The production of composite materials is booming in France as it is in the rest of the world, i.e., the output is increasing at a rate of +6% per year. Composite materials usually combine plastics and fibre reinforcements in glass or carbon. Although the cost of composite materials is higher than standard materials, this is offset by the substantial advantages their properties afford users such as light weight and resistance. These serviceable properties have allowed composite materials to break into major markets in automotive construction, aeronautics, and the building trade. The composite material industry built on small enterprising companies adapts through innovation and partnerships. The control of the product life cycle from design to recycling, and the improved characterisation of the products and their performance are the requisites for considering the sustainable development programs.

The output of the composite material industry was at 300,000 tons in France for 2000, making it a small industry compared to the 18 million-ton output of wrought metal every year. The industry belongs to the larger plastics industry; however, booming composite material industry has not yet been clearly indexed in statistical nomenclatures. Accordingly, the DiGITIP assigned Nodal Consultants1 to conduct a study so that the Directorate could gain a clearer grasp of the industry.

The first composite materials were developed during the Second World War. The heterogeneous materials are made of an organic (polymer) plastic matrix combined with fibrous reinforcements, usually glass or carbon, (see box 1). The history of the thermoset or thermoplastic materials dates back to fifty years or barely ten, as the case may be. However, more than a dozen processing procedures have already been developed (see box 2), i.e., more than the major metal processing technologies over the last two hundred years.

1 This four-page newsletter is the summary of a study conducted for the DiGITIP Service of Manufacturing Industries. The study is entitled L’industrie française des matériaux composites: des enjeux prioritaires pour un développement durable, étude Digitip 2001 (the French industry of composite materials: priority challenges for sustainable development, DiGITIP Study, 2001).
A Recent, Fast-Growing Market

The world market for composites has been growing in volume by 5.7% per year since 1994. In 2000, output was at 7 million tons, including more than 95% for the mass market (see box 1). The output of composite materials might reach 10 million tons in 2006.

Thermoplastic composites are enjoying a higher growth rate than thermoset composites, at 9% and 3% per year, respectively. Thermoset composites were first developed in the early eighties. These more recent products are also more promising. However, thermoset composites still account for more than two-thirds of the market.

The North American market, by far the biggest, accounts for 47% of composite processing (3.4 million tons) worldwide. Then comes the European market (28%, i.e., 2 million tons) followed by the Asian market (23%, i.e., 1.6 million tons). Market growth rate is higher in Asia and Europe than in the US (7% and 4.5% per year, respectively). The thriving, albeit small (2% of world consumption) South American market boasts a yearly increase of more than 8%.

The French composites output accounts for 15% of European production, (third rank behind Germany (28%) and Italy (18%). However, the value of the French market is at over €2 billion, i.e., 18% of European production. Actually, France produces more high performance composites than its European partners do. These composites cost more than mass market materials, ranging from €9 to €38 per kilo, whereas mass market composites cost from 3 to 6 euros per kilo.

Two Major Assets - Lightweight and Resistance

Composite materials have advantages over competitive products. Composite materials offer many functional conveniences: lightweight, mechanical and chemical resistance, low maintenance, and easy design. Their mechanical properties (rigidity and fatigue strength) as well as their chemical properties (corrosion resistance) help prolong the life cycle of some equipment. They also bolster safety thanks to greater shock- and fire resistance. Composite materials provide improved heat or sound insulation and some have good electric insulation. They afford many more creative design options because structures in composite materials are lighter and because complex, multipurpose shapes can be fashioned.

Composite manufacturing costs are higher than costs of standard materials such as steel, wood or aluminium (prices range from $3 to $38 per kilogram for composite materials depending on the required performance, and from $1.5 to $5 per kilo for standard materials). However, composite materials provide added value in terms of usage because they require fewer attachment parts and machined parts, they slash maintenance costs, increase life cycle, and provide greater safety.

Actually, the ‘composite solution’ is always a ‘technological leap’ for designers. Composites afford the opportunity of making a product that is specially adapted to the required performance, and of optimising price-performance ratio. 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 (wood, steel, and aluminium) seem to be a 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).

Actually, if composite materials are to be chosen over standard solutions, they absolutely have to make a difference in...
terms of their positive benefits relative to at least five basic criteria (see box 1).

Mass market Composites in the Automotive, Electrical and Electronic Engineering Industries

The automotive and industrial vehicle industry consumes more than one-third of France’s volume production of composite materials and one-fourth of the world’s output. Because automakers have major cost constraints, they widely use mass-market composites made of polyester resin reinforced with glass fibres. These materials are less expensive than high performance composites, and are used for the reinforcements of covering panels, spoilers, body parts, bumper beams, and tailgates. Designers have enormous leeway with easy maintenance composites. These much lighter materials mean that automakers can afford an additional cost of € 3 for each kilo saved. The overall lighter weight of a vehicle means a fuel saving of roughly 1.5 per 100 kilometres.

The electrical and electronic engineering industry accounts for 15% of the value of the world composite application market. The industry also uses large amounts of mass-market composites that meet safety needs: electrical insulation and electromagnetic wave transparency. The composites are used to build longer-lasting, reliable equipment, such as electrical equipment boxes, circuit breakers, electric meter boxes, power transmission poles, and satellite dishes.

High Performance Materials for Aeronautics, Sports & Recreation

High performance composites are mostly used in Aeronautics and aerospace used. Costs are high, reaching up to € 38 per kilo when large amounts of carbon fibre reinforcements are used. The aeronautics industry accounts for a large share of the composite market in value (22%), and for a much smaller share of the market in volume (roughly 4%).

Because of the performance, lightweight and flexible shapes of composites, they have become requisites for the manufacture of framework parts in aeronautics, as for instance the central aircraft fuselage, the belly girders stiffening the fuselage of the A340/600, and the outer wing on the ATR 72. The overall weight cut of 450 kilos on an Airbus means the aircraft can accommodate six extra passengers. The loss of 100 kilos on the structure of a rocket extends its trajectory by 100 kilometres. Composite materials also boast very high corrosion resistance, hence lowering maintenance costs proportionately. For instance, composite helicopter blades are replaced after several months of use whereas metal blades have to be replaced every fifty hours.

The sports & recreation industry accounts for 11% of the composite market in value (and 8% of the market in volume). For instance, composites can offer a customised increase of ski and racket performance and reliability.

A Range of Composite Materials for the Building Trade, Industrial Equipment, and Pleasure-Craft Building

In the building trade, composite materials face tough competition from standard materials, everything ranging from concrete, metal to ceramic joists, whose performance levels customers know well. Composites are used much less in France’s industry than in the building trade elsewhere. The building trade only accounts for 21% of the French market in volume compared to 35% in Japan, 32% in Brazil, and a world average of 30%. However, flexible shapes, weather resistance, heat and sound insulation, and fire resistance are appreciable advantages. Composite materials can be used for a range of purposes: decorative panels, the rehabilitation of buildings and works of art, large complex forms (monobloc bathrooms), girders and framework parts, and roof components. Also, the vibration resistance of carbon fibre composites and their high energy-absorbing power warrants their use in earthquake zones.

In France, industrial engineering and equipment account for a mere 8% of the composite market in volume. Their cost is high for applications that usually must comply with ordinary safety standards. Composite materials can increase the reliability and extend the life cycle of equipment because of their resistance and heat insulation properties: chemical product tanks, pipelines, and pressurised machines. Composite materials also show high resistance to earthquake tremors and could be used for the piping systems at nuclear power stations.

In the pleasure-craft building industry, composites are irreplaceable for boats under 40 metres long. Composites combine lighter structure with the possibility of designing complex shapes (hulls, bridges, and tanks). Their high corrosion resistance means that carening is required less often and the life cycle of a boat is longer. This industry mainly uses low-cost composites made of polyester resin reinforced with glass fibre and only accounts for 4% of the market (volume and value).

The Path to Sustainable Development

Composite development should soar in the upcoming years: + 50% in five years, i.e., twice as fast as the GDP. However, the composite material industry will have to integrate the constraints of durable development if it is to reach this figure.

Starting in 2004, 85% of unserviceable vehicles will have to be recycled. Currently there is no fully operational, economically viable solution
for recycling the composites used in the automotive industry. Most of the composites are thermostet. If the composite industry is to meet this major challenge, the prime movers in the field and their research & development efforts will have to pull together. Several industrial efforts are being rolled out in Europe, specifically Mecelec Composites et Recyclage in France, the operator of the only composite recycling plant, and Ercom in Germany.

Crushing is a technically viable solution for the reclamation of thermostet materials; the resulting pellets can be used as low added value fillers for resins, asphalt and cement. Incineration in cement plants is another option. However, recycling requisites should promote the use of thermoplastic composites that are reprocessed more easily.

In the shipbuilding industry, the personnel is subjected to emanations from organic volatile compounds (VOC, especially styrene). In Europe, the Scandinavian and German industries enforce stricter standards than in France, and are campaigning for the harmonisation of national regulations. The reinforcement of the standards currently in effect in France would entail an additional constraint for dip-mould processors, and affect their costs.

Composite materials will need improved characterisation in the future to prompt design and engineering offices to use composite materials more extensively. This will enable design engineers to develop a functional analysis integrating all their features and properties. Actually, composite materials suffer from a lack of modelling and standardisation compared to standard materials such as steel, regulated by national or European standards. Design and modelling software will have to be more broadly developed to characterise composite materials more efficiently.

Small Entrepreneurs with Drive

In France, the business of the 400 to 450 companies in the field is dedicated mainly to composite material processing. The companies have roughly 20,000 employees.

SMEs make up most of the industrial fabric. These small scattered companies labour under major price pressure, caught as they are between the big raw material suppliers claiming high prices due to small purchases, and major customers who can dictate their terms.

The small companies have rolled out reclamation, innovation and industrial partnership strategies to tackle this situation and break into European markets. For instance in the railways, the GHFF is a special purpose economic pool bringing together six equipment suppliers, handling everything from design to manufacture.

In France, the upstream industry manufactures sufficient amounts of glass fibres (Saint-Gobain Vetrotex), basic resins, polyesters and polypropylene (Elfatofina) that are built into current mass-market composites. However, the offering of raw materials is insufficient for high performance composites or future mass-market composites. Indeed, the production of carbon fibres is primarily Japanese (Toray, Sumitomo) while international chemical groups (Dupont, Ems, Bakelite AG) handle the production of innovative resins. The deficiency of the French output of top-of-the-line or innovative materials may eventually imperil the balanced growth of the industry.

The national industry of composite processing has kept a technological edge over other European or international countries. However, the weak development of the pultrusion process in France is a distinct handicap, especially for the building market.

Innovation

Innovation is the best way for companies in the field to meet the double constraints of suppliers and customers. Some companies are innovating by marketing new products: resins and new, safer and faster semi-products. Others are engineering new processes by developing faster and more efficient methods or tools.

Companies will have to innovate by developing efficiently designed tools.

France has research & development centres (Ecole des Mines de Paris, Ecole des Mines de Douai, Ensams, Insa Lyon, Ecoles Normales Superieures', ONERA'). It also has many regional resource centres assisting industrialists in their innovation policies: Pôle de Plasturgie de l’Est, and Compositec. France is involved in far-reaching European projects (Brite Euram, Eurêka) through consortiums at a par with the United Kingdom and Germany. However, European competition is tough, especially with Germany (IVV Kaiserslautern, IKV Aix la Chapelle).

The materialisation of the innovative policy through patent applications is not as high as in other countries. In 2000, some one hundred patents for composites were filed by French public or private laboratories compared to 800 in the United States, 200 in Germany, and 200 in Japan.

Evaluating composite performance, engineering the equipment and procedures for product characterisation, and validating the recycling technologies for composite materials are the three major challenges for research & development in the composite materials sector. Creating partnerships is a way for companies in this industry to meet to these challenges.

Hervé CHALAYE (SIM)

Suggested reading

- Technologie des composites, Maurice Reyne, Hermès ed., 1995
- Pratique des Plastiques et Composites, coll. authors, référentiel DUNOD, 1999 et al.
- L’industrie française des matériaux composites : des enjeux prioritaires pour un développement durable, Digitip study, 2001

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