ANALYSIS OF THE DEFORMATION OF A COMPOSITE MATERIAL OF SCRAPES OF TIRE AND LATEX WITH TEMPERATURE VARIATION

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Abstract. *The great majority of the applications of thermal isolation in the strip of drops and averages temperatures (up to 180ºC), it is made being used from aggressive materials to the nature such an as: glass wool, rock wool, polystyrene, EPS among others. Such materials, in spite of the effectiveness in the retention of the flow of heat, possess considerable cost and when discarded they are long years to be to decompose. In that context, trying to adapt the world politics the about of the preservation of the environment, a study began with intention of developing a material composite, with properties of thermal, originating from insulating industrial residues. It was analyzed, in this research, the behavior of this composite, when submitted to traction efforts. For this, an analyzer term-mechanic was used (DMA) with which the composite was submitted to loads differentiated under variation of the temperature. It was also certain the gradient of temperature of the composite when submitted the source of heat, the conductivity and thermal diffusive. As consequence, in function of the answers of the system, was possible to observe the deformation of the composite when submitted the tension and temperature variation, as well as the temperature gradient for each proportion of the composite.*

Keywords: *Composite, Latex, Deformation.*

1. INTRODUCTION

There is a world tendency in looking for alternatives for the traditional materials in all the sections of the economy. In this context, it has been increasing the studies addressed to the rational use of the natural resources and the use of residues spilled in the nature.

Being like this, the recycle that it has been a lot stimulated. Now, in the market, several products that are produced with recycled materials already exist: paper, packing's of aluminum and other metals. Santos (2005), affirms that in spite of this progress, the accelerated development of the society takes every day, to the environment, a great number of materials pollute the vital elements to the human being survival, such as: soil, air and water. Several residues have been studied for the application in mortars and isolation materials (PIERCE e BLACKWELL, 2002). They are many the materials that can be used as insulating; the choice of the appropriate material to a certain process of transfer of heat is made of mechanical property analyses, physics and thermal.

As a material insulating ideal, the comparison among the available options doesn't exist it makes possible the choice of that that best satisfies to the fundamental beginning of the engineering: relationship cost x benefit. Besides, should be considered environmental parameter and of safety.

Now the great majority of the applications of thermal isolation in systems domestic, commercial and industries in the drop strip and average temperature (up to 180ºC), it is made being used aggressive materials to the nature such a mainly as: glass wool, rock wool, polystyrene, EPS among others. Such materials, in spite of the effectiveness in the retention of the flow of thermal energy, possess a considerable cost and when discarded they are long years for they be absorbed by the nature. Trying to adapt to a world politics concerning the preservation of the environment, it was made a study with the intention of developing material composite reinforced with you scrape of tire, residue that is characterized for they have low cost, besides low density when compared to conventional materials.

In that way, to present research it was motivated by the promising economical advantages and you adapt offered by the use of tire residue, tends as objective the development of a composite to be used as insulating thermal to the base of it scrapes of tire and latex for application in hot surfaces (200ºC).

For this, they were used them you scrape of tire as reinforcement of the composite. Abundant material in every country and with little use, and that has as characteristic principal: lightness, flexibility and low cost. As head office the latex was used. Material originating from of the "*Hevea brasilliensis*" whose production in Brazil is of the order of 90.000 ton/year, and that has as characteristic principal the little humidity absorption, high elasticity and low cost.

2. THEORY

2.1. Residues of tires

With the development of the automobile industry in the century XX, there was also an increment in the generation of residues and by-products, turning important the regulation of the destination of those materials. The cost of garbage deposition has been increasing, so much for the generated volume, as for the new demands of environmental stamp (GRIPPI, 2001). The need of creation of techniques exists capable to reuse such materials.

In a general way, the transports are vital for the development and the economical and social well-being, however, your high noxious effect is recognized in environmental level. Among the several ones modal existent, it is the road that produces a larger impact in the several components of the atmosphere. The principal caused negative effects are the pollution of the air, for the emission of gases and resulting particles of the combustion and the pollution of the soils for residues of oils, tires and scraps.

Among the components of the section road the tire possesses fundamental and unquestionable paper in the people's daily life, so much in the passengers transport as in the transport of loads. That paper becomes still more important in the countries in development, where the transport of goods is made in your great majority by trucks.

However, the consumption of tires reached expressive numbers. The amount of produced tires every year in the world surpasses 2 million tons in Europe and North America, in Japan that production passes of 1 million tons. The China presents a problem in wide scale, because 80 million scraps of tires were produced and studies show that in 2011 the country will have 200 million abandoned tires (CAO, 2007).

In the world the problem of the inadequate discard of tires in the environment is being a great concern of the society in what refers to the administration of solid residues (BOVEA and GALARDO, 2006). In Brazil, they exist 900 million discarded tires approximately and disposed at inadequate places (LARSEN et al, 2006).

The tires when useless they cart a series of problems: they are of slow degradation, perceptible and voluminous, needing appropriate conditions of storage and deposition. According to the classification of residues effective in Brazil (ABNT/NBR 10004), the tire is considered residue class III (inert residue). The placement of tires without use in embankments sanitarium has not been showing if a good solution, once the material is practically incompressible and of slow degradation (approximately 500 years), when compared to the residues to which the embankments are destined.

In Brazil, there is not any verification on the part of the federal government, on the forms of final deposition of the used tires, as well as there is not rising of the deposits of abandoned tires in every country. Some estimates indicate that 35 million carcasses of tires are generated annually (FIORI, 2009).

Still in agreement with Fiori (2009), in the united states they are generated more than 1 tires/person/year; Bertollo (2008) it esteems that in the state of São Paulo 0,46 tires/person/year and in Brazil 0,26 tires/person/year.

It's also unacceptable, under the sanitary point of view, that carcasses of tires are discarded to open sky once it is focus of proliferation of insects and rodents. That problem can still be accentuated at places where diseases exist transmitted by those you encourage, as: primness and fever yellows. According to data of ministry of health in 2008 (MS, 2008) more than 20% of the registered cases of "dengue" in the country they are caused by insect that are born in accumulated waters in old tires.

2.2. The Latex

Some vegetables produce latex, which flow of cuts as resin. Cells called special "latíciferes" produce latex. The alkaline latex was coagulated to form a matrix starting from which the balls and other goods were made. During the first millennium, eraser balls were used by the Mayan. Those "toys" had been made starting from the latex originating from of one it hoists native of Central and South America's. The ashes of the bonfires, that they were used to heat up, might have been the black acquaintance's "black of smoke" first contribution, that from that time went the responsible to give larger resistance to the rubber goods (LEBER, 2001).

All the latex is emulsions, in other words, aqueous suspensions of insoluble materials among them can be included: resins, felonies, proteins, sugars and carbon hydro's. Nor all the latex is elastic; those with elasticity contain carbon hydro's of long chains. Rubber is a coagulated of elastic latex. Vegetables that produce latex elastic band are thoroughly "new tropics". The commercial natural rubber is produced of the latex of the "*Hevea Brasiliensis*", originally collected of wild trees in South America.

As the rubber was recognized as a material that presented interesting physical properties, the researchers of the beginning of 1700 began to study the behavior of natural rubber when mixed in solvents, with the objective of developing some material that goes water balloon that possessed elasticity for production of balloons to hot air.

The modernization of the industry of polymeric began with the development of the rubber in Europe. Your first appearance in the commercial scenery dates of the century XVI, when French began to discover the advantages and applications of that material. In 1820, Thomas Hancok began the obtaining of products of the rubber and in 1837 it patented an equipment for mixture and rubber mastication (HANCOK, 2008).

M. Faraday in 1826 was the first to analyze the chemical structure of the material and it was the first to postulate that was treated of a material constituted exclusively of carbon and hydrogen. The heating took the one reside and one distilled of carbon hydro's with one formulates empiric equal C_5H_8.

The volatile fraction was characterized in England in 1860 as tends an ebullition point among 37-38ºC, and it was called isoprene. Your structure was determined by W. Tilden, when studied the volatile fraction separately. And it concluded that that fraction was the responsible for your elasticity.

The fundamental discovery for the development of the rubber happened in 1839 for Nathaniel Hayward and Charles Goodyear, in the United States and Thomas Hancok in England, in independent works. Although the merit has been granted to Goodyear, both obtained similar plenty results. They heated up the natural rubber with sulfur and white lead obtaining this way a material with superior properties to the one of the natural rubber. The properties of the rubber vulcanized, name of the cure process then developed, it constituted, and it still constitutes, a model so that one can have idea of your properties elastic including among other, the possibility of great prolongations, high hardness, resistance to the stretching and fast retraction.

Brazil was already the largest producer and exporter of the natural rubber of latex of the world, same because the "*seringueira*" is original of the Amazonian. Time that the North area of Brazil tried a moment of great prosperity, becoming the economical area of the country in the beginning of the century XX. That position was occupied until the decade of 50. Economical problems and curses in the area impeded the maintainable development of the activity.

Today, most of the world production of 6.850.000 ton/year of natural rubber comes from the Asian Southeast, with a total of 5.126.700 ton/year. Brazil answers for a production of 90.000 ton/year of a total of 134.000 ton/year of Latin America. In Brazil the cost is of US$ 0.98/kg (EMBRAPA, 2011). Nowadays, the natural rubber is produced at the country through cultivation of plants of high productivity, selected and also adapted the areas Southeast and Center-west of the country.

2.3. Composite

A composite consists of the combination of two or more materials with different individual characteristics. One is the phase continuous or main and the other is the phase it disperses, being obtained, starting from that combination, a new material with properties different from the individual phases (CALLISTER, 1997).

The composites represent a case of matter importance inside of the group of the mixtures polymeric, where, in a general way, it can be said that constitute a class of heterogeneous materials. Given your vast application, special attention has been given all over the world by researchers, in the sense of to get better and to create new way materials the one that a range every time larger of that important material is had and with this, to increase the consumption perspectives (MANO, 2000).

The principal elements that are part of the structure of the composites: reinforcement - gives larger responsibility in the load support. Matrix - responsible for the form of the piece and some properties physical-chemistry polymeric. The reinforcement can be of nature organic or inorganic (metallic or ceramic), in way regular or irregular. In general the same is available in the form of fibers (fabric or no-fabric) or particles (spherical, plane…). The matrix is almost always a polymeric one organic soft or hard, thermoplastic or thermo fix, could also be metallic or ceramic. The paper of the matrix in the transfer of the applied load to the reinforcement is of highest importance, since the same feels through the interface reinforcement /matrix.

3. MATERIALS AND METHODS

Aiming at the production of the composite for development of the research in subject, it was used scrape of tire originating from of recycled residue to serve as reinforcement and the natural rubber (latex) to serve as matrix polymeric.

3.1. Reinforcement

As reinforcement, was used scrapes of tire (figure 1), obtained through the process of tire recycled, supplied by tire companies, located in the city of Natal - Brazil.

Figure 1. Scrapes of tires.

3.2. Matrix

As matrix, was used natural rubber (latex), originating from the Amazonian - Brazil. Where was extracted of *Hevea Brasiliensis* (Figure 2).

Figure 2. Extraction of natural rubber (latex).

3.3. Composite

For production of the composite the tire residue was used scrapes with aleatory distribution, interfering in this residue, the natural rubber (latex) as matrix polymeric. Composites were manufactured in the proportions 1:2 (33:67%); 1:1 (50:50%) and 2:1 (67:33%) (Scrapes of tire : latex) (table 1), kindred that roots possible to identify the advantages and disadvantages of the increase or decrease of the proportion of the reinforcement or matrix.

Table 1. Composition of the composites.

Composites	**Reinforcement/Matrix**
Composite 2:1	67:33%
Composite 1:1	50:50%
Composite 1:2	33:67%

3.4. Production of the composite blankets

For the production of the composite blankets, the scrape of tire and the latex they were heavy in the wanted proportions, mixed until the formation of a pasty mass and placed in forms of steel of geometry rectangular 25 cm of length, 12 cm of width and 1 cm of thickness. After approximately 24 hours of cure the blankets were removed in the ways and they were ready for used, as can be observed in the figure 3.

Figure 3. Composites 1:2; 1:1 and 2:1 (scrape of tire - latex) respectively.

3.5. Deformation and temperature

To determine the suffered deformation for the composites, under simultaneous action of load and of temperature variation of 25ºC at 120ºC, with rate of heating of 15 ºC/min, a term-mechanic analyzer was used (DMA) of mark Instrument DMA Q800 V20.6 Build 24A with uncertainty of 1%. All the samples had length of 35 mm, width of 10 mm and thickness of 5 mm, which were fastened in the extremities. The methodology is in consonance with the procedures recommended by the manufacturer of the equipment. Were analyzed samples of natural rubber (latex) and composites 2:1 (33:67%); 1:1 (50:50%) and 1:2 (67:33%). The rehearsals were accomplished in Lab. of Polymeric in INEGI / University of Engineering of the Porto - FEUP - Portugal.

3.6. Resistance to the flow of heat in hot systems

The variation of greatness temperature along the mass of a material die characterizes the gradient of temperature of that material, which is associated to the resistance of that material to the flow of heat.

For analyses of this property a source of heat was used in a circular pin of steel carbon 1020 with 20 mm diameter, 120 mm length and a source of potency of 1100 watts. Involving the warm circular pin the composite was placed of scrape of tire and latex in the proportions 1:2 (33:67%); 1:1 (50:50%) and 2:1 (67:33%) in form of blanket of 10 mm of thickness, as it can be observed in the figure 4 and 5.

The experiment was accomplished in Lab. of Mechanics of the Fluids / Federal University of Rio Grande do Norte - UFRN - Brazil, and it was accomplished in agreement with the norm ASTM C-518-76.

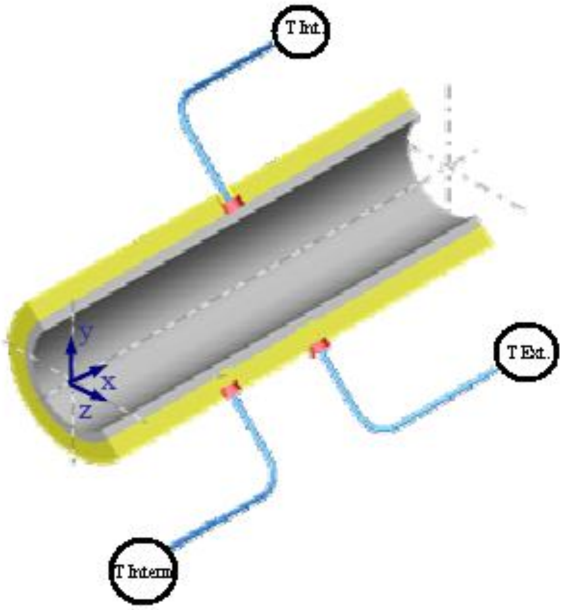

Figure 4. Outline of distribution.

Figure 5. Details of the experiment.

4. RESULTS AND DISCUSSION

4.1. Deformation x temperature

Verified through the technique of analysis term-mechanic (DMA), that the natural rubber (latex) obtained a modulate of storage of 0,969 MPa (±0,01), was also possible to observe that due to your discharge elasticity the latex it suffers little variation under the action of the temperature, obtaining a behavior practically constant. Already for the composite 2:1 was obtained a modulate of storage of 2,733 MPa (±0,02), for the composite 1:1 a modulate of 3,899 MPa (±0,03) and the composite 1:2 a modulate of 2,631 (±0,02), as it can be observed in the figure 6.

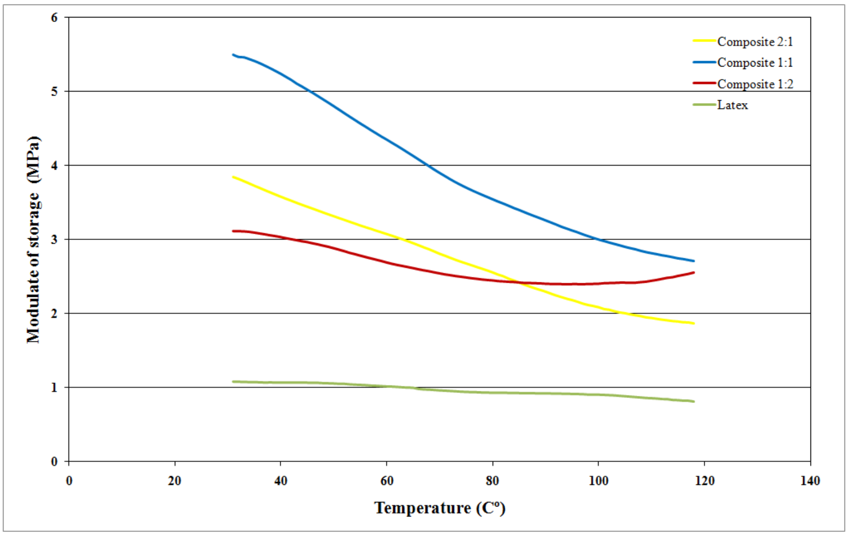

Figure 6. Behavior of the composites under action of the temperature and of loads.

Comparatively the composite 1:2 was what suffered minor it influences of the temperature with load application, tends to 120ºC modulate of storage similar to the of the composite 1:1, that is due to the largest tenor of latex, increasing the elasticity of the composite. The composites 1:1 and 2:1 obtained a variation with relationship to the temperature fellow creatures increase. The composite 1:1 obtained the largest modulate of storage, however was also what suffered larger variation under action of the temperature. The composite 2:1 was what obtained minor modulate of storage, owed mainly the great number of empty spaces in your surface.

4.2. Resistance to the flow of heat in hot systems

The low diffusion of the heat on the part of the composite was proven when in the analysis of the temperature gradient in the composite. It was verified in the experiment that, for the composite 2:1 (scrapes of tire - latex) a temperature of 172ºC in the interface warm pin - composite, followed by values of 110ºC and 99ºC for distances of the interface of 5 mm and 10 mm respectively. In that way, it was obtained a difference of temperature of 73ºC as it can be observed in the Figure 7.

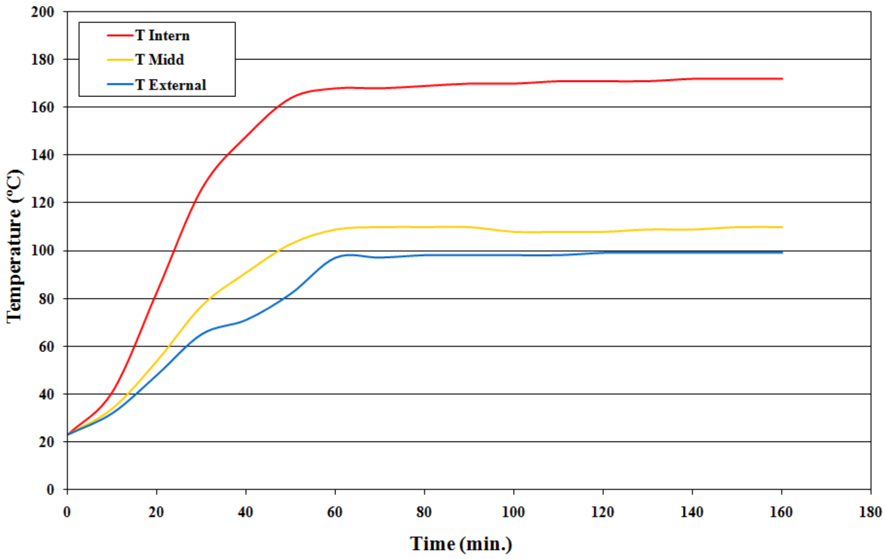

Figure 7. Gradient of temperature of the composite 2:1.

For the composite 1:1 (scrapes of tire - latex) a temperature of 172ºC in the interface warm pin - composite, proceeding respectively of the values 89ºC and 59ºC for distances of the interface of 5 mm and 10 mm. In that way, it was obtained a difference of temperature of 113ºC as it can be observed in the Figure 8.

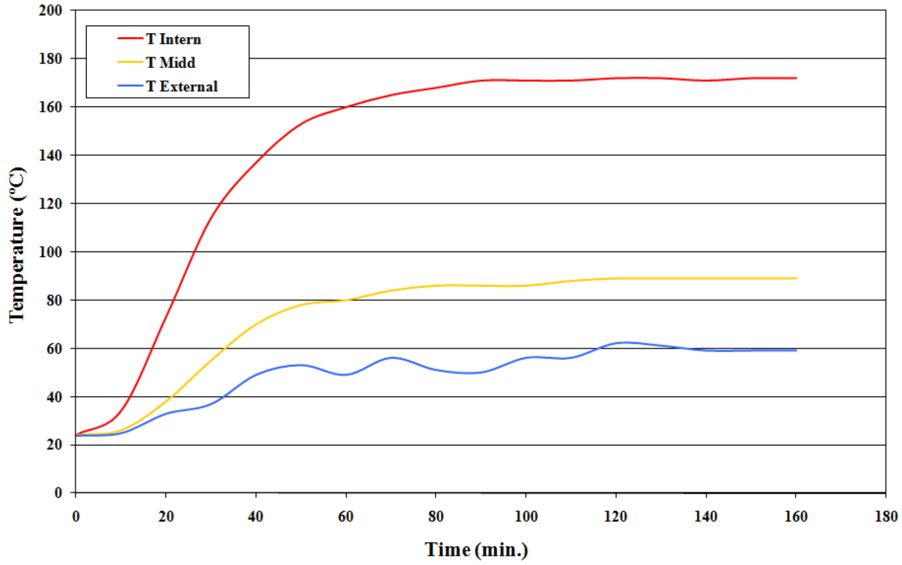

Figure 8. Gradient of temperature of the composite 1:1.

For the composite 1:2 (scrapes of tire - latex) a temperature of 171ºC in the interface warm pin - composite, proceeding respectively of the values 99ºC and 81ºC for distances of the interface of 5 mm and 10 mm. In that way it was obtained a difference of temperature of 90ºC as it can be observed in the Figure 9.

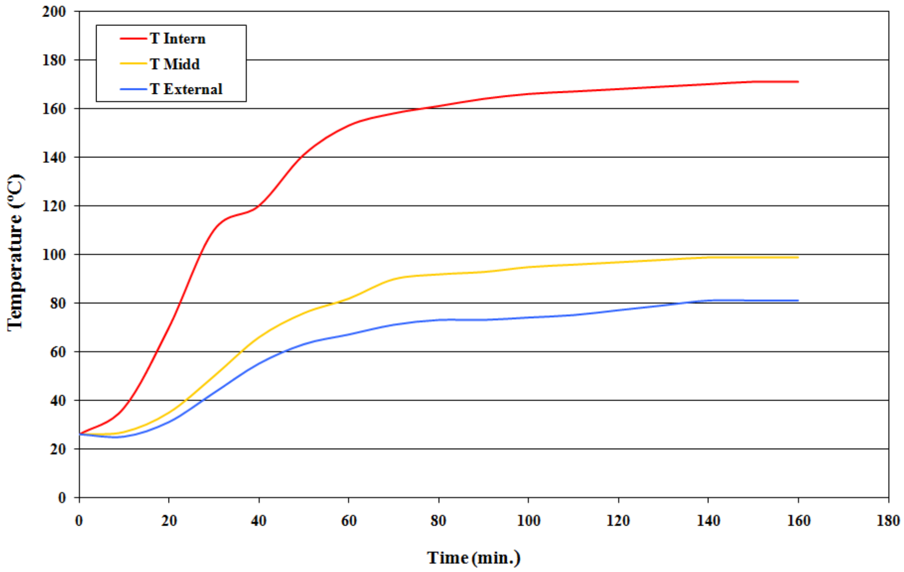

Figure 9. Gradient of temperature of the composite 1:2.

Therefore, it was verified that the composite 1:1 obtained the best acting among the analyzed proportions, with a difference of temperature of 113ºC in only 10 mm of thickness of the analyzed material, in other words, of the insulating thermal, denoting the characteristic of retention of heat of the same clearly.

4.3. Thermal conductivity

The analyses of the thermal conductivity, one of the most important properties of the insulating ones thermal, they showed values differentiated among the composite 2:1; 1:1 and 1:2. These small differences were related to the differences among the densities and to the humidity of the samples.

For the composites with proportion 2:1 (67:33%); 1:1 (50:50%) and 1:2 (33:67), the values of 0,033 W/mK (±0,001); 0,034 W/mK (±0,002) and 0,038 W/mK (±0,002) respectively for the thermal conductivity, where the small variation in the value is associated to the variation in the densities of the same ones.

In a general way, the value of the thermal conductivity of the composites oscillates around a medium value of 0,035 W/mK (±0,002). in other words, close to you value of other insulating ones diffused commercially as: glass wool (0,039

W/mK), stone wool (0,036 W/mK), porcelain (1,04 W/mK), asbestos (0,173 W/mK), polyurethane (0,033 W/mK), EPS (0,036 W/mK), among others. (KREITH, 2008).

Therefore, it is ended that the composites have a value of thermal conductivity that classifies it as a good insulating material for thermal applications; as it can be observed in the table 2.

Table 2. thermal Conductivity of the composite and of some insulating ones thermal.

Material	**Composite 1:2**	**Composite 1:1**	**Composite 2:1**	**Stone wool***	**Glass wool***
K (W/mK)	0,033	0,034	0,038	0,036	0,039

*KREITH(2008)

4.4. Calculation of the thermal diffusive

Another important thermal property associated to the insulating materials, the thermal diffusive, was also analyzed. For the calculation was considered values of K=0,033 W/mK,, ρ=668 Kg/m3 and cp=990 J/KgK, for the composite 2:1 (67:33%); values of K=0,034 W/mK, ρ=860 Kg/m3 and cp=990 J/KgK for the composite 1:1 (50:50%) and values of K=0,038 W/mK, ρ =922 Kg/m3 and cp=991 J/KgK for the composite 1:2 (33:67%). In that way, the representative thermal diffusive for these materials were of 0,00017 m^2/h; 0,00015 m^2/h and 0,00015 m^2/h for the composites 2:1; 1:1 and 1:2, respectively; compatible values with the one of thermal insulating materials found commercially such as: glass wool (0,00011 m^2/h), stone wool (0,0009 m^2/h), cork (0,00055 m^2/h) (KREITH, 2008). These low values express well the little capacity of transfer of heat and high capacity of storage of energy on the part of the composites, enabling them be used it as thermal insulating materials, as observed in the table 3.

Table 3. Thermal diffusive of the composites and of some insulating ones thermal.

Mat.	**Composite 2:1**	**Composite 1:1**	**Composite 1:2**	**Stone wool***	**Glass wool***
Thermal diffusive (m^2/h)	0,00017	0,00015	0,00015	0,0009	0,00011

*KREITH (2008)

5. CONCLUSIONS

- The composites can be used as insulating thermal so much for applications in hot systems, with temperatures of work of 200ºC.
- Among the analyzed composites, the 1:1 came as the most appropriate for end of thermal isolation, in hot systems (up to 200ºC), due to the best thermal stability.
- The certain values experimentally of 0,033 W/m.K; 0,034 W/m.K and 0,038 W/m.K for the thermal conductivities of the composites 2:1; 1:1 and 1:2, respectively, they classify the same ones as thermal insulating materials.
- The proximity among values of properties as specific heat and thermal diffusive of the composites 2:1; 1:1 and 1:2, and of insulating thermal commercially available, it proves the technical viability of the composite as insulating thermal.

6. ACKNOWLEDGEMENTS

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