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CONSIDERATIONS REGARDING THE MANUFACTURING OF THE COMPOSITE STRUCTURES USING THE RTM PROCESS

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Abstract: *This paper analyze the technological variants concerning the manufacturing of the parts made of composite materials using the RTM (Resin Transfer Moulding) process.*
This procedure consists of low pressure injection of a thermosetting polymeric matrix in a closed mould who has fiber reinforcements disposed there previously.
This method allows the realization of complex high dimensions parts, with superior quality, having both exterior surfaces polished.
We propose a few technological solutions regarding the improvement of the manufacturing process.
Keywords: *Composed materials, resin injection, fiber glass.*

1. INTRODUCTION

In recent decades due to the unprecedented development of all branches of industry was needed to create new products and services, with a high degree of complexity, resulting in complex and lengthy trials that end. In the general development, an important role have the materials, used in increasing amounts and applied to the rising properties. This does not happen only in areas of high technology (ships and space stations, aviation, telecommunications, medical, sports or military), but also in everyday life. It is understandable that after their 'additional training "in areas of high technology, these materials reach the current life, their place being occupied by new materials more efficient.

Attempts to obtain super performing materials led to the development of new classes of materials known as composites.

Composite materials are not an entirely new concept. The common examples are in nature such as wood, which is composed of cellulose fibers linked together by lignin or bone, comprising the periphery of a compact tissue, inside the bone marrow, the whole being embedded in a fibro-elastic membrane richly vascularized, [6].

Composite materials are arrangements of fiber - continuous or discontinuous – resistant materials (reinforcing elements) that are coated with a matrix whose strength is much lower. The matrix sustain the fibers geometry and sent the effort which the part is exposed ,[4].

Formation processes of composite parts from thermosetting materials

The mixture of reinforcing material and matrix become a true MC only after the end of the last phase of production, that is by strengthening the basic material, the matrix, (for example: resin). The material obtained will then be impossible to change in terms of mechanical characteristics as we can change the structure and characteristics of a metal alloy by heat treatment.

In the resin composites materials the last phase of development (manufacturing) is polymerization. For example unsaturated polyester resins in the liquid passing through copolimerization solid with a monomer that is mixed. This phenomenon causes hardening. The mixture is activated either by a chemical agent "accelerator" or by application of energy from outside.

The manufacturing technologies of composites materials are numerous, basic concepts of each differ from one another. The choice of technology depends on the following factors: the geometric shape of the part or product, composite material structure, piece size, dimensional accuracy and quality parts, production batch requests, the destination of the parts, etc.,[6].

The main manufacturing processes of composite materials are:

- Shaping through contact (manual process),
- Shaping by cold pressing,
- Shaping by continuous rolling,
- Shaping bag (vacuum pressure),
- Shaping transfer (ZMC, RTM),
- Shaping by running filament.

2. MANUFACTURE OF COMPOSITE STRUCTURES BY RESIN TRANSFER PROCEDURE MOULDING

Resin Transfer Moulding (RTM) is a low pressure, closed moulding process which offers a dimensionally accurate and high quality surface finish composite moulding, using liquid thermoset polymers reinforced with various forms of fiber reinforcements. Typically polymers of Epoxy, Vinyl Ester, Methyl Methacrylate, Polyester or Phenolic are used with fiberglass reinforcement. Other reinforcements, are offered for more demanding applications such as Arimid, Carbon and Synthetic fibers either individually or in combination with each other.

The matrix selection of polymer and reinforcement dictates both moulding material cost, as well as moulding mechanical and surface finish performance. Along with the polymer and reinforcement the addition of mineral fillers may be added to enhance fire retardancy, flex modulus and surface finish.

By the geometry of the fibers, reinforcing materials used in RTM process can be: unidirectional, bidirectional and special fabrics 3D architecture, which possesses some special lanes through the resin flow.

Reinforcements are presented in their dry form to the mould in either binder-bound chopped mat, random-continuous strand mat or woven cloth format. The fiber has been either "preformed" to the exact shape of the moulding tool in a previous operation or is hand-tailored during the loading process in the moulding tool. After the fiber is installed into the mould, a premixed catalyst and resin is injected into the closed mould cavity encapsulating the fiber within. The primary surface of the moulding may be gel-coated, a process of spraying the mould surface before installing the fiber. If a gel coat is not required, the exterior finish would be the same from the front to back of the moulded part. The RTM process has the inherent advantage of low-pressure injection, it usually does not exceed 100 psi of resin injection pressure during the mould-fill process.

The principle scheme of an installation of RTM is presented in figure 1.

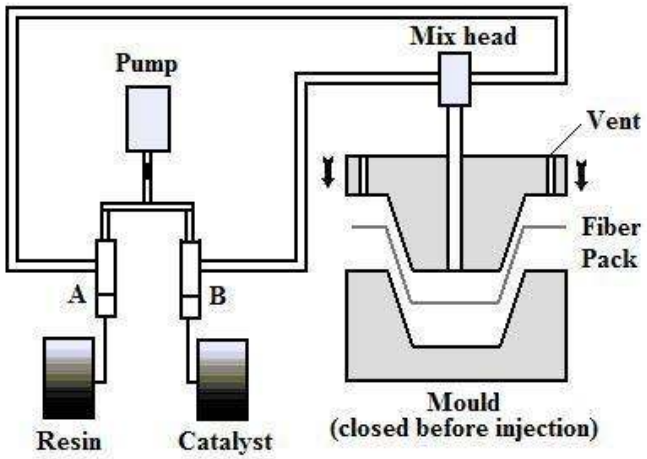

Figure 1: The principle scheme of an installation of RTM.

a) Steps of the RTM process.

Formation by RTM process stages are shown schematically in figure 2.

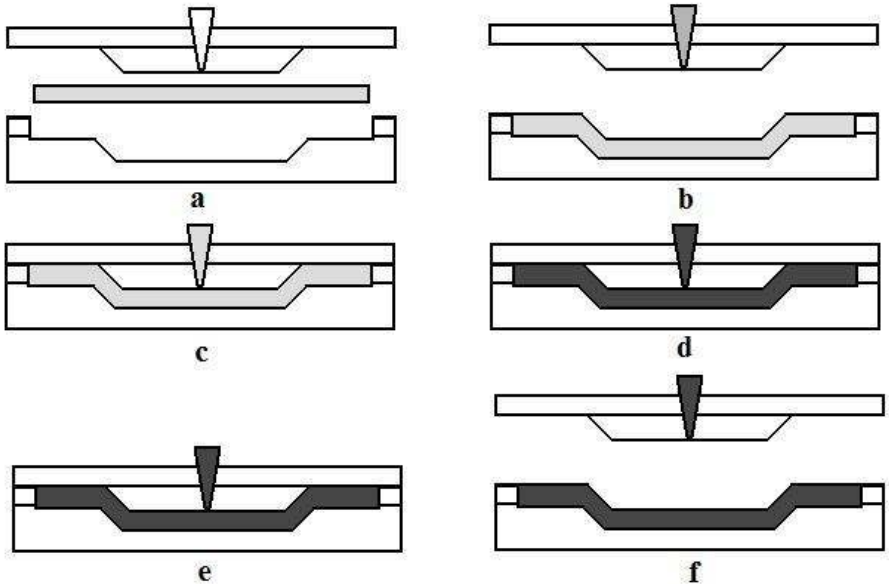

Figure 2: The steps of forming parts by RTM process.

a) cutting reinforcement, b) pre-forming reinforcement, c) installing preformed reinforcement, closing and heating the mould; d) resin injection and mould filling e) achieve polymerization cycle in matrix, f) opening the mould and extracting the piece (demulation).

b) Advantages and disadvantages

The main advantages are:

- Production of large parts with complex reinforcing structures;
- Obtaining high quality surfaces;
- Obtaining some complex configuration geometry;
- A very good behavior regarding heating properties.

Disadvantages:

- Duration of the process is relatively high, because the polymerization step takes a lot of time;
- Materials made from thermosetting resins can not be reused;
- Not impregnated areas that can lead to reject the piece, all depending on staff training.

c) Fields of application

Application of RTM technology is very broad, starting from the space industry to the consumer field, the main areas is: automotive – most parts of this area are made by RTM process, aeronautics industry – fuselage panels, aerodynamic profiles, trees for helicopter rotors, engine and pump housing, propeller blades of the helicopter and in the shipbuilding can be found on submerged parts of ships and the carcasses of submarines.

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d) Technological variants for RTM process

Several modifications of the phases which make up this process led to the development of new technologies, considered as variants of the process, these processes are:

- SRIM Process (Structural Reaction Injection Moulding);
- HSRTM Process (High Speed Resin Transfer Moulding);
- ICS Process (Injection Compresion);
- FRTM Process (Flexible Resin Transfer Moulding);
- TERTM Process (Thermal Expansion Resin Transfer Moulding);
- CRTM Process (Continuos Resin Transfer).

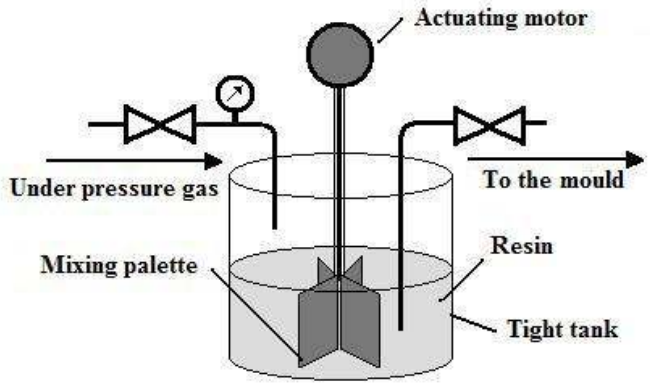

Figure 3: Under pressure tank

In figure 3 is presented one of the technological process of RTM, is the pressure tank, it consists of a vessel which is sealed. An adjustable gas pressure acts on the surface fluid . Under the effect of gas pressure vessel content is pushed through a pipeline siphoning mass immersed in resin, which is sent to the mould cavity,[8].

e) Constructive particularities of moulds used in RTM process

Formation by RTM process, resin transfer, can only apply to closed moulds consisting of two parts. The design of moulds should basically take into account the four aspects: shape of the cavity, the point of injection, the edges of the mould and guidance systems, locking, heating or hardening of the two parties.

Point of injection is the hole through which resin is injected under pressure inside the cavity. Position in space of this point is very important because it depends largely on the complete filling of the mould cavity, and avoid creating goals or points where the resin does not have access. Resin flow has to be done with constant speed, gradually, from the lowest point of the form to higher points.

Another method is injection side of the resin, this method is advantageous because it does not influence the geometry of the fibers. For large parts is recommanded several injection point, as their position is very important.

Mould cavity is in fact the geometric shape of the piece, it has to follow the geometric form and the dimensions of the part. The cavity can be driven by technological methods adopted: with mechanical processing on machine tools, if mould is made of metal, by transposition (fingerprint) by a track model is used if matrix composite, concrete or epoxy or by electroforming and electroplating, when are made moulds of hybrid construction,[8].

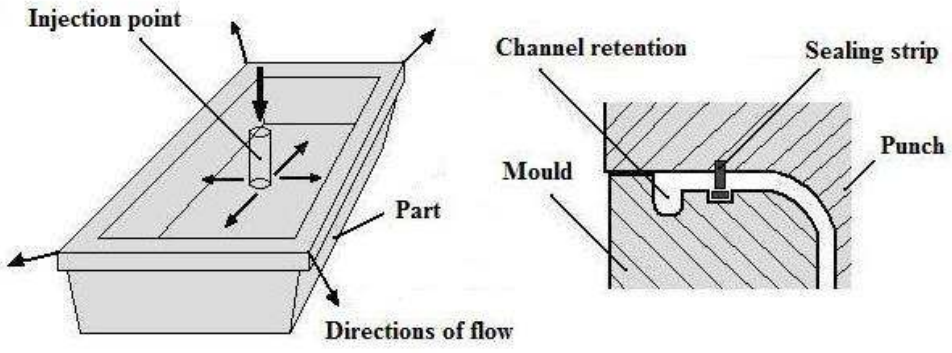

Figure 4: Execution example of the mould

The figure 4 presents a way of conceiving the edges of the mould with partial local packing on some portions, so that the flow of resin to make not on the radial direction but only in precise points, on the corners of the piece.

Another solution is to develop a retention channel of the surplus resin, which must surround the outline of the part and who should be in a position lower than the highest level of the part.

A third solution is the sealed mould version, which supply continues to do through the heart by injection or through a point in the lower zone, the excess resin is collected in a single point of contact with the outside. In this case the inner cavity of the mould no longer communicate with the outside except through the collection point.

f) Technological peculiarities of the RTM process

Flow in a porous medium occurs in very small spaces and pores of variable sizes that communicate with them.

Darcy's Law indicates that the flow Q which flows through the filter of porous material is proportional to the filter surface area S and the level difference Δh, but inversely proportional to filter length L.

$$Q = Kf * S - \frac{\Delta h}{L} \quad (1)$$

where the constant Kf is the *filtration coefficient.*

3. CONCLUSION

For mass production than are needed plants that provide a mixture of resin with the catalyst when their penetration in the matrix, because they prevent bottlenecks related technology that can remove debris polymerized to remain in the instalation.

For large parts that are subjected to mechanical stress is indicated solution reservoir pressure, which ensures preactivation resin before entering the mould, it provides good mixing of the resin with the catalyst and leading to an efficient polymerization reactions.

The problem of resin flow through porous media is very complex due to factors that influence the nature and flow mode. It requires a modeling of resin flow in the mould, considering some simplifying assumptions.

An important problem is the front direction of flow in convenient especially when complex parts.

About the future aims and further research we want to build an experimental instalation and significant tehnological improvments of the RTM process to increasing the quality of composites parts.

Also we want to do research regarding some special arhitectures of the materials used in this process and to increase the reinforcement of composite structures obtained by this process.

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