method	stair
7	Bending test, the pattern was bent on a “38mm rod.	The paint film does not crack or fall off.
8	Franklin test, 150°C 5°C/3 MPa/0.5V leakage current measurement	Average ≤20mA Maximum < 50mA
9	Franklin burn-out test, measuring leakage current at 150°C 5°C/3 MPa/0.5V.	Maximum ≤100mA
10	Core stacking factor	94.5% ~ 98.5%

3.4 stator bar fixing structure

The combination of the lower wedge corrugated plate and the side semiconductor corrugated plate ensures the in-slot fixation of the stator bars of large generators, which not only can prevent the bars from loosening but also can prevent the occurrence of electrical corrosion phenomenon in the bar slots.

1) Under-wedge corrugated plate increases initial deformation stress and deformation stress requirements after treatment at 120! and 24 h according to GE technology in Westinghouse Electric Corporation and Canada, which is of great

significance for strengthening stator bar slot internal fixation and improving safe operation of motor.

2) The mechanical and electrical properties of the flour semiconductor corrugated plate fully meet the technical requirements of large generators, providing reliable guarantee for stator slot fixation of nuclear power generators.

3) Through the research on NAZ epoxy adhesive and binding rope, it is found that the bending strength of NAZ adhesive at 100! is relatively high, which can greatly improve the overall thermal mechanical performance of stator winding end fixing of generator and meet the binding and fixing requirements of large generator.

3.5 Rotor Insulation Structure

The rotor insulation structure comprises a rotor shaft, an iron core and a touPNngfodlonjledNnggonglU which are assembled on the rotor shaft, and is characterized in that two ends of the iron core are respectively provided with Insulation cover, wherein one Insulation cover outer end is provided with a commutator, the Insulation cover consists of a positioning cylinder assembled with the rotor shaft and a plurality of Protection strip which are arranged at intervals along the circumferential direction to form a cup shape, the Protection strip consists of a radial part extending radially outwards and an axial part extending axially from the radial part outer end, and the two ends of touPNngfodlonjledNnggonglU are positioned in the cup shape structure surrounded by insulating sheets of Insulation cover.

1) Class F turn-to-turn padding strips with the straight part of the rotor being long are used to reduce the overlap between the padding strips and improve the overall electrical and mechanical performance of the turn-to-turn padding strips.

2) spraying a layer of dry lubricant with small friction coefficient on the inner surface of the groove lining and the guard ring insulation, wherein the lubricant is formed by matching polytetrafluoroethylene fine powder with a special adhesive, has good wettability and can form a uniform covering film on the surface of metal and paper, thereby reducing the friction coefficient and improving the surface sliding effect.

CONCLUSION

1) Feasibility.

Through the introduction of technology in digestion, absorption and sub-contract manufacturing, China has quickly mastered the key core technologies for the design and manufacture of large-scale Francis turbine generator units.

2) Material.

With the improvement of the voltage level of a million kilowatt hydropower unit, its electrical properties (electrical aging life, partial discharge, corona onset voltage, Dielectric strength) and thermal mechanical properties, heat conduction, dimensional stability and other design requirements will change. Therefore, technical development and improvement of main insulation materials are required.

A develop and perfect multi-adhesive mica tape with high mica content and high Tg process adaptability to ensure electrical performance and high temperature mechanical performance requirements.

B To carry out research on the manufacturing technology of mica with less glue, starting with raw materials and tooling, adopt dry gluing technology to develop partly cloudy master tapes and high thermal conductivity mica tapes with high mica content, high air permeability and accelerant, so as to improve the domestic manufacturing level of materials.

C to carry out research on styrene-free VPI resin matching with mica tape with less glue, starting with raw materials.

D according to the design requirements, develop the research and improvement of transposition insulation materials, end fixing insulation materials, anti-corona materials and other materials.

3) Process.

It is difficult to determine whether to adopt multi-glue molding or less-glue VPI process, and both processes coexist internationally. From the perspective of mature technology and localization of materials, it is advantageous to adopt multi-adhesive technology of

pressure molding. However, the less glue VPI process is also one of the mainstream technologies in foreign countries and has been successfully applied to a million kilowatt turbine generator set. Although it is seldom applied to large units in China and is also affected by many factors such as tooling, process maturity and materials, necessary research should be carried out.

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