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WASTE PROBLEMS AND MATERIAL EFFICIENCY IN THE AREA OF WOVEN REINFORCED POLYMERIC COMPOSITE MATERIALS

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Abstract: Waste problems that cannot be solved by simple procedural adjustments or improvements in practices require more substantial long-term changes. It is necessary to develop possible prevention options for the waste problems, but also, several policies regarding the re-using materials or using the recycled materials are necessaries. In this sense, the concept of the raw materials substitution implies effective and efficient use of raw materials in scope to minimize losses along the process system, as well as using different raw materials that will not generate waste during the manufacturing processes. This concept also further implies re-using materials or using recycled materials. In this way, the natural resources should be used in the most efficient way. Recycled waste can be returned back into the economy as secondary raw materials, thereby achieving the full potential of these materials.
Keywords: waste, material efficiency, recycled materials, secondary raw materials, composite industry

1. INTRODUCTORY NOTES

Material efficiency is part of sustainable development, and taking it into account is now more important than ever due to the growing scarcity of natural resources. Material efficiency covers the minimization of raw materials used in the production process, selection of the most economical raw materials possible, and the reduction and recycling of waste to minimize the amount of unutilized material. A circular economy system keeps the added value in products for as long as possible and eliminates waste. They keep resources within the economy when a product has reached the end of its life, so that they can be productively used again and again and hence create further value. Transition to a more circular economy requires changes throughout value chains, from new ways of turning waste into a resource to new modes of consumer behavior. This implies full systemic change, and innovation not only in technologies, but also in methods and policies. Even in a highly circular economy there will remain some element of linearity as virgin resources are required, and residual waste is disposed of.

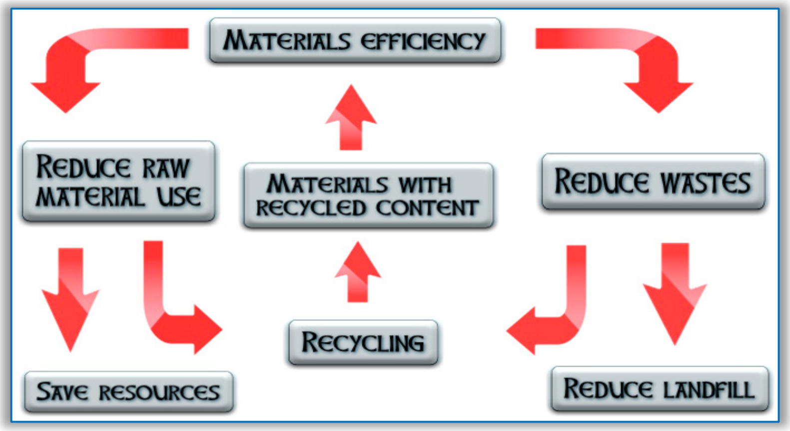

Figure 1. Materials efficiency

The integration of the waste management in the resource policy is therefore absolutely necessary. Redirecting the material flows away from the landfill into the production of basic materials and goods may constitute a valuable supplement to the conventional extraction of raw materials.

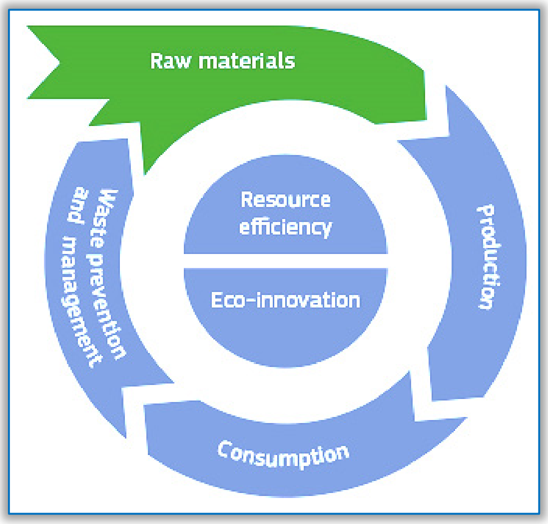

Figure 2. The resource efficiency concept

2. TECHNICAL IMPROVEMENTS

The process or production changes that may increase production efficiency, reduce resource consumption and reduce waste generation include:

- optimization of existing process conditions or changes in the production process, process control and automation – i.e. process optimization improvements.
- innovation of existing equipments and installations – i.e. minor or major innovations in the main process equipment.

- process substitution with cleaner technology where appropriate – i.e. adopting new and cleaner technologies.
- raw material reduction in the quantity or type of raw materials used in production – i.e. resource efficiency in the manufacturing process .
- raw material substitution using alternative materials as a substitute through the use of wastes as raw materials or the use of different raw materials that produce less waste.

In practice, there are a number of ways in which technical improvements can be achieved:
- by changing the manufacturing processes and technologies, through optimization, automatization or major innovations;
- by changing the process parameters, like the ingredients or the technological factors;
- by developing new alternative products, like composites.
- by reuse of wastes and by-products, as new resource in the manufacturing processes (as secondary raw materials).

The use of waste materials can be a new resource for any manufacturing processes and must poses an important opportunity to recycle it. Therefore, instead of the extraction of minerals, this innovative way of thinking enables the recovery of many strategic and critical metals from waste materials. In this way, the innovative product design and reusing, recycling and remanufacturing products can help to deal with a raw materials shortage. Both recycling technologies and the efficient ways of collecting of waste materials which contain usable raw materials can make the production more resource resilient. Targeted recycling should make it possible to obtain as many important secondary raw materials as possible from waste and reintroduce them into the economic cycle.

In fact, we can concluding that:
- Optimizing the existing manufacturing processes can reduce resource consumption. Also, innovations in the process equipment can reduce waste generation and may increase production efficiency. These options are typically low to medium cost for any manufacturer.
- New innovation and technological practices can reduce waste generation and improve the quality of the inputs in the production phase. Therefore, adopting new technologies can reduce resource consumption and minimize waste generation through improved operating efficiencies. These options can be attractive, but are often highly capital intensive.
- Efficient production practices can led to waste minimization. In industry, using more efficient manufacturing processes and better materials generally reduces the production of waste. The application of waste minimisation techniques has led to the development of innovative and commercially successful replacement products. Waste minimisation efforts often require investment, which is usually compensated by the savings. However, waste reduction in one part of the production process may create waste production in another part.
- By raw material substitution and/or reduction, some environmental problems can be avoided by replacing virgin materials with more environmentally benign materials. Also, more efficient use of raw materials means reduced costs of purchasing new materials. These options can result in benefits, including reduced use of raw materials, reduced waste disposal, reduced energy consumption, and more-efficient production processes.
- The concept of the raw materials substitution implies effective and efficient use of raw materials implies re-using materials or using recycled materials. Reusing waste as raw material for new product offer interesting practical opportunities.
- The waste that can be recycled is returned back into the economy as secondary raw materials. To increase the quantity and quality of these secondary raw materials, waste management must improve, for instance in terms of separate collection and sorting and recycling facilities.
- New products will create new markets.
- Minimizing the use of raw materials and utilizing cheaper materials will provide cost benefits.

In a world increasingly fixated on the demands of sustainable development, too much attention has been focused on the widely used materials, mainly on those tools and strategies for their reuse and those characteristics for considering them as environmental-friendly materials. Among the strategies are the following:
- increased reliability on waste and recycled materials—such action will have to incorporate the substitution of recycled for virgin materials;
- improved durability through reduction of materials needed for their replacement; and
- improved mechanical properties, which reduces the use of raw materials.

Extensive research and development activities in recycling materials used in composites have been conducted, and various technologies have been developed in this field.

3. ENVIRONMENT-FRIENDLY AND LOW-COST ALTERNATIVES

In recent years, ecological awareness and other environmental issues led to the development of composite materials based on renewable resources. These materials are environment-friendly and low-cost alternatives to replace synthetic fibers like glass and carbon fibers. The composites sector recognizes the increasing importance of landfill diversion, recycling and improved resource efficiency. The main resource efficiency issues affecting the sector is relate to the waste (including recycling and "closed loop" manufacturing).

In the last decades, the uses of textile structures made from high-performance fibers are finding increasing applications in composites. High-performance textile structures may be defined as materials that are highly engineered fibrous structures having high specific strength, high specific modules, and designed to perform at high temperature and high pressure (loads) under corrosive and extreme environmental conditions. Significant developments have taken place in fibers, matrix polymers, and composite manufacturing techniques.

Composite materials reinforced with woven fabrics, braids, and knits are becoming increasingly popular in various structural applications from automotive, aerospace, furniture, and so on. Processing techniques of materials to obtain composites include technologies to obtain reinforcement layers, stratification technology, transfer resins in textile layers through molding, molding with vacuum/pressure, and autoclaving fabric (reinforcement structures) for impregnation products with properties of thermosetting and compression/preforming molding of thermoplastic and thermosetting composites.

Figure 3. Preimpregnated woven fabrics – manual textile preforming

Preimpregnated fabrics play an important role in the technology of composite structures because they can perform various structures from different natural materials (fibers and textile fabrics, glass fibers, aramid fibers, carbon, and mixed structures). Advantages of woven reinforced composites are reduced cost, improved machinability, and, in particular, the use of a wide range of textile structures. Woven reinforced polymeric composite materials have broad applications in the structure of airplanes and ships, having good stability and easy machinability. Inserting textile elements in composite structures aims to:

- improve the mechanical behavior of the composite material, the advantageous orientation of the textile insertion relative to the direction of mechanical stress; and
- improve the resistance of bonding areas of the pieces.

Compared to unidirectional composites and nonwovens, composites that use fabrics like the reinforcement system are more resistant to impact and have uniform properties in all directions. Textile structures used as insertions in composites can be obtained by different methods of binding/joining of textile materials (fibers, fiber preforms, yarns, etc.) such as weaving, knitting, and braiding. They are different textile structures used as reinforcement, such as fabrics.

Textile preforming operations play a key role in most of the composite manufacturing processes. The basic textile yarn and fabric forming processes have been modified and developed to a significant extent to meet the increasing demand from the composite manufacturing sector. Apart from being cost effective technology employed for obtaining different fiber orientations and near net shapes, textile preforms also lead to improved mechanical properties of the resulting composites in certain aspects. Developments in the field of preforming have led to the production of preforms with fibers orientated in different directions with weaving, knitting and braiding individually or in combinations. Very good drapability and complex shape formation with no gap and reduced manufacturing cost are the main features of woven fabrics.

4. CONCLUSIONS

Natural fibers are now interesting alternative to replace synthetic fibers due their good specific properties (per unit weight). They have been used to develop different composites based on thermoset and thermoplastic matrices. As for any composite, their mechanical, thermal and physical properties are function of the properties of the matrix and the reinforcement, as well as fiber loading, fiber source and manufacturing process. Nevertheless, interfacial conditions are always important to optimize the general properties. Plain woven fabric, from bast yarns (flax, hemp, jute, etc.), can be used to obtain cheap composite materials. This class of composites is based on some raw materials that are available on our internal market–animal glue (together with some curing and stabilizing agents) and bast fiber fabrics. The samples are firstly preformed, by impregnating the polymeric matrix in the suitable textile reinforcement arrangements, and then consolidated by moderately hot pressing. The choice of a particular type of textile fabric used as reinforcement elements for the production of composites depends on the capacity of multi–axial reinforcement and between the layers, namely the ability to obtain different forms of spatial composites. Depending on how composites processing and requirements, certain structures of reinforcement elements may be adopted.

A new possibility to improve the properties of natural fiber composites is to add a second reinforcement to produce hybrid composites. Based on this concept, different class of materials was also developed such as all natural fiber hybrid composites (combination of two different natural fibers) and auto-hybrid composites (combination of two different sizes of the same fiber). This opens the door to a new field of investigation as several parameters can be controlled to optimize the final properties of the materials and to design new applications for these multi-functional composites.

In the recent years, the use of textile structures made from high performance fibers is finding increasing importance in composites applications. Besides economic advantages, textile preform technologies also provide homogenous distribution of matrix and reinforcing fiber. Thus, textile preforms are considered to be the structural "backbone" of the composite structures. This technology is of particular importance in the context of improving certain properties of composites like inter-laminar shear and damage tolerance apart from reducing the cost of manufacturing.

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ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665