Design Modification and Analysis of Performance of Heat Exchanger by Replacing Copper Tubes with Polymer Tube and Composites Material- A Review

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Abstract

The paper compares the polymer heat exchangers to the current technology in metallic heat exchangers. A review of state of the art of polymer heat exchangers is presented and technological problems are identified. In a current metallic heat exchangers copper tube is used for transferring the heat exchangers, copper tube is used for transferring the heat. Since the thermal conductivity of the copper tube is high so when the copper tube transfers the heat there are some heat losses. The thermal expansion coefficient of the copper tube is high so when the high temperature is achieved into the copper tube than the shape and size of the copper tube also changes. Copper is a reactive metal so when the chemical treatment process is done for removing the chocking defect, copper metal react with the chemical so strength of the copper tube will be decrease. In this simulation models were developed and used to explore the thermal-hydraulic, packaging and weight tradeoffs associated with polymer heat exchangers. Finally, the results are used to provide essential background for deciding if and where to allocate resources to more detailed analyses and prototype development.

Keywords: Polymer, Heat Exchanger, Copper Tube, Composite Material.

I. INTRODUCTION

A heat exchanger is a device built for efficient heat transfer from one medium to another. The media may be separated by a solid wall, so that they never mix, or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, natural gas processing, cryogenics applications and sewage treatment. One common example of a heat exchanger is the radiator in a car, in which the heat source, being a hot engine-cooling fluid, water, transfers heat to air flowing through the radiator (i.e. the heat transfer medium). The conductivity of polymer tubes in heat exchangers is ~1000 times less than their metallic counterparts. But polymer/non-metallic heat exchangers could offer such benefits as design freedom, low thermal expansion, chemical resistance etc.Thet teleconferences also called attention to several other applications of polymer heat exchangers which are under development for Applicat.

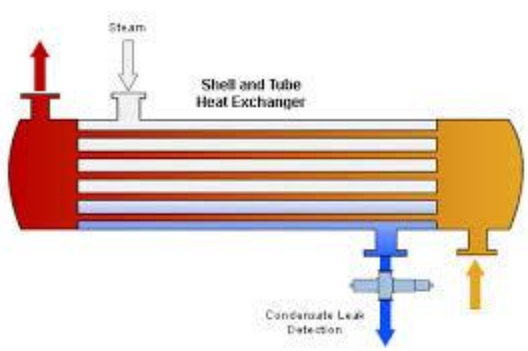

Fig. 1: Shell and Tube Heat Exchanger

It is clear that the state of the technology of the polymers, which can be used with standard refrigerants like R134A, R22 or R410A, is still in its premature stage because of issues relating to diffusion of the refrigerant and high pressure requirements. Laminated tubes composed of layers impermeable to refrigerant, water and other gases would probably be needed – perhaps similar to those needed to prevent diffusion through vacuum panel insulation where the pressure differentials are actually much smaller.

A. POLYMERS

Polymers are substances made up of recurring structural units, each of which can be regarded as derived from a specific compound called a moanomer.The number of monomeric units usually is large and variable, each sample ofa given polymer being characteristically a mixture of molecules with differentmolecular weights. The range of molecular weights is sometimes quite narrow,but is more often very broad. The concept of polymers being mixtures of moleculeswith long chains of atoms connected to one another seems simple andlogical today, but was not accepted until the 1930's when the results of theextensive work of I-I. Staudinger, who received the Nobel Prize in Chemistryin 1953, finally became appreciated. Prior to Staudinger's work, polymerswere believed to be colloidal aggregates of small molecules with quite nonspecificchemical structures.

B. COPOLYMERS

When polymerization occurs in a mixture of monomers there will be competition between the different kinds of monomers to add to the growing chain and produce a copolymer. Such a polymer will be expected to have physical properties quite different from those of a mixture of the separate homopolymers. Many copolymers, such as GRS, ethene-propene, Viton rubbers, and Vinyon plastics are of considerable commercial importance.

II. LITERATURE REVIEW

(1) Enhanced mechanical properties of polymer-matrix nano composites reinforced by grapheneinclusion: A review.B L.A.Ovid'KO Rev.Adv.Mater.Sci.34 (2013)19-25

In this paper represent a short overview of recent research efforts addressing the mechanical properties of polymer-matrix Nano composites containing grapheme inclusions. A particular attention is devoted to experimental data giving evidence for enhancement of tensile strength, Young modulus and Fracture toughness due to the effect of grapheme inclusions due to the effect of grapheme inclusions in such film and bulk nano composites. Due to the effects of grapheme inclusions, severalimportantmechanical characteristics (tensilestrength,Youngmodulus and fracture toughness)of grapheme-polymer Nano composites significantlyincrease at expense of some decreasein plasticity, as compared to pure host polymers.

(2) Electrical and thermal conductivity of polymers filled with metal powder. Ye.P.Mamunga, V.V.Davydenko, Pepsis, E.V.Lebedev European Polymer Journal 38 (2002) 1887–1897.

In In this paper The electrical and thermal conductivity of systems based on epoxy resin (ER) and poly(vinyl chloride) (PVC) filled with metal powders have been studied The composite preparation conditions allow the formation of a random distribution of metallic particles in the polymer matrix volume for the systems ER–Cu, ER–Ni, PVC–Cu and to create ordered shell structure in the PVC–Ni system. One of the most important characteristics of the fillerpolymercomposite is the filler packing factor F. The value of F depends on the particle shape and on the possibility of the skeleton or chained structure formation.

$$F = V_f/(V_f + V_p)$$

The parameter F is a limit of system filling and equal to the highest possible filler volume fraction at agiven type of packing.whereVf is the volume occupied by the filler particles at the highest possible filler fraction and Vp the volume occupied by the polymer (space among filler particles).For statistically packed monodispersed spherical particles of any size, F is equal to 0.64. F decreases in thecase of deviation of particle shape from the sphericalone, as well as in the case of formation of the volumefiller skeleton structure, due to increase of Vp. The use ofpolydispersed filler particles results in the increase of F.

(3) Polymer-Tube-Bundle Heat Exchanger for Liquidto-Gas Applications, Younggil Park, Anthony M. Jacobi, International Refrigeration and Air Conditioning Conference (2007).

A polymer-tube-bundle heat exchanger was conceptualized as a potential replacement to a conventional metallic plate-fin-and-tube heat exchanger for water-to-air applications. The lower thermal conductivity and mechanical strength of polymers were systematically overcome by employing a larger number of thin-walled small-diameter tubes. An optimal geometry was not found within the parameter space covered in the present study. However, are fined model capable of yielding a design optimum may be obtained by including other factors such as manufacturing cost.Major benefits of polymers as heat exchanger materials are: (1) reduced weight and cost, (2) manufacturing flexibility for complex designs, and (3) chemical stability. The main weaknesses of polymers in comparison to more conventional heat exchanger materials (i.e. metals and alloys) are low thermal conductivity and strength. If the metallic materials of a heat exchanger are simply replaced by polymers without any design modifications, significant increase in the overall heat transfer resistance will result. For this reason, polymer heat exchangers can require a larger surface area (and volume) than the conventional metallic counterparts unless the design is changed. In addition to the low thermal conductivity, comparatively lower limits of operating temperature or mechanical strength are the weaknesses of polymers. The use of polymer-based composites can mitigate these thermal and structural issues and improve thermal conductivity. However, such composite materials may not be as attractive in terms of material cost and manufacturing, and their usage should be justified by other benefits such as reduced weight or chemical stability.

(4) Mechanical and thermal properties of polymer composites based on natural fibers: Moroccan hemp/ fibers polypropylene, A.Elkhaoulani, F.Z.Arrakhiz , K.Benmoussa , R.Bauhfid , A.Qaiss,(2013)

In this paper the torsion tests were carried out for hemp fibers polypropylene composite and the compatibilized composite at different fiber content. A gain of 50% on the young's modules of pp. /hemp 25 wt. % without coupling agent and 74% on the pp./hemp 20 wt.% composite with the coupling agent wear found. Tensile strength curve shows a remarkable stabilization when the coupling agent was used. The values of tensile properties, such as Young's modulus, tensile strength, for binary and ternary composites compatibilizedSEBS-g-MA are summarized in Fig. 4a and b. Fig. 4a illustrated the evolution of the Young's modulus of the composites, a marked increase in the Young's modulus was observed for PP/hemp fibers (Alk) up to 1562 MPa at 25 wt.% when compared to the neat PP(1034 MPa). In the presence of SEBS-g-MA an increase in Young's modulus with fiber content is marked, until it reached one maximumpoint at 20 wt.% (1796 MPa) which is attributed to the good adhesion between fibers and the matrix. It is worth to notice that the interactions between the PP matrix and the hydroxyl groups on cellulosic fibers are enhanced as the fiber weight percentages increased.

(5) Mechanical properties of polymer modified lightweight aggregate concrete,Joao A Rossignolo , Marcos V.C.Agnesin Concrete Research 32 (2002) 329–334.

In this paper deals with the properties of styrene-butadiene rubber(SBR) modified lightweight aggregate concretes(LWAC) for thin precast components ,made with two Brazilian lightweight aggregates(LWAS) properties in the fresh state , compressive strength ,slotting tensile strength ,flexural strength and water absorption of LWACs were tested.Polymer-modified concrete (PMC) has been a popularconstruction material due to its excellent properties incomparison with ordinary concrete. Polymers are used inproducing PMC in order to improve its workability,drying shrinkage, strength, and durability. Recentpapers by Ohama and Fowler review the recentdevelopments and uses of PMC. However, there are a fewstudies about the use of polymer on lightweight aggregateconcrete (LWAC).

(6) *Mechanical properties of continuous natural fibre-reinforced polymer composites***.** P.JHerrera-Franco,A Valadez-González. Composites: Part A 35 (2004) 339–345.

The The mechanical behaviour high density polyethylene (HDPE) reinforced with continuous henequen fibres (*Agave fourcroydes*) was studied. Fibre-matrix adhesion was promoted by fibre surface modifications using an alkaline treatment and a matrix preimpregnation together with a silane coupling agent. The use of the silane coupling agent to promote a chemical interaction, improved the degree of fibre-matrix adhesion. However, it was found that the resulting strength and stiffness of the composite depended on the amount of silane deposited on the fibre. A maximum value for the tensile strength was obtained for a certain silane concentration but when using higher concentrations, the tensile strength did not increase.The mechanical properties,specifically, the tensile strength did not improve significantlywhen high silane concentrations were used to treatthe fibresurface. The increase in the mechanical properties.Effect of various fibre surface treatments on the flexural modulus ofHDPE–henequen composites.Fig. 8.Effect of various fibre surface treatments on the shear strength ofHDPE–henequen composites. Scanning Electron Microscope photographs of the failure surface ofcomposite materials with longitudinally oriented fibre tested in shear: (a)with fibre without any surface treatment; (b) with silane treated fibreranged between 3 and 43%, for the longitudinal tensile andflexural strength and a 339% increase in the stiffness valuesas compared to the stiffness of the HDPE matrix. Thecontribution of the henequen fibres to the compositelongitudinal stiffness was lower than that calculated by therules of mixtures.

III. CONCLUSION

In general the researchers give different polymer and composite properties and reinforced structure for improving the thermal and mechanical properties. Young-Gil Park and Anthony Jacobi has given the review of polymer tube bundle heat exchanger and also given some specification of heat exchanger. Following are the some points which shows the entire review of the above research's paper and thesis. Researchers outlined thermal and mechanical properties of the polymer and composite material.
Some researchers has developed reinforcement structure and various composite material structure to improve various properties. Some researcher has also improve the mechanical properties of natural fibre reinforcement polymer composites and natural fibres: Moroccan hemp/fibers polypropylene. As per review of research papers, we can see that research focus on polymer and composite material for their good properties. After study of many research papers and market survey, it should show that if we use the polymer material or composite material instead of copper tube then we improve performance of the heat exchanger.

REFERENCES

[1] Bra L.A.Ovid'ko (July 03 ,2013)"Enhanced mechanical properties of polymer-matrix nano-composites reinforced by graphene inclusion:A revie.", Rev.Adv.Mater.Sci.34(2013)19-25
[2] Ye.P.Mamunga, V.V.Davydenko, P.Pissis, E.V.Lebedev(Febuary 07 ,2002)"Electrical and thermal conductivity of polymers filled with metal powder",European Polymer Journal 38 (2002) 1887–1897
[3] Younggil Park , Anthony M. Jacobi(January 2011)"Polymer-Tube-Bundle Heat Exchanger for Liquid to-Gas Applications",International Refrigeration and Air Conditioning Conference.
[4] A.Elkhaoulani , F.Z.Arrakhiz , K.Benmoussa , R.Bauhfid , A.Qaiss(January 23 ,2013) "Mechanical and thermal properties of polymer composites based on natural fibers:Moroccan hemp/ fibers polypropylene",journal homepage: www.elsevier.com/locate/matdes.
[5] Joao A Rossignolo , Marcos V.C.Agnesini (February 28 , 2002)"Mechanical properties of polymer modified lightweight aggregate concrete",Cement and Concrete Research 32 (2002) 329–334.
[6] P.J Herrera-Franco, , A Valadez-González(November 19 ,2003)"Mechanical properties of continuous natural fibre-reinforced polymer composites", Composites: Part A 35 (2004) 339–345.