INFLUENCE OF STAINLESS STEELS CORROSION RESISTANCE ON THE SERVICE LIFE OF HEAT EXCHANGERS

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Abstract: *Highly important in the heat exchanger calculation is the choice of the materials to be used when making such an installation. The materials to be used largely determine the endurance and operating safety, having an impact on the constructive shape, manufacture technology and the costs. The paper presents the research results in order to establish the influence of austenite transformation into martensite during the stamping process on the corrosion resistance of heat exchangers. AISI 316 stainless steel was used for plates manufacture.*

Key words: *stainless steel, heat excenger, plate, stamping, crevice corrosion, austenite, martensite, transformation*

Introduction

This paper is focused on the influence of phase transformation of stainless steel on the corrosion resistance of heat exchanger plates.

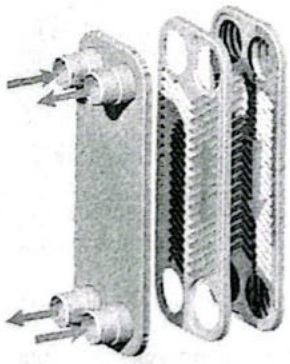

Figure 1 Heat excenger

The heat exchanges with removable plates (figure 1) are used in heating, warm weather production, air-conditioning units with working pressure and temperature of heating agents between safe working limits, depending on exchanger type.

The heat excengers were made out of AISI 316 stainless steel corrugated sheet plates, clamped together in a frame. (N.N.,1993).Between each pair of plates there is a rubber gasket, which prevents the fluids from mixing and from leaking to the surroundings.The extreme working pressure is 10 bars and the extreme working temperature is 150°C.

The manufacturer of heat excengers ensures the following characteristics (N.N., 1997)

- high heat exchange capacity on account of turbulent flow and plate small thickness;
- heat adjustment on account of the number of working plates, changeable;
- low risk for clogging and soiling on account of high turbulence;

- easy cleaning of plates, since they can be removed;
- easy detection of heating agent leakage;
- high grade materials;

AISI 316 stainless steel was used for plates manufacture. It has a good corrosion behavior, considering the fluid action (chlorine-treated water) in the district heating circuit as well as in the secondary circuits (Chesa, 1984, N.N., 1997). Even though AISI 316 stainless steel has a good corrosion resistance in the analyzed case a strong corrosion appeared on several plates and consequently the heat exchangers were damaged.

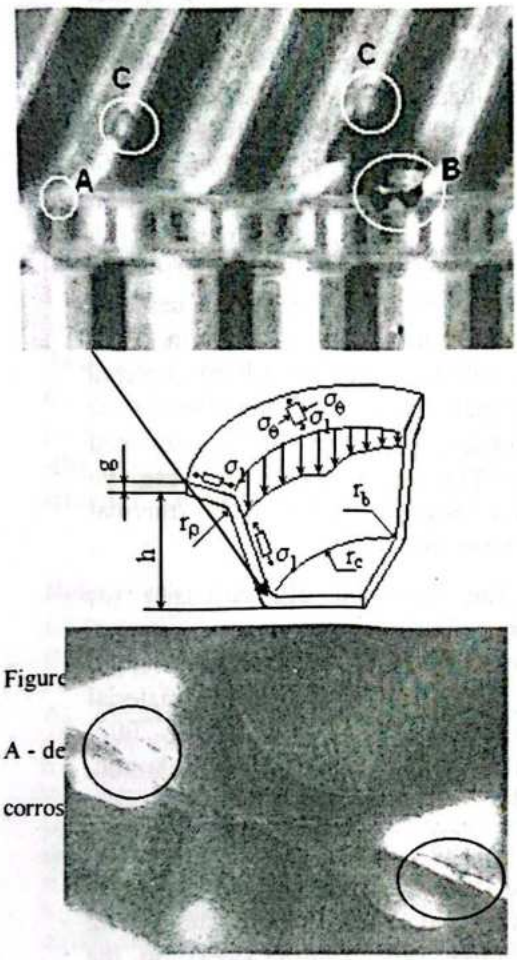

Figure .3. Traces of deformation tools

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using AISI 316 stainless steel, 0.8 mm thickness with the following prescribed

-sheet surface roughness before and after stamping process;

-roughness and geometric shape of stamping tools;

Analysis of plates manufacturing process

The analyzed heat exchanger plates with "chevron" were made out by stamping (figure 2) chemical composition: 17%Cr, 12%Ni, 2.5%Mo. The performed chemical analysis has given the following: 0.5 % C, 16.87%Cr, 10.53%Ni and 2.07%Mo. AISI 316 is an austenitic stainless steel from the CrNiMo type (Chesa, 1984; Gabrielson, 1999; N.N., 1993, N. N., 1999). Austenitic steels possess high plasticity characteristics and can be easily stamped at room temperature, however during cold processing, the hardening phenomenon may occur and that may or may not be in favor of further processing. It can be noticed that all areas of the plate were submitted to an unfavorable stretching (figure 2). That means for the stamping process only materials with a good plasticity are necessary. (Solomon, 2000; Teodorescu, 1980, 1992, 1994).

As a result of the stamping process the quality of stamped parts must be appreciated by both sides -inside and outside -roughness and by modification of basic sheet material properties. The quality of stamped parts depends on a several factors, such as (Solomon, 2000; Teodorescu, 1980, N. N., 1999):

-clearance of stamping tools;
-deformation rate
-grade and stucture of sheet material;

The quality of the stamped parts is influenced by the grade and the stucture of the deformed material. A material low plasticity, but still in prescribed domain,

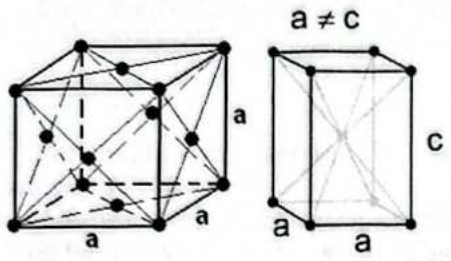

Figure 4 Face centered cubic a); Body-centered tetragonal b)

Figure 5 Corroded zone

combined with a die rough working zone or with an inadequate die dimensions (too small hollow radius, inadequate clearance, wearing, not lined up, etc), a high roughness will occur on the stamped parts. The matter is getting worse if the part is submitted to a static friction or if a bad lubricant is used during stamping process, as the small particles of the processed material could adhere to the punch and/or die surface and scratches on the processed surface could appear (figure 3).

Austenitic stainless steels are widely used alloys because of their superior mechanical properties. The final mechanical characteristics of deformed material are very important for an appropriate behavior of heat exchangers during their exploitation. An unexpected material hardness was noticed on the stamped plates. This happened because a phase transformation can occur in some metastabile austenitic stainless steels during room temperature deformation. Austenite (γ) which has a face centered cubic structure (fcc) was transformed into martensite (α) which has a body centered tetragonal structure and this affected the mechanical properties of the stamped plates. This transition between these two phases requires very little thermal activation energy.

The formation of martensite (α) during plastic flow within stamping process caused an increase in strength and hardness of deformed material (Ganesh, 1994; Mumtaz, 2003; Gabrielson, 1999, Gâdea, 1988, Solomon, 1999).

Analysis of plate's corrosion process

Heat exchange consists of pressed corrugated AISI 316 stainless steel plates which are assembled in a pack. The heating agent flows along every side of the plate to encrease thermal transfer efficiency.

The working conditions effect on the plates corrosion resistance, which leads to wear and inadequate running, and finally to shutdown.

Corrosion means breaking down of essential material properties as a result of material characacteristics and its various interactions with the surroundings during working life (Constantinescu, 1976; Leidkeiser, 1982; Zamfir, 1994). So, the material structure suffers damages and do no more comply with the customer requirements.

The material in the gasket area is often submitted to crevice corrosion, since the fluid is easily kept in the small space between the gasket and the material (figure 5).

Pitting is induced in the presence of crevices or impurities such as sand, dirt, etc. when the material is stainless steel.

Crevice corrosion is also likely to occur due to manufacture deficiencies such as inadequate tools which can detemine local damages or due to material structural trensformation. Phase transformation occurs in some metastabile austenitic stainless steels such as AISI 316, during plastic deformation proces at room temperature. Austenite is transformed into martensite and this affects the mechanical properties, especialy material hardness. This transformation does not occur in the whole plate, and conequently some local areas are harder than others. Martensite which is harder than austenite has a less corrosion resistance and therefore piting corrosion can easily appear in such areas (figure 2).

Crevice corrosion may vary in appearance from almost uniform attack up to pitting to the metallic surface inside the crevice.

Any aggressive solution (acid or neutral), including natural waters, but especially those containig chlorine anions are the ones resulting most frequently in this type of corrosion.

In the case of stainless steels the corrosion under tension determines the intergranular braking. As usually the cracks begin from the places hardened by plastic deformation.

Conclusion

Taking into account the above mentioned results we could conclude the following:

-heat exchanger corrosion resistance is mainly influenced by the fluid chemical properties.

-the martensite presence in the steel structure contributes to a special local hardness of heat exchanger plates and therefore can influence heat exchanger corrosion resistance;

-the material in the gasket area is often submitted to corrosion crevice, since the fluid is easily kept in the small space between the gasket and the material.

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