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MANUFACTURING PROCEDURE OF POLYMERIC REINFORCED WITH EXPANDABLE POLYSTYRENE

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***Abstract*—** This paper has the aim to present a manufacturing procedure of polymeric reinforced material used in building at isolation. A new composite material with matrix of modeling alpha-plaster with expandable polystyrene waste was achieved. At recycle and recovering into powder of waste from expandable polystyrene (EPS) was required a quality smoothing of waste, which due to a composite material with specific properties and low costs.

***Keywords*—**Expandable polystyrene (EPS), Manufacturing, Polymeric reinforced, Waste

I. INTRODUCTION

THE composite materials are knowing a large and widely applications in all cutting-edge ranges of advanced materials as their spectacular characteristics and performances of final parts. Engineering composites are defined as the systems of reinforcing fibrous materials in a polymer matrix binder [1]-[10].

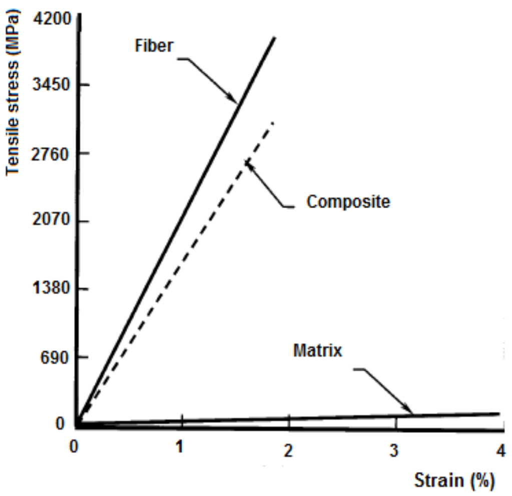

Fig.1. Tensile properties of fiber, matrix and composite [4].

The reinforcing fibers assures stiffness and strength to the composite, while the matrix material binds the fiber together, provides form and rigidity by transferring the load to the fibers, and protects the load-bearing fiber from wear and corrosion.

The matrix material has a lower modulus and greater elongation than the fibers reinforcement, surrounding and binding the fiber in the composite structure.

Polymer matrix materials are achieved from thermoset and thermoplastic resins, which determine the service operating temperature of the composite as well as processing parameters used at parts manufacturing.

The manufacturing techniques of composites are multiple and diversity processes. The selection of optimal composites' process is performed by specific rules, such as:

1) *Type of composites,*
2) *Applications,*
3) *Quality parts,*
4) *Size of production,*
5) *Costs, etc.*

The primary manufacturing techniques used to produce composite materials include [4]-[8]:

a) *Manual Lay-up*
b) *Automated Lay-up*
c) *Spray-up*
d) *Filament Winding*
e) *Pultrusion*
f) *Resin Transfer Molding (RTM), etc*.

Composites can be divided, after the volume process, into categorized as low and high-volume. Low-volume processes are represented by the manual and low-pressure lay-up in low-cost molds and high-work cost. Lamination, filament winding and RTM are high-volume processes that have an initial high cost of tooling and equipment but they are compensated from low-intensity of work. Moreover, lamination can be found both categories, as a hand lay-up process, or as automated using sheet-molding compounds.

Lamination, filament winding, pultrution and RTM are relevance in the production of continuous fibers composites with closely controlled properties to obtain comparative flat parts. By filament winding can be performed a potential and high-speed process in fabrication of tubs and other cylindrical parts. Pultrution can be used for the parts with constant cross sectional shapes, and RTM produces thin-walled, intricate shapes similar to the injection molding process.

After their functions of composite constructions, those materials can be divided in two large categories:

i. Laminates, which have layers bonded together,

ii.Sandwiches, which are multiple-layer structural materials containing a low-density core between thin faces (skins) of composites.

As an observation, it can be mentioned that in some applications of advanced composite materials, the individual layer may themselves be composites, usually of fiber-matrix type.

In general, the common features of composites processing routes are the following steps:

A. Infiltration,
B. Consolidation,
C. Effects of applied pressure,
D. Cure of thermosetting resins,
E. Processing thermoplastic matrix-systems,
F. Heat transfer,
G. Flow processes during molding,
H. Drape.

The goal of this paper is to present a practical solution to obtain a new composite material from gypsum plaster reinforced with expandable polystyrene waste, which has specific lightweight, greater porosity, available isolator properties and low costs.

II. THEORETICAL ASPECTS

The modeling alpha-plaster manufacturing at “Congips” Co. from Oradea has the base of patent [11], being formed by group of air binder material obtained by gyps has dehydrated G90, $CaSO_4 \cdot 2H_2O$ in conformity with norm- SR EN ISO 1587-1996 [12] and [13]-[15], due to calcium sulphate semi-hydrate ($CaSO_4 \cdot 1^{1/2}H_2O$).

The obtaining of modeling alpha-plaster at this plant has realized by gyps de-hydrated in closed installations at pressures of 0.8 MPa and temperatures of 160-180^{0}C, with breakage of gyps in autoclaves and boilers, its primary heat treatment has depicted in Fig. 2.

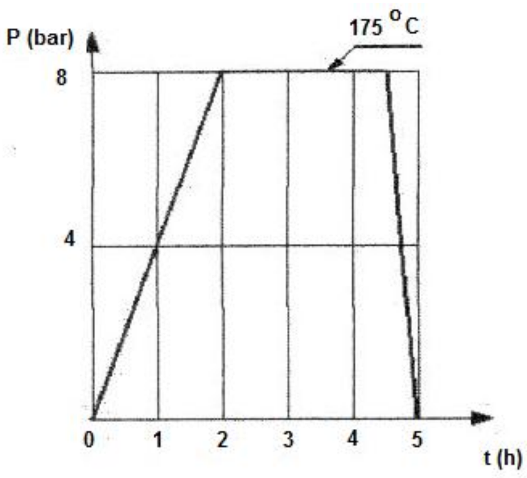

Fig. 2. The primary heat treatment of gyps.

De-hydrated has continued inside of tunnel oven with warm air in counter-current at temperature of 170^{0}C and a pressure of 200 mmH_2O (196.2Pa) during of many hours (5-8 hours), following by a fine grinding with mixture of 1.5-3 % of white cement weight (Fig. 3).

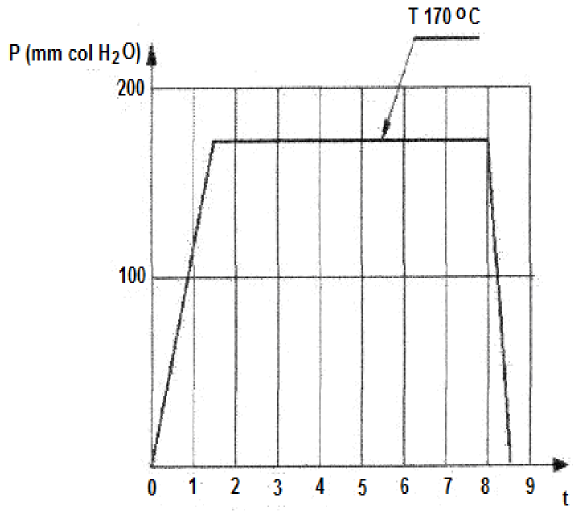

Fig. 3. De-hydrated treatment of gyps.

The transformation of gyps dehydrated, as calcium sulphate dehydrated ($CaSO_4 . 2H_2$), at 170^{0}C is:

$$CaSO_4 \cdot 2H_2O \rightarrow CaSO_4 \cdot 1/2H_2O + 1 \cdot 1/2H_2O \quad (1)$$

, obtaining semi-hydrated plaster ($CaSO_4 . 1/2H_2O$), which in mixture with water (H_2O) has reaction resulting gyps:

$$CaSO_4 \cdot 1/2H_2O + 3/2H_2O \rightarrow CaSO_4 \cdot 2H_2O \quad (2)$$

The gyps obtained has solidified, resulted a porous mass with a structure formed by concrescence crystals with many micro-capillaries.

The characteristics of modeling alpha-plaster produced of this plant are in conformity with UE norm-SR EN 13279-1/2005, which was used to obtain a new composite by reinforced with expandable polystyrene waste.

III. MANUFACTURING OF POLYMERIC REINFORCED FROM EXPANDABLE POLYSTYRENE WASTE

The expandable polystyrene (EPS) in granules form is a valuable polymer therefore of its specific properties, as specific lightweight, great porosity and excellent thermo and sonic isolator. The new composite material with matrix of modeling alpha-gypsum plaster reinforced with breakage flasks of EPS will be presented in next.

At “Congips” Co. from Oradea is produced the EPS, in the pressed form of 600x600x24.4 (or 50) mm^3 panels, with large applications, in special at building’s insulation. During the pressing process of EPS panels in metallic form results an appreciable amount of waste under form of flasks and broken due to a great ecological problem with their deposition. In this way, it was realized researches and experiments of recovering, recycling and reusing of EPS waste, in cooperation with our university; this plant has produced panels from EPS and construction materials as modeling alpha-plaster, gyps-cartoon, etc.

The flakes and broken granules of EPS with the value of 0.1 to 6 mm resulted from waste, were been grind and breakage with mobile cutters on a disintegration device, which has a rotor with cutters, and a spindle speed of 5000 rev/min. The powder resulted from breaking process is characterized of its lower density in settled bulk by granule-metric distribution from riddling. The weight loss by grind is near zero, the recycle material obtained could be used entirely.

The EPS waste resulted from grinding were been mixed with powder of modeling alpha-gypsum plaster in percentage of 0.5 to 7% from total weight of plaster due to a new material.

For introducing in manufacturing process of EPS waste under forms of flasks, grains and broken grains, these must be recycled by preparing operation due to desire form and size of reinforced material, which are mixed in this case with powder of modeling alpha-gypsum plaster. The flow or expandable polystyrene preparing operation is presented in Fig. 4.

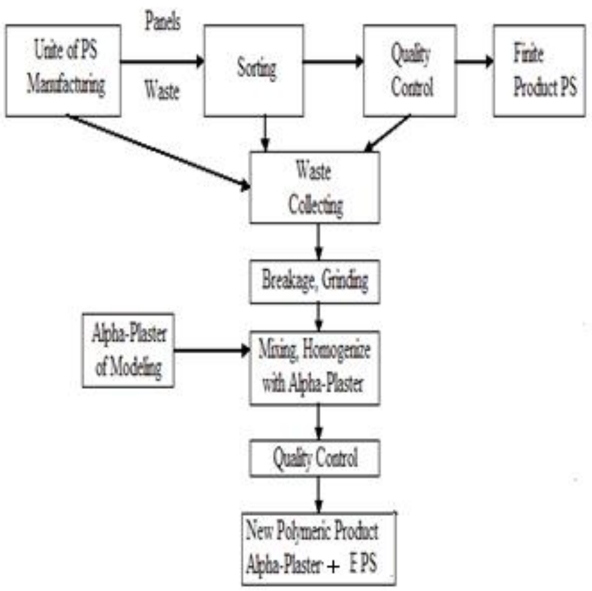

Fig. 4. The flow of EPS preparing operation

By adding of water in weight percentage of 35-40% and alpha-gypsum plaster of 60-65 %, plus the EPS and the smoothed, which was resulted in sprocket form, due to variety of parts and forms by well-known forming process.

The sort process of EPS was done by depreciation grade, form and size of grain. The grinding process was realized in breakage rooms composed from a framework, rotor with blades and higher speeds and a sieve of sorting.

The braked material is getting in breakage room and under cutters acting, the size was diminished at particle form, which passed from the sieve. The size of holes sieves was determined the maximal dimension of resulted particles by breakage.

The depreciated material from EPS was been grind in a mill of ULTRA-ROTOR, depicted in Fig. 5.

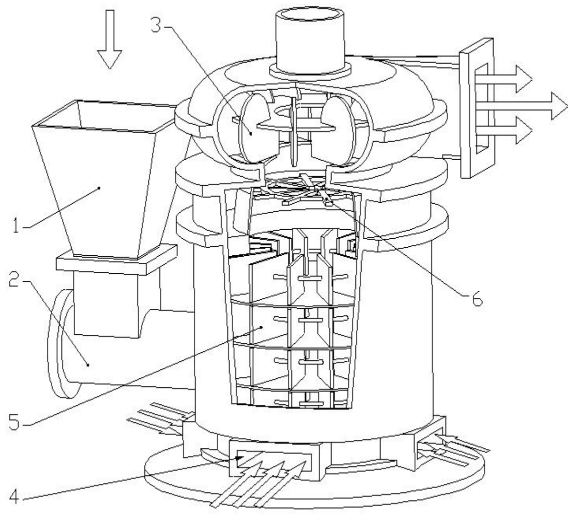

Fig. 5. ULTRA-ROTOR mill [6].

Where: 1-feed hopper, 2-conveyer with worm, 3-fan rotor, 4-inspire orifices of air, 5-rotor with cutters, 6-sort rods of grinding material.

The grinding and breakage material has involved again by air current in a cyclone, depicted in Fig. 6, and going in manufacturing process of modeling alpha-plaster, where has mixed and smoothed in desire concentration. In new composition has added the accelerators as de-hydration powder lime and white cement.

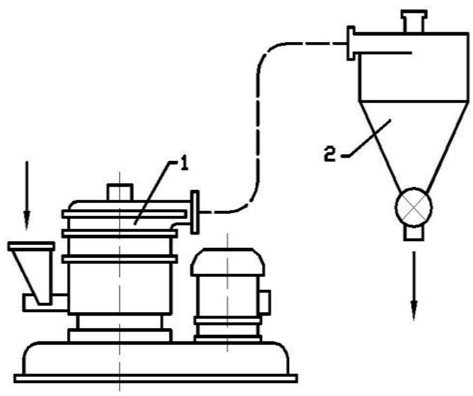

Fig. 6. The grinding installation with cyclone [6]

Where: 1-is Ultra-Rotor mill, 2-cyclone.

In Fig.7 is presented the density variation of settled bulk of waste from EPS, recycle by grinding, with grinding time referenced to 5000 rev/min. The plotted diagram has only quality principal.

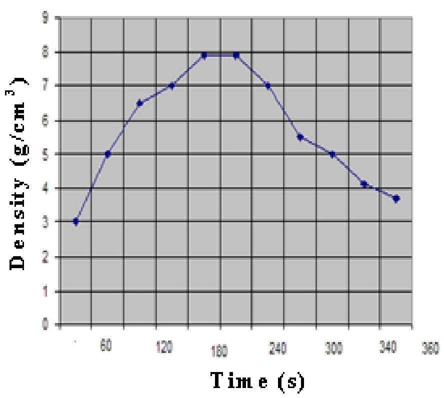

Fig. 7. The density variation of EPS waste in settled bulk, in dependence of grinding time

The bulk density of EPS has growing with grinding time, reached at maxim of 9 g/cm ^{3} at 1.8 min, after that has decrease at grinding carrying on.

This behavior its can be explained by changing of geometrical form particles during grinding process. At maxim value of density bulk, the geometrical form of grinding particles is spherical. For Ultra-Rotor mill has determined a grinding time of 5 min working of cutters revolution of 5000 rev/min, which assuring an optimal density in bulk.

It can be emphasize that grinding and breakage powders has resulted until a size of 0.5-1 mm and bulk density between 6-9 g/cm^3 has presented in different forms.

Other better results of breakage it can be obtain by cryogenic treatment of EPS waste and a cutters' revolution over 10000 rev/min.

In other using stage, the recycle recovering has used as reinforced material obtaining plates and panels for ceilings and inner walls on gyp's base due to improving of them specific characteristics and properties.

For recycle and recovering in powder of waste from EPS has required a quality smoothing of waste.

In collector and recycle phase of waste has avoided them contamination with varied mechanical impurities.

The recycle material of EPS can be use with success as reinforcement in composition of new lightweight composite materials, as orthopedic modeling alpha-plaster, because of its small size and specific lightweight, higher porosity.

IV. CONCLUSION

The paper has presented an original practical procedure used at manufacturing of polymeric reinforced as modeling alpha-gypsum plaster with expandable polystyrene waste modeling alpha-gypsum plaster with expandable polystyrene waste. This processing achieved at our university was been implemented with success at "Congis Co from Oradea, which due to a new composite with specific higher properties and low costs of fabrication.

The composite material with matrix of modeling alpha-plaster and reinforcement of breakage flasks from EPS has a good application in manufacturing of phonic-absorbent panels for ceilings and walls.

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