German Tap Changer Manufacturer Extends Product Range to Hollow Core Insulators
Maschinenfabrik Reinhausen (MR), one of the world’s major suppliers of tap changers and monitoring equipment for transformers, has recently entered the fast-growing field of hollow core composite insulators. The move is not the surprise it might appear at first glance since MR has long been a manufacturer of perhaps the most vital component within these insulators - namely the FRP tubes which provide their mechanical strength.

INMR visits the new insulator production facility located outside Regensburg and discusses the factors behind this expansion decision as well as how MR has organized its manufacturing process.
According to Jürgen Hauck, the recent move into the market for hollow core insulators is consistent with the basic corporate strategy to supply all types of items linked to the transformer. Says Hauck, whose background at MR has been on the tap changer side, “we see everything around the transformer as fitting into our sphere of business, except for the transformer itself, which we regard as the business of our customers. Since composite hollow core insulators are a key component for a range of devices such as bushings, this philosophy has made them a logical product addition.”

Having the FRP tube capability in-house is seen as giving MR’s Power Composites business unit a great strategic advantage in the insulator market.

To better promote and develop this product area, MR has chosen to establish a separate Division called the Power Composites Business, of which Hauck is Director and which now groups together items built around FRP tube technology. These include the FRP tubes themselves, the new line of hollow core insulators and specialized wind energy accessories. According to Hauck, this Division has in short time become the fastest growing within the company with double digit increases in sales volume every year since 2005.

Manufacturing of the new line of insulators takes place in a large plant located in Haslbach, about a 10-minute drive from the company’s longtime main facility in the historic town of Regensburg and where all tap changers are still being produced. The Haslbach plant was built in 1993 but, with the rapid expansion in sales, there are now plans to enlarge it significantly.

Hauck explains that tube manufacturing at MR began some 25 years ago at a time when this expertise was hard to find on the market even though it was one of the keys to the tap changer business. Indeed, the FRP tube is still regarded as one of the most vital components of a tap changer (both on-load and off-circuit type), which apart from the motor drive can consist of thousands of separate parts. Having this tube capability in-house is seen as giving MR Power Composites a strategic advantage in the insulator market. Says Hauck, “Most other insulator manufacturers do not produce their own tubes. But we already have this knowledge and, given our familiarity with issues of leakage current as well as attachment of metal fittings, we knew we could do this business ourselves without relying on any outside sources.”

Indeed, Head of Marketing for the composite insulators product line, Jens Frost, explains that MR is among the only insulator manufacturers who can also design, machine and test its own flanges. “This additional capability,” he points out, “is fairly unique in our business area.”

Head of Production, Roland Höfner, whose background is in the insulator industry, agrees. “Generally,” he notes, “while most other insulator manufacturers have to rely on outside support in such areas as mechanical and electric field calculations, we can do both ourselves. We can also take CAD drawings from a customer and use them as the basis for our own finite element analysis calculations.”

Taking INMR on a tour of the new insulator production area, Hauck begins by noting that some Euros 7 million (about US $ 10 million) have been invested here just this year and a similar amount is planned for the coming year as well. Entering the large area where FRP tubes are produced by the filament winding process common to this industry, one of the first things Frost points out is that the Division’s FRP tubes such as these are seen as a strategic component in producing hollow core composite insulators.

Ensuring perfectly smooth inner surfaces in FRP tubes required polished mandrels free of any surface blemishes.
The name of Power Composites was selected because all the tubes produced in this facility are designed to possess an energy withstand capability. This, he says, differs from most other tube suppliers who have to offer two separate production lines for tubes – one for HV electrical applications and the second for unrelated end uses.

Winding of the tubes is done on polished steel mandrels whose chrome surfaces must be completely free of any defects or scratches so as to ensure a perfectly smooth inner surface for the tube. At the moment, the MR facility has two large winding machines, one of which is new while the older model is scheduled for a retrofit to incorporate the latest winding technology. Höfner indicates that additional new winding machines are now on order and to be delivered in the coming months. These, he says, will further improve production by permitting very small winding angles resulting in tubes with even better bending resistance. At the moment, most existing machinery in this industry is limited to a minimum winding angle of about 20°. Höfner also notes that a new milling machine is on order and will be able to accommodate tubes of up to 11 meters.

Production of single tubes of such a length is not practical and, as is commonly done for very long hollow porcelains, whenever tubes of this dimension are required, they are produced by gluing together two separate units. Höfner emphasizes that the strength of the resulting bond is so good that if bending tests are performed to destruction, the break will almost always occur at another point along the tube and not at the glued joint.

Among the keys to a well-produced FRP tube are the rovings as well as the epoxy resin system into which they are dipped for impregnation just before winding onto the mandrel. Sales Manager, Georg Schütz, explains that the basic raw material for a tube is the glass fiber filament that is supplied on spools already wound into larger cross-sections called rovings. Their unit of measurement, based on weight, is referred to as ‘tex’. Typically, smaller rovings are combined and comprise one larger one with different possible tex weights. Says Schütz, “to manufacture a good tube, it’s critical to combine a high glass content with the correct computer-controlled winding program.” This, he adds, is because the final mechanical strength of the tube for any torsional or bending loads is determined entirely by its wall thickness as well as by the angle of winding of the impregnated rovings.

“Being able to offer variable wall thicknesses for most mold diameters,”
he says, “enables us to tailor-make our insulators according to our customers’ precise requirements.”

Höfner says that MR employs two types of electrical grade resin systems for dipping the rovings just before they are wound onto the mandrel: a standard resin with a glass transition temperature (tg) of 128° C, which he claims is very good by most industry standards; and another which retains its mechanical strength up to 156° C. The latter tubes usually find application in tap changers.

Another investment planned for the coming year is an automated system for preparing and delivering this resin, which consists of six components including the epoxy, a hardener and various accelerators. Automation is seen as key to increasing process efficiency and also the consistency of the resin mixture from one batch to the next. Another goal, according to Höfner, is reducing any risk of bubbles from manual mixing.

MR’s manufacturing process sees the tube put through a continuous heating cycle designed to make the curing process more efficient and increase the productivity of each machine. With this system, each machine can apparently produce more than 20 tubes per day.

After curing, each finished tube is removed from the mandrel and proceeds to the next step, which involves cutting the ends and turning. Now, the tube is ready for attachment of the flanges – a highly guarded process that must be done in a room free of any dust or outside contaminants and where a great deal of know-how is apparently involved. Höfner states that attachment of the flange to the tube is based on ultrasonic cleaning of each part followed by a combination of gluing with an epoxy resin glue having a tg similar to the epoxy resin, and shrinking.

Frost points out that the Power Composites plant has been divided into two main areas – one section that processes all the metal parts such as flanges and the other for all kind of insulation material including hollow-insulators. “We never mix metal working and composite manufacture in the same hall,” he emphasizes. “That’s another reason we use only E-glass and none with carbon fibers which would pose a hazard through their conductive dust.” Another of the concerns in this production area is to keep all flying insects out.

Frost goes on to emphasize how important it is that every manufacturer of tubes for insulators should have an in-depth knowledge of their ultimate applications. Otherwise, he states, there may be sources of partial discharge activity and the tubes will not survive under the high electrical stresses encountered during service. In fact, he points out that it is for this reason that every tenth tube manufactured at the facility is tested for puncture in both axial and circumferential directions. Also slab or ring samples taken from tubes are exposed to a minimum of 75 kV for one minute and usually no puncture occurs, even up to 145 kV.

The MR factory is equipped with a special in-process quality control area where, apart from puncture testing, a number of other required tests are performed on sample tubes, including mechanical as well as leakage tests under helium. Every tube is then assigned a unique bar code, which identifies all its relevant production.
parameters and which stays with the tube all the way through the remaining production steps. Höfner says that such a tracing system allows each tube to have its complete production history available at a glance.

After attachment of the flanges and completion of all required tests, the final major step in the production process involves casting a silicone shed onto the tube. Before entering the molding machine, however, the tube is sprayed with a thin layer of chemical primer intended to ensure a perfect bond between the silicone rubber and the FRP tube.

Molding equipment can be quite costly and for this reason typically represents the bottleneck for any factory manufacturing insulators or similar components such as arresters. It is for this reason that every supplier tries to optimize the molding cycle with the goal to shorten it as much as possible. Frost sees the fact that MR is a recent entrant into this business as a major advantage. “Since we started only recently,” he explains, “we built into the design of our machinery and process the latest knowledge and industry experience.” Among the customized machine features he refers to are high-speed filling and reduced vulcanization time for the rubber.

The silicone material itself is a standard, low viscosity LSR formulation produced by one of the large chemical companies in Germany. It is delivered as a two-component system pumped into a static mixer and from there dosed directly into the mold cavities. Höfner points out that MR has developed its own molding tool, flexible enough to accommodate alternating sheds and different insulator lengths without having to alter the profile. He also points out that tooling technology is much more complex than might appear at first glance since it also includes specialized surface treatments designed to reduce both the molding cycle and the pressure needed to remove the insulator from the mold after vulcanization.

The shed design selected is not a horizontal angle profile but rather tilted on its lower side, as is often seen with
porcelain. This, claims Höfner, yields larger shed diameters and allows the spacing between sheds to be wider for the same creepage so as to minimize risk of ice bridging or flashover. “Our special profile design,” adds Frost, “gives better protection for the lower portion of the shed during rain, even when it does not fall vertically.”

After removal from the mold, the finished insulator is placed into a nearby heating chamber for an additional curing cycle of up to four hours – a step not usually seen in this industry. Höfner recognizes this but insists that this additional curing ensures that the silicone material will then offer its maximum resistance to deformation under any loads. After this final curing, the insulator undergoes a brief treatment to remove any evidence of the mold line and afterwards is ready for final packaging. But first each unit enters a final quality control station that assembles all the production data for every single piece produced. A special code is engraved on the flange providing both the product serial number and the customer part number for easy identification.

An additional quality control facility nearby performs regular testing on each batch of silicone that arrives at the plant in order to allow adjusting the molding cycle requirements to any slight change from one batch to the next. A special testing device is also available to check the bonding of the silicone to the FRP tube material and examine the interface between epoxy and silicone. This is being done for each batch of every type of insulator produced.

Hauck and Frost are optimistic about the future of MR’s new insulator business and claim that there is now clear evidence of a growing level of substitution for porcelain, meaning that this segment will grow rapidly. In fact, even though the first insulators equipped with silicone sheds were not produced at the facility until early 2007, MR already has nearly two-dozen customers from all over the world. Nor is being located in a country with comparatively high labor costs seen as posing any competitive disadvantage in the increasingly global insulator industry. Says Sales Manager Schütz, “for these types of products, from 60 to 80 percent of the final cost of the insulator is material driven and the bigger the insulator, the greater the cost component contributed by materials. Therefore, what differentiates the competition is not so much price but quality, lead time and reliability of delivery. This is what the customer is focused on.”

In regard to delivery, Hauck sees this as one of the keys to future market success. Recognizing that the relatively long production lead time of porcelain is one of its strategic weaknesses, he says that MR can typically supply a finished insulator to its customers in less than a month and, in special cases, sometimes even less – a lead time that he claims can rarely be matched by porcelain or other competitors. “We have new tubes coming through the factory every three days based on incoming orders,” he says, “and this means that, unlike other insulator suppliers, we can move very quickly to the next stages of production.”

Adds Schütz, “the key to success in our business is having a very high vertical integration, meaning the capability to produce both tubes and flanges. In our case, having both in-house means that we can take full control over the entire manufacturing process while competitors must rely on outside suppliers to ensure good delivery times.”
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