EXCELLENCIA
INTERNATIONAL MULTI-DISCIPLINARY JOURNAL OF EDUCATION
Volume 02, Issue 09, 2024 ISSN (E): 2994-9521

Composite Materials History

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Abstract:

The content of this article deals with the history of composite materials, their origin and areas of practical application. Also, introducing the advantages of the production of composite materials that meet the requirements of the new era. Due to their role in the industry, durability and various properties. scientific proposal and practical recommendations are embodied.

Keywords: Composite, ceramic, reinforced concrete, pykerite, plastic, carbon, aluminum, thermal, space and aviation, carbon, aramid fabric, hybrid fabric, fiberglass, multiaxial fabric, prepreg.

Composites appeared several thousand years ago [1,3]. The burial masks of the ancient Egyptian pharaohs were made of composite materials - they were made of papyrus impregnated with tree resin. Bricks made of clay and straw, and bricks are also considered composite. Brick houses were built in the 9th millennium BC. Of course, there was no question of any science - the masters of that time did not even think of combining different materials and creating a composition. They just shuffled around and chose the combination that worked for them. ***So, let's talk about the compositions.***

Reinforced concrete is the first "meaningful" composite material [2,3]. It was invented at the end of the XIX century. We can say that composite technologies appeared at that time. A composite consists of several materials and the most important thing is a clear macro boundary between them. Thus, the above-mentioned reinforced concrete consists of two components: a metal mesh and concrete with a clearly visible boundary. Another multi-component material, steel is not a composite. In it, carbon is inserted into the iron crystal lattice and the boundary is indistinguishable.

A lot of interesting materials appeared thanks to military productions. During World War II, the All-Union Aviation Materials Institute developed a light and durable delta-wood material made of wood veneer impregnated with phenolic-cresol formaldehyde resin. Due to the acute shortage of

Delta - wood metal, only the power structures, fuselage parts and wings of the aircraft were produced. Wooden planes performed well in combat. Another unusual material - paykerit - is also a service of the military [1].

The British have created a flexible and durable composite of cellulose and ice. The material has the same blast resistance as concrete, but melts much more slowly than ordinary ice. In the 1940s, **Pykerit** was planned to be used in the Habbakuk project, the British composite aircraft carrier program. The military wanted to build a flight deck on the surface of an artificial iceberg - an aircraft carrier made of pykerite, and inside its hangars for aircraft. But the project was closed due to technical problems. It took three hot summers to completely melt the prototype ice ship built in Canada [2].

The XX century is considered the plastic century. It seems that everything in the world is made of this light and flexible material. But plastic has its disadvantages - brittleness. In order to make it stronger and more durable, technologists decided to reinforce the plastic in a way similar to reinforced concrete. This is how carbon and fiberglass plastics, which are increasingly used in industry - for example, in the automotive industry - appeared. The first mass-produced composite German car was the Trabant. The external elements of the machine are made of droplets made from cotton waste mixed with phenol-formaldehyde resin [1].

An important advantage of the composites is the unlimited size of the product. The largest fiberglass ship is the Russian minesweeper "Alexander Obukhov". The 62 m long hull is made of monolithic fiberglass without seams and rivets. This construction is reliable and airtight. Today's technologies do not allow creating monolithic ships from metal, but from composite materials - no problem. According to experts, composites open up new opportunities [2].

In 1889, in London, Mendeleev was presented with a scale, one circuit of which was made of gold, the other of aluminum. In the 19th century, aluminum was considered a very expensive material: it sold for $34 an ounce, compared to $19 for gold.

Composites go about the same way. These are still expensive materials for mass use, but technology is advancing and composite materials are becoming cheaper. In the space industry, composites are used not only for the construction of ships. They are used, for example, to manufacture space antennas in geostationary orbit. These antennas, located at an altitude of 25 thousand km, can withstand a temperature difference of 150-170 °C when they leave the shadow of the Earth. To prevent this difference from affecting the construction of the antenna, it is made of carbon fiber, which does not expand when heated.

The development of the composite industry made it possible to take another step forward in the field of astronautics. For the Buran, it was necessary to develop new carbon-carbon materials for the most heat-stressed parts - the nose fairing and the leading edges of the wing. Special "Gravimol" carbon material was created for Buran.

On November 15, 1988, the former Soviet Union made the first and only flight of the reusable Buran space shuttle. He developed carbon-carbon materials and anti-oxidation coatings for the nose fairing and wing leading edge that can withstand temperatures up to 1600°C. In addition, different versions of the composite material, differing in the type of carbon fiber, were used for these elements. The production technology was multi-stage: molding, impregnation with carbon and silicon at high temperature (up to 3000°C), then precise machining [3].

The thickness of each element is 5-7 mm. Carbon-carbon materials for "Buran" were given the brands "Gravimol" and "Gravimol-V" (from the names of the main enterprises involved in their creation - "NIIgrafit", VIAM, "Molniya", VNIIVProekt). The friction disks of the brakes of the "Buran" spacecraft, as well as the An-124, Tu-160, Tu-204, Tu-214 aircraft are made of the "Termar" composite material developed at "NIIgrafit". [3].

Composite material - it is any type of integrated material consisting of two or more components with a clear difference between them. The most simple example is a simple glued plywood. But there are even more interesting technologies and materials used in aircraft manufacturing, automotive engineering, and other industries.

Materials consisting of two or more components are used together to create a new unique material or to improve the characteristics of one of them. The first use of this method dates back to 1500 BC, when mud and straw were used to build buildings in Egypt and Mesopotamia. Straw was also added to the composition to strengthen ceramic pots and boats.

The next century is the year 1200 AD. The Mongols tried their best: they created the first composite bow out of materials such as wood, bone, and animal glue. Mongolian bows are usually made of several layers of wood (mainly birch) glued together using animal glue[2].

The age of plastics

Modern composites would not exist if scientists had not invented plastic. In the past, the only source of glues and binders were natural resins (tars) obtained from animals or plants. At the beginning of the XX century, vinyl, polystyrene, phenol and polyester were developed. These materials were significantly superior to those previously used.

But the plastics did not provide sufficient strength. Better reinforcement was needed, and in 1935 Owens-Corning developed fiberglass. In combination with plastic polymers, it creates a very strong, but very light structure. This was the beginning of the reinforced polymer industry [1,3].

The first advertisement for Owens-Corning's fiberglass product dates back to 1939. This was the air filter. In 1957, the company advertised fiberglass blinds printed on a printer. In 1970, another thing - fiberglass panels for thermal insulation in construction began to be produced.

Early Innovations in Composite Materials: World War II

Many inventions in this field were invented during the wars. Just as the Mongols created their composite bow, World War II allowed reinforced polymers to move out of the lab and into the real world.

In the construction of military aircraft, alternative materials were needed to reduce the weight of the final product. Engineers quickly realized the advantages of composites in terms of weight and stiffness.

Engineers also learned about advantages of fiberglass composites, such as radio conductivity. And they began to use "obtekatels", which protect the radio modules from external factors, including wind.

During the war, Germany also tried to develop a stealth aircraft long before the US Stealth. At that time, the glider body of the aircraft had to be made of composite material, where between layers of plywood, a filler made of light balsa - a tree that grows in South America - was used. But in 1944, this material was impossible for the Germans, so they had to use an ersatz "Formholz" composite: between layers of 1.5 mm plywood, there was a mixture of sawdust and porous coal impregnated with resin [2,4].

Adaptation of composites

In general, by the end of the war, the small niche of the composites industry was filled. And now there was a difficult task: how to transition from military orders to products for peaceful purposes.

Boats were among the obvious options. The first boat with a composite hull was introduced in 1946. At about the same time, they made fiberglass surfboards.

Space and aviation

In the production of aircraft parts, aluminum and other metals are being replaced by low-density composites, which makes it possible to reduce the weight of aircraft. This, in turn, allows you to save fuel. Thus, composites are currently widely used in civil aviation.

In the Boeing 787 DreamLiner aircraft, 50% of the fuselage elements are made of carbon-based composite materials. Thus, this aircraft is lighter and stronger than a regular airliner with an aluminum fuselage.

Composite materials were also used in the Genx horse General Electric engine: the body, the blades of the turbine, the nozzles that spray fuel into the combustion chamber.

The H-215 helicopter and many parts of the C-295 aircraft are also designed from composite material [2,4].

Weapon

Of course, composite materials are currently being used to create weapons. For example, the Topol-M intercontinental ballistic missile is one of them. It consists of 90% composites, including the engine structures and the warhead. [3].

The exchangeable barrel of the Christensen Arms rifle is also made of carbon fiber. The rifle is made on the basis of the shutter group of the Remington-700 base.

Sleeves for screws made of composite materials. Presented by the Russian manufacturer HC "Composite" at the "Open Innovations" exhibition in 2020 [4].

Modern polymer composite materials

Polymers are the most interesting group of composites. It is not straw or plywood in brick, but a material that is difficult to manufacture, sometimes even requiring work at the nanoscale (10 to 9 degrees).

Carbon cloth is used for strengthening.

Carbon (carbon fabric) is a material created from carbon fiber and used as a reinforcing filler for the production of composite materials. Carbon fabrics are characterized by high heat resistance and belong to the group of difficult combustible materials.

Aramid fabrics (Kevlar)

Kevlar is a trademark of para-aramid (polyparaphenylene-terephthalamide) fiber produced by DuPont. Kevlar has high strength (five times stronger than steel, strength limit 3620 MPa) [2,3].

Hybrid Fabrics (Carbon + Kevlar)

A hybrid fabric is a combined material that includes several types of fabric. For its production, the main amount of carbon fibers, as well as aramid or glass fibers are added. The combination of several materials with different properties allows to summarize their positive technical characteristics and compensate for the shortcomings of each of them.

Unidirectional Hybrid Fabrics. A unidirectional (UD = **unidirectional**) fabric is one in which the main strong yarns lie on the base, while the fine yarn is used only to hold the base. Such fabrics do not have "transverse" strength, all their constructive properties are "longitudinal" [2].

Fiberglass

Fiberglass cloth - is a technical material obtained from the processing of glass fiber threads. Lubrication is a special emulsion composition containing paraffin. The raw material used is aluminum and boron-containing silicate glass. The production process is carried out by melting the

glass and pressing the resulting mass through the holes of a thin mold. As a result, the thinnest fibers (3-100 microns) are obtained and the length is up to 20 km.

Multiaxial fabrics

Multiaxial fabrics are special glass fabrics consisting of several layers of threads oriented in different directions according to the given reinforcement pattern, calculated based on the load on the material [3,4].

Carbon tapes

Carbon tapes are unidirectional carbon fiber fabrics used as reinforcement. The specific stiffness of carbon fiber is 8-17 times higher, and the elastic modulus is 5-13 times higher than that of steel, aluminum and titanium [3].

Prepreg

Prepreg - is considered a semi-finished composite material, consisting of reinforcing filler and binder with serto fiber binding on both sides. First of all, a reinforcing filler made of glass and carbon fiber is used. The binder can be epoxy based (or another thermoset, such as a phenolic binder) and can be made from thermoplastics - polyethylene or PETF. Depending on the binder, the prepreg can be soft and sticky (epoxy base) or hard and smooth (PETF) [3].

Conclusion

In conclusion, I would like to point out that in the process of studying the history of composite materials, I have become convinced that even in prehistoric times, mankind has been researching and, continuing these researches, new forms have been developed in the present time. I witnessed the results of a number of research works being carried out in the search for and creation of high-quality composite materials adapted to the requirements. Nowadays, there is no field left where composite materials have not entered. Composite materials stand out on the world market due to their cheapness, lightness, strength and durability, and are rapidly entering our industry. We can even see it manifesting itself in the field in which we operate. At the same time, composite materials are widely used in the production of components of many flying machines. I emphasize that this leads to lighter weight and lower price of flying machines. As a result of the process of studying and analyzing the above information, it is desirable to invent new types of composite materials, to improve them, and to apply them to areas where they have not yet entered.

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