OPPORTUNITIES AND CHALLENGES OF EMPLOYING COMPOSITE MATERIALS IN SWITCHGEAR INDUSTRY

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ABSTRACT

Composite materials have emerged as a necessity rather than compulsion in the present era of industrial applications. This scenario has caused the industry to look for better alternate materials which come at affordable prices to maintain the requisite price margin, besides considering the depleting natural resources of conventional materials. However apart from offering better advantages in terms of lightweight, resistance, ease of maintenance and better environmental protections to name a few it also poses few disadvantages in terms of processing cost and the choice of material. Composite materials provide the opportunity to tailor make product that is specifically adapted to the required performance, and thereby optimizing the price-performance ratio. This paradigm shift can translate only after extensive evaluation of available materials at the design stage aided with required experimental tests. Experimental procedures needs to be extensive as the material properties could be unpredictable in some circumstances.

This paper discusses the opportunities available to discover areas of avenues in switchgear industry in particular with panel builders to replace the primitive metallic components with Polymer composite materials. As an instance of a practical application of polymer matrix composite a case study is presented at the end of this paper to demonstrate how polymer composites could be integrated in LV panels innovatively.

INTRODUCTION

The extravagant achievements of basic science, thus far unheard-of integration of science and technology have become the catalysts of the changes occurring in our life, and this applies largely to structural and functional materials which also make up the material world surrounding us. This paper discusses about the opportunities and challenges faced in replacing conventional materials by composite materials. This introduction of an alternative to conventional metal materials thus needs to be “environment friendly”.

A study was taken up at Schneider electric with an intention to replace certain materials within their products, with polymer composite materials or metal composite materials which could be functionally advantageous. Metals pose an economic threat to their future prosperity, due to their ever-increasing consumption which would result in depletion of natural resources. Accepting the challenges posed by this is necessary in order to achieve any degree of success.

Present context

This section discusses the growth of the worldwide steel industry over a period of years. There has been a decided amount of growth in the amount of steel produced by developing countries. This growth contrasts with somewhat declining output in the industrialized countries [1]. However, the share of the Western countries in the world consumption of steel decreased to an even larger extent than production, in the last couple of decades.

It is believed that the developed industrial countries prefer to import steel, transferring the ecologically deleterious metallurgical production to developing countries. It is believed that steel structure has considerable impact on the resource depletion, compared to polymer composites. Therefore it is important to study the impacts on natural resource depletion as well as other factors like Global Warming and Acidification.

The High commission of the European community in Brussels is attempting to reduce the raw – steel capacity in the EC by some 30 million tones. It is expected that each of the major countries will make a contribution to this reduction. [2].

Trends in the development of composite materials

In the early 1900’s, scientists increased their experimentation and development of innovative new materials. Invented originally by accident by Owens-Corning (“Fiberglass”), FRP research was then encouraged heavily by the defence industry during World War II. There is also a cultural change going on in the electrical switchgear market. The market is expressing new expectations which, is beyond price, and, involve a requirement for performance levels with due emphasis on the environment and sustainable development.
Over the last 15 years the utilization of Polymer composites has superseded that of Aluminium or steel. Figure 1 shows the growth in world consumption (base 100 for 1985) of polymer composites in comparison with conventional materials like Aluminium and steel. [3] Suggestive that the annual growth rate of polymer composites being at forefront thus offering many more creative design options calling for innovation. Though Composite manufacturing costs are higher than costs of standard materials such as steel or aluminum. Actually, the composite solution is always a technological leap for designers. However, the benefit of composite materials over alternative solutions has to be evaluated at the time of design along with the required testing. Unlike composites, standard materials (steel or aluminum) seem to be reassuring solution because their technical performances are known and on file, and their wear performance is predictable. Also, these standard materials are regularly being improved (lightweight, special metal processing).

**Material selection**

A simplified flow diagram (Figure 2) illustrates the various tasks performed in trying to choose a successful material. It is not proposed to discuss the costs here but obviously they do have a bearing on the final selected candidate.

**COMPOSITES IN ELECTRICAL APPLICATION**

Composite materials are traditionally designed for use as structural materials. With the rapid growth of the electrical industry, Composite materials are finding more and more Electrical applications. Owing to the vast difference in property requirements between structural composites and electronic composites. The design criteria for these two groups of composites are different. While structural composites emphasize high strength and high modulus, electronic composites emphasize high thermal conductivity, low thermal expansion. Figure 3 Below shows a study conducted by Nodal consultants which estimated the percentage usage of composite materials in various industries in Europe. Only about 10% of electricity / electronics industries apply these materials. Which makes it evident that still there is still a lot of scope to utilize and reap the benefits of composite materials.

Switchgear insulation materials range from glass polyester phase barriers to flame retardant polypropylene (as RF shields & low voltage phase barriers). A few other examples are Polycarbonate Thermoplastic for Sight windows & phase barriers. Silicone Bonded Mica Laminate for high temperature arch chutes.

Controlled – order thermo sets are attractive for their thermal stability and dielectric properties. Thermosets offer comparative tracking index values in excess of 600 volts and dielectric strength of over 15 kilovolts per millimetre for dielectric applications. For heat sinks and enclosures, conducting fibers are used, since the conducting fibers enhance thermal conductivity and the ability to shield electromagnetic interference (EMI). EMI shielding is particularly important for enclosures to protect sensitive electronics against the effects of electromagnetic interference [4].

In the electrical industry, (sheet molding compound) & BMC (Bulk molding compound) are used to make parts with track resistance greater than 600 minutes and arc resistance greater than 180 seconds. SMC & BMC are much less expensive than traditional enclosure materials, such as...
stainless steel, making them an ideal replacement for metal. Furthermore, thermo set components are up to 35% lighter than steel parts of equal strength, helping to reduce costs associated with transportation.

**OPPORTUNITIES**

Composites are a solution to the designer’s main problems. Polymer composite offers the following opportunities for a designer viz.

I. Design requirements
   i) design freedom: realization of all shape and size parts feasible with metals
   ii) integration of several functionalities by using the property versatility such as structural and other additional properties: damping, shock and noise absorption, heat insulation, electrical insulation, & electromagnetic neutrality
   iii) the possibility of selective reinforcement in the direction of the stresses by selecting particular composites or by part drawing.

II. Technical requirements
   i) Solidity, reliability and permanence of the parts in the face of increasingly harsher environments and higher temperatures
   ii) Durability, the absence of rust and corrosion
   iii) Ease and reduction of maintenance
   iv) Slow damage propagation

III. Environmental requirements
   i) Weight reduction thanks to good mechanical properties combined with low density.
   ii) The reduction of suppression of periodic painting of metals contributes to a reduction in pollution.

There were several prospects for application in switchgear industry, to list some examples:

- Improvements of insulators (rising of electrical insulation, mechanical stability, thermal load behavior, chemical resistance)
- Miniaturizing of design, reduction of used material, higher reliability
- Improvement of electromagnetic compatibility (EMC)
- Long-term improvement of efficiency and elongation of life time period

All of these ideas can not be put into reality within days or months; it will take a middle-term to long-term period from the idea to research work, over first prototypes and to industrial production and the application by the consumers.

**CHALLENGES**

Evaluating composite performance, engineering the equipment and procedures for product characterization, and validating the recycling technologies for composite materials are the three major challenges for research & development in the composite materials sector. Recycling is one of the key issues of the composite industry. A major challenge that faces the FRP industry over the coming years is how to deal with production and end-of-life waste. In case of MV switchgear enclosures the most severe design constraints pertain to internal arc withstand force and gas pressures evolved henceforth. Also the panels need to withstand high mechanical strength predominantly in joints and clamping locations.

Creating partnerships is a way for companies in this industry to meet these challenges. New research is being done on introducing more organic polyester. Studies undertaken to use polymeric materials from recycling have brought a paradigm shift in the effort to find alternates for metal.

**CASE STUDY**

A study has been taken up at Schneider Electric to identify potential alternates for metal components (electrical insulation barrier, exterior panels to name a few) under its LV equipments product range made out of conventional steel, with a drive for INNOVATION. Figure 4. gives an overview of an overall composition of different materials under its Prisma plus (3200 A ranges) metal enclosed switchgear product, which shows that about 70.7% of the components make use of sheet metal CRCA material out of the analysed 180 kg of the enclosure. It was found that about 23% of the steel components consisting of form partitions and exterior panels could be replaced with relative ease.

To demonstrate this accomplishment a case study of how a conventional sheet metal component could be replaced by an alternate polymer composite sandwich material is described below.

![Figure 4. Distribution of materials in mass weight of analyzed Prisma Plus electrical switchboard: 180 kg.](image-url)
The study of replacing steel components by alternate polymer composite material is best illustrated by the replacement of an existing gland plate, used in LV distribution of Prisma Plus product range.

The gland plate’s function is to fulfill two purposes:

- To prevent any kind of foreign elements (like dust or rodents) from entering inside the switchboard.
- Taking the load of incomers or outgoing cables and supporting the force exerted by the cable due to bending.

Unlike the existing solutions which are offered in this range, gland plates are made of sheet metal with rubber grommet or foam packing. Study has been done to replace this gland plate with a flexible membrane sandwiched with GFRP which is an innovative solution developed (pending patent grant). The composition of this flexible membrane is made up with one or more flexible foam materials which are RoHS compliant and consists of fire retardant fillers as the core material which is then sandwiched with Glass fiber reinforced thermoplastic laminates which are cut to a specific profile to support cable insertions. This sandwich structure is then held in the switchboard with help of a metallic supports. Figure 5. below shows the application of an innovative solution of flexible cable gland sandwiched with thermoplastic GFRP laminate.

![Figure 5. Flexible cable gland sandwiched with thermoplastic GFRP laminate](image)

A considerable weight savings of about 42.5% was achieved with the composite sandwich gland plate (~2 kg) compared to that of Metal Gland plate (~3.5 kg). Thus Usage of GFRP-sandwich structure helps in significant weight reduction with increased structural capability.

**CONCLUSION**

The opportunities available to discover areas to replace the primitive metallic components with Polymer composite materials of avenues in switchgear industry in particular with LV / MV metal enclosed switchgear, is thus envisaged. With the present scenario calling for enormous amount of metal consumption in various industrial applications, this gradual trend is driving the natural resources to deplete. With an ambition to improve the environmental profile of switchgear industry polymeric composite materials have been looked into as an alternate.

Our ability to solve the engineering challenges of today and tomorrow is still being driven by the cost and availability. One needs to overcome this challenge to achieve the required degrees of success. Our understanding of how materials interact, how they can be reliably integrated with combinations in functional requirements have to be explored. The challenges, as well as the opportunities, will be in the areas of materials development, synthesis, fabrication, integration, characterisation and validating the recycling technologies, which of course aids caputulate lot of potential in Innovating new ideas. Thus the electrical industry has to be more proactive in implementing environmental progress plans which will reduce the depletion of non renewable resources like steel.

**REFERENCES**


