

A Paper on the Analysis of Effect of Material Used In Heat Exchanger and Its Performance

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Abstract- Heat exchangers are one of the most important devices of mechanical system which involves exchange of heat between two fluids. A power plant chemist/engineer has many choices when selecting tubing materials for heat exchanger. Most industrial process the transfer of heat to be controlled by the use of suitable heat exchanger material. This paper concerned with the study of different types of reliable material used in heat exchanger. AURUBIS offers high-performance foil and strip of the finest quality and with the tightest tolerances for industrial heat exchangers. In material science ceramics and ceramic matrix composite open opportunities for new heat exchanger designs. In air-conditioning and energy-recovery applications, heat exchangers are very important to the overall efficiency, cost, and size of the system. Some research directed toward using ceramic materials for heat exchangers in other applications.

Key Words: Heat exchanger, ceramic material, Fluid, performance.

1. INTRODUCTION

Heat exchanger is the equipment that permits to transfer heat from a hot fluid to a cold one without any direct contact of fluids. Heat exchangers are commonly used in practice in a wide range of applications, from heating and air conditioning systems in a household, to chemical processing and power production large plants. The Performance of heat exchanger defines the system efficiency & optimization of operating costs and It is depends on the operating variables and specification of Heat Exchanger [1]. The heat exchanger is governed by various parameters like mass flow rates, pressures and temperatures of working fluids, etc. Heat exchanger effectiveness takes into consideration the limitations of heat transfer between two heat exchanging streams due to these parameters. There are various types of heat exchanger used in industry like as shell and tube type Heat Exchanger, Plate Heat exchanger [2].

2. AURUBIS HEAT EXCHANGER MATERIAL

AURUBIS is the world's leading supplier of thin gauge copper and copper alloy strip for the heat exchanger industry. AURUBIS offers high-performance foil and strip of the finest quality and with the tightest tolerances for industrial heat exchangers. Copper from AURUBIS is the preferred choice for BRAZED PLATE and FINNED TUBE HEAT EXCHANGER due to its excellent thermal conductivity, high corrosion resistance, high pressure resistance, Smooth braze

ability foil and strip of the finest quality. The ability to withstand harsh conditions can be improved by AURUBIS state-of-the-art surface coatings. AURUBIS offer in-house surface coatings (hot-dip tinning and electroplating) as well as additional surface coatings via service partner offers a wide range of Cu+ alloys in thin gauges with antimicrobial properties for use in air conditioning (AC)[3].

3. CERAMIC MATERIAL

Solid material should promise for use in heat exchanger scan generally divided into four categories polymers, metals, ceramics and carbonaceous materials. Current ceramic materials (both monolithic and composite) are used in heat exchangers. Ceramic materials are inorganic non-metallic materials made from compounds of a metal and a non metal. Ceramic materials may be crystalline or partly crystalline. They are formed by the action of heat and subsequent cooling.

3.1 Composite Ceramic Material

Composite materials are constructed of two or more materials, commonly referred to as constituents, and have characteristics derived from the individual constituents. The constituent that is continuous and which is often, but not always, present in the greater quantity in the composite is termed the matrix. These co constituent is referred to as the reinforcing phase, or reinforcement, as it enhances or reinforces the properties of the matrix. The American Society for Testing and Materials

(ASTM) defines a ceramic materials “an article [whose] body is produced from essentially in organic, non-metallic substances and either is formed from a molten mass which solidifies on cooling, or is formed and simultaneously or subsequently matured by the action of the heat. By combining matrices with thermally conductive reinforcements such as special carbon fibers, silicon carbide particle, sand diamond particles, it is possible to create new materials with high thermal conductivity sand a wide range of coefficients of thermal expansion (CTE).

Silicon carbide, silicon nitride, alumina,, aluminum nitride, and ceramic matrix composites(CMC). Silicon nitride (Si_3N_4) exhibits excellent strength and creep resistance at elevated operating temperatures but may be limited by its ability to oxidation at temperatures exceeding $1000^{\circ}C$. Alumina (Al_2O_3) is very stable and highly resistant to chemical attack under both oxidizing and reducing conditions[4].

3.2 Common Ceramic Material Used

Table:-Thermal mechanical properties of various ceramic material [2].

properties	Density g/cc	Tensile strength, Mpa	Youngs Modulus Gpa	Rapture modulus Mpa	Flexural Yield Strength, Mpa	CTE, linear $20^{\circ}C$, $\mu m/m-K$	Thermal Conductivity, $20^{\circ}C$, W/m-k	Thermal Conductivity $100^{\circ}C$ W/m-K	Thermal Conductivity $1000^{\circ}C$ W/m-K
SiC	3.21		427			4.8			42
SiC			410		400	4.6			40
SiC	3.10		410		379				
SiC	3.10	186		110		4.6	125		
SiC	2.2-3.2					2.8-4.2		12.6-200	
Si_3N_4	3.20			690		3.5	3.0		
Si_3N_4	1.9-3.0					1.5-3.6		7-43	

4. ADVANTAGES OF CERAMIC MATERIAL

The main advantages for using ceramic materials in heat exchanger construction over more traditional metallic materials are their temperature resistance and corrosion resistance.

- Ceramic materials can with stand operating temperatures $1400^{\circ}C$ that is exceed for those of conventional metallic alloys.
- The second major advantage of ceramic-based heat exchangers is their resistance to corrosion and chemical erosion.
- Greater heat exchanger thermal conductivity.
- Higher strength for high pressure applications.
- Better long-term durability and general resistance to corrosion.
- Lower cost of maintenance when metal-work is required.
- More compact heat exchangers may be possible, due to higher strength and conductivity.

- Ability to be in contact with water (in heat pump water heater application).
- Ease of joining (brazing and soldering) and field repair, including transition joints. (Aluminum heat exchangers often require special and/or costly transition connectors to the system)[5].

5. SELECTION OF MATERIAL FOR HIGH TEMPERATURE HEAT EXCHANGER

- High temperature ferrite steels: - it can withstand the temperatures around $750^{\circ}C$.
- Advanced carbon and silicon carbide composites: - it has excellent mechanical strength to withstand temperatures exceeding $1000^{\circ}C$ [6].

6. SEVERAL FACTORS IMPACT THE TOTAL THERMAL EFFICIENCY OF THESE MATERIALS

- Actual wall thickness and corrosion allowance.

- Boundary layers on both the outer diameter and inner diameter surfaces can act as additional thermal resistances.
- Deposits can form creating additional resistances[7].

7. CONCLUSION

A number of factors need to be considered when selecting a tube material of the heat exchanger. They include corrosion and erosion, maximum temperatures, consideration of vibration and mechanical properties requirements. High temperature heat exchanger technology has become important for improving the performance of power generation. Possible uses for ceramic materials in heat exchangers merits are discussed. These materials increase overall heat transfer performance of heat exchanger. The total heat transfer performance improved by using small-diameter inner-grooved tubes with additive benefits from both internal surface enhancement and diameter reduction in ceramic material, but it has higher cost of ceramic tubes. These materials decrease fouling because these materials decrease the chance of deposition of metal inside heat exchanger. Stainless steels are the most cost-effective heat exchanger tube material. When all factors are considered in the material decision, these materials can provide service for the life of a plant.

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