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Review On Reliable Material For Heat Exchanger

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Abstract: A power plant engineer has many choices when selecting tubing materials for his condenser, feed water. Through this feed water corrosion may be occurs and this corrosion regularly dissolution of surface metal heater or balance-of-plant application. This paper provides an overview on a number of factors known to cause failure of a tube or pipe material. Knowing the limitations of material is crucial when making a selection for a specific application. Properties compared in this paper include corrosion resistance, stress corrosion cracking potential, thermal and mechanical properties, erosion resistance, vibration potential, and temperature limitations and various type of heat exchanger with their best suitable application and limitation are also listed in this guideline. Also some theories are included in this guideline.

Key word; Heat, temperature, material, properties, cost.

1. Introduction

The basic concept of a heat exchanger is based on the premise that the loss of heat on the high temperature side is exactly the same as the heat gained in the low temperature side after the heat and mass flows through the heat exchanger. Heat exchanger 'simply' exchanges the heat between those two sides; as a result, it is decreasing the temperature of higher temperature side and increasing the temperature of lower temperature side. But designing heat exchanger might be a challenge; it needs iteration for manual calculation. Hence, a guideline to properly select and sizing is needed. Many factors have to be considered in heat exchanger selection. Generally, suitability of types of heat exchanger to be used in processing industrials is selected based on TEMA (Tubular Exchanger Manufacturers Association) Standards. TEMA divides heat exchanger into classes based on their application. Comparison of each class in TEMA is summarised in this guideline. Besides, various type of heat exchanger with their best suitable application and limitation are also listed in this guideline. Selection might be done by referred to some valid standards or guideline, but understanding the basic concept and theory behind heat exchanger is also important. Furthermore, basic theories about heat transfer are also extremely needed to do heat exchanger sizing. Hence, some theories are included in this guideline. Selection and sizing are related each other; changing in heat exchanger component, such as tube pattern and baffle, would affect the calculation. Some required data is commonly pictured in a graph or listed in a table; they are already attached in this guideline as well. To do manual calculation, it is mentioned before, iteration is needed. This guideline gives some approximation values as a 'boundary' for iteration.

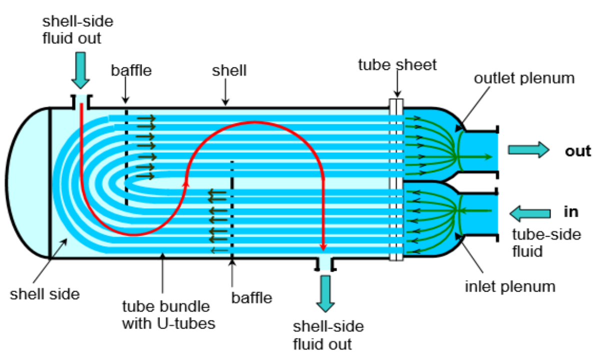

Figure1- *Heat Exchanger [1]*

2. Work of heat exchanger

1. To cool process streams
2. To heat process streams
3. To exchange heat between hot and cold process streams.

3. Corrosion

Corrosion may be grouped into two broad categories, general corrosion and localized corrosion accelerated by an electrochemical mechanism. The latter group can be divided into several well-known specific mechanisms. A heat exchanger can be designed to accommodate general corrosion, and in many instances, an alloy susceptible to this type of corrosion may be a cost-effective design option.

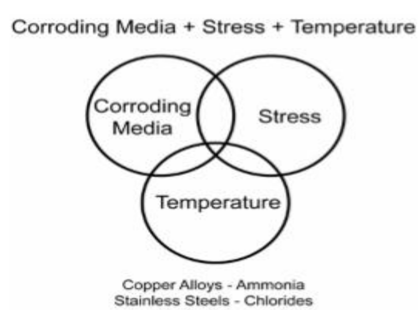

Figure2: *production of corrosion in the heat exchanger surface. [2]*

4. General criteria for material selection

The engineer making the materials selection must know all the aspects involved in the construction, operation and maintenance of the heat exchanger. The importance of this is illustrated with the following examples: an operator may isolate a heat exchanger with raw water for sufficient time to initiate a pitting corrosion; partial blockage of tubes, specially of small diameter, would result in stagnant conditions that may cause pitting in alloys that are so prone; fouling may result in operating the heat exchangers in throttled/part load condition. A general procedure that could be used for identifying the most appropriate material for a specific heat exchanger application would consist of the following steps.

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4.1. DEFINE THE HEAT EXCHANGER REQUIREMENTS

The engineer must consider the normal operating parameters (e.g.: nature of the fluids on both the tube and shell side, flow rate, temperature and pressure), start up and shutdown conditions, upset conditions, special conditions like product purity requirements, hazardous effects of intermixing of shell and tube side fluids, radioactivity and associated maintenance, etc.

4.2 ESTABLISH A STRATEGY FOR EVALUATING CANDIDATE MATERIALS

The main factors to be considered are cost and reliability. The minimum cost strategy would mean use of less expensive materials and rectifying the problems as they show up. Maximum reliability strategy would mean going for the most reliable material regardless of its cost. Both strategies have to be weighed against initial cost, loss due to possible shutdowns, repair cosies, indirect loss to other industries etc.

Identify candidate materials

It is desirable to narrow the field to a comparatively small number of materials for more extensive evaluation. There is no hard and fast rule as to how many candidate materials should be selected for detailed study. The initial identification and selection procedure, if done properly, will eliminate those materials which are unsuitable and those which are excessively expensive. This calls for use of operating experience.

Physical Properties

High heat transfer coefficient (requiring high thermal conductivity for tube material) - Thermal expansion coefficient to be low and as compatible as possible with those of the materials used for tube sheet, tube support and shell to provide resistance to thermal cycling.

Mechanical Properties

Good tensile and creep properties high creep rupture strength at the highest temperature of operation and adequate creep ductility to accommodate localised strain at notches are important. Good fatigue, corrosion fatigue and creep-fatigue behaviour. - High fracture toughness and impact strength to avoid fast fracture.

Corrosion Resistance

Low corrosion rate to minimise the corrosion allowance (and also radioactivity control in heat exchangers for nuclear industry) - Resistance to corrosion from off normal chemistry resulting from leak in upstream heat exchanger or failure in the chemistry control - Tolerance to chemistry resulting from mix up of shell and tube fluids.

4.3 Manufacture

Ease of fabrication is an important aspect for selection of materials. The usual manufacturing steps involved for heat exchangers are bending of tubes, joining of tube to tubesheet by rolling, welding or rolling and welding, forming of shell geometry and welding of shell plates and shell to nozzle and the heat treatments associated with the welding steps.

4.4 Operating Experience

A great deal of knowledge is gained by the operating experience of similar units. Lessons learnt from the failures of others is an important consideration in materials selection.

Evaluate materials in depth

After narrowing down the list of candidate materials (for tube, tube sheet, shell), the next step is to perform the design of heat exchanger with candidate materials so as to establish the initial cost. Also the failure probability with each design needs to be established so as to establish the outage cost.

Select the optimum material

Criteria for making the final selection will include an assessment of each of the following: - initial cost - maintenance cost, including consideration of how frequently the equipment will need to be inspected for corrosion - cost of loss in production - consequences of failure. Is failure likely to create unsafe conditions or cause discharge of an undesirable chemical Into the environment or serious repercussions to an emerging technology. Generally materials selection is based on qualitative comparisons of the candidate materials. However, it is worthwhile to make the assessment based on financial parameters. [3]

5. Design Consideration

(a) Operating temperature

The operating temperatures of the exchanger are usually set by process conditions. However, in certain cases, the exchanger designer will establish the operating temperatures. In a typical refinery or petrochemical plant, exchangers may be operating at temperatures as high as 1000°F or as low as -200°F. These limits are dictated by material considerations, safety, economics and ASME Code requirements.

(b) Effective temperature difference

The driving force for heat transfer is the “effective temperature difference," CMTD, between the hot and cold fluids. This temperature difference is calculated from the counter-current log mean temperature difference with a correction factor applied to account for the actual flow arrangement. Temperature approach Temperature approach is the difference of the hotside and coldside fluid temperatures at any point within a given exchanger. A temperature cross indicates a negative driving force for heat transfer between the fluids. It requires either a large area for heat transfer or high fluid velocities to increase the overall heat transfer coefficient. If outlet temperatures form a cross in a multi-tube pass heat exchanger, a lower than desirable LMTD correction factor will occur. A simple way to avoid this is to use more exchanger shells in series.

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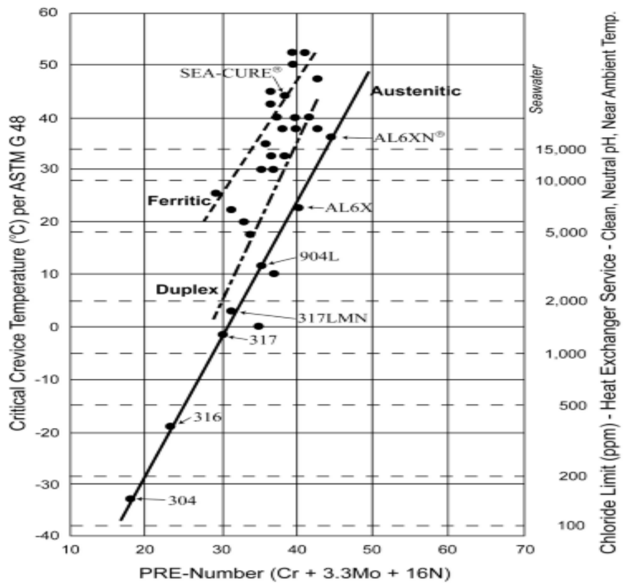

Figure3: *Critical Crevice Temperature and Maximum Chloride Levels versus PREn of Various Stainless Steels [4]*

(c) Fouling factors

The increased resistance to both heat transfer and fluid flow caused by deposits on a heat transfer surface is called fouling. Fouling works as an insulating layer on the heat transfer surface, reducing heat transfer efficiency (reduced duty) or decreasing available flow area (reduced throughput). The increased resistance to heat transfer is represented by a quantity referred to as the fouling thermal resistance, which is added to the total thermal resistance. The values of fouling thermal resistance have generally been observed to increase with time. To account for the effect of fouling on pressure drop requires an estimate of the fouling layer thickness.

(d) Pressure drop

The pressure drop through an exchanger is made up of two losses:

- the frictional loss due to flow, the losses due to changes in direction of flow and losses due to expansion and contraction into and out of nozzles and tubes.
- In some exchangers, a change in the vertical elevation of the fluid as it passes through the exchanger may cause a hydrostatic pressure loss or gain.

Conclusion

Stainless steels can be the most cost-effective heat exchanger tubing choice. A number of factors need to be considered including potential for corrosion and erosion, maximum temperatures, vibration potential, and mechanical property requirements. When all factors are considered in the material decision, now a preferable group of material is decided the life of plant and if it is right so we can say that the suitable material selection should be necessary for the life of the plant.

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