STUDY OF IMMUNITY CORROSION - PROOF STEEL USED IN FOOD INDUSTRY AGAINST WASHING AGENTS

Jitka PODJUKLOVÁ, Antonín ZÁVADA, René SIOSTRZONEK, Daniela PAVELKOVÁ, Lenka KOLDOVÁ

VSB-Technical University of Ostrava, Faculty of Mechanical Engineering, Department of Mechanical Technology, Ostrava, EU, Czech Republic, EU, jitka.podjuklova@vsb.cz, antonin.zavada@vsb.cz, rene.siostrzonek@vsb.cz, daniela.pavelkova@vsb.cz, lenka.koldova@vsb.cz

Abstract

The actual theme is study of immunity corrosion - proof steels used in food industry against corrosive environment of washing agents. The experimental work samples were used with two types of surface of the blade. Experimental part is focused on corrosion resistance where firstly corrosion test in water bath was implemented and subsequently the knives were washed in the dishwasher. Two distinct kinds of detergents were used for this test and as a part of the research water bath pH value was also measured. Subsequently a corrosion test according to the norm intended for cutlery testing was performed. In conclusion we can determine stainless steel suitable for use in manufacturing cutlery.

Keywords: Corrosions tests, washed in the dishwasher, knives blades, Finish Calgonit, cleanness

1. INTRODUCTION

Stainless steels are characterized by number of useful properties. These properties are also used in the food industry, where the products are used in contact with food. Hygienic suitability of materials is determined by the Ministry of Health, which indicates the hygiene requirements which are in their final form intended for contact with foodstuffs. The material of these food products does not have to release their constituents into the food in quantities which could cause of personal injury and at the same time cause of an unacceptable change in the composition of foods and affect their properties.

On the basis of the requirements are for products of steel materials specified maximum number of elements, namely: 21% Cr, 14% Ni and 10.5% Mn. Other steel materials that are susceptible to corrosion attack can be used only if they are protected with suitable coatings.

For these reasons is a stainless steel suitable and also used for articles in contact with food (for example dishes, cutlery, etc.).

2. STAINLESS STEEL IN CUTLERY MANUFACTURE

The most frequently used basic material for the cutlery manufacture is austenitic and martensitic stainless steel.

Selects the type of material depends on the functionality of the dining cutlery. For example, a spoon is less mechanical stresses than the blade of the knife. Blade of the knife is made of a mechanically more resistant material, therefore a martensitic stainless steel, which after the heat treatment has a significantly higher hardness. For the production of spoons and forks is suitable austenitic stainless steel.

The most commonly used is austenitic stainless steel with the designation X5CrNi 18-10, which contains 18% chromium and 10% nickel. This steel is used to make cutlery achieving high quality. It is very suitable for oxidation environments (at normal temperature for the contact with low concentration inorganic acids and with weak aerated organic acids). This steel is also used in the pharmaceutical and cosmetic industries, drinking water filling stations and in architecture.

Martensitic stainless steel with the designation X20Cr13 containing 13% chromium is another type of material used for the cutlery production. It is mainly used for the knife blades manufacture. Compared to austenitic stainless steel has lower chromium content. For products of this steel must be perfectly performed surface treatment to provide excellent corrosion-resistant properties. Knife blades cutlery will therefore most vulnerable to possible corrosion attack.

The following figure (**Fig. 1**) illustrates the polarization curve showing the corrosion behavior of stainless steel X5CrNi 18-9.

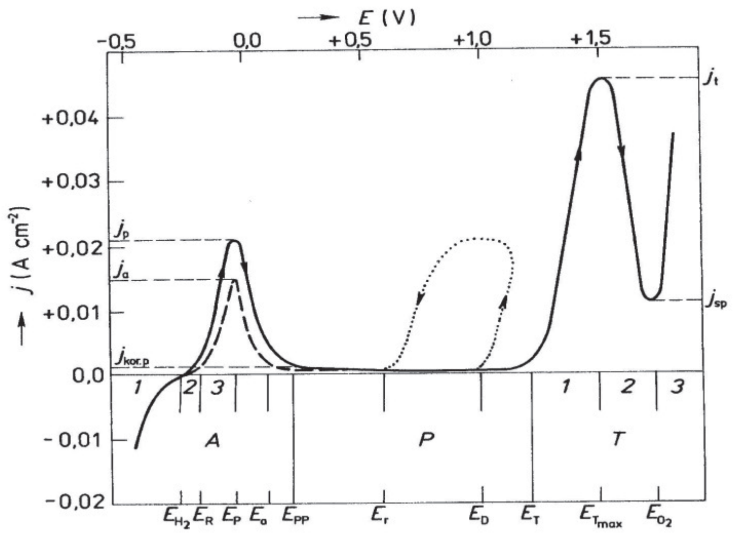

Fig. 1 Polarization curve of stainless steel [4]

The polarization curve shows the dependence of the electrode potential of the steel E and the electric current in the electrode-electrolyte interface. The area A represents the area of activity of the steel, i.e. an area of corrosion. Area P represents an area of passivity steel, i.e. an area where steel is corrosion protected. The last part T represents the area of transpasivity, i.e. an area which is again corrosion with maximum current density.

3. CUTLERY CORROSIVE ENVIRONMENTS

Cutlery as a result of their use appears in a various corrosive environments. In recent years there has been a significant expand of automatic dishwashers that cause unwanted corrosion attack cutlery, so we will focus only on the process of washing . In the process of washing are cutleries in contact with the corrosive environment, which is characterized by several factors - the type used in drinking water, type of detergent, washing method, temperature, etc.

As a concrete example we use two different detergents in tablet form, mixed with drinking water. Both detergents are designed for use in dishwashers.

3.1 FINISH Calgonit - Tablets

Ingredients: <5%: nonionic surfactants, phosphonates, polycarboxylates, perfume (limonene), 5-15%: Sodium percarbonate (oxygen bleaching agent), 15 to 30%: sodium carbonate,> 30% phosphates. Also contains: enzymes (protease - subtilisin, amylase). Hazardous substances: sodium carbonate, sodium percarbonate.

3.2 Soma MULTI-PERFECT - Tablets

Ingredients: > 30% phosphates, 5-15%: bleaching agents based on oxygen, polycarboxylates <5%: phosphonates, nonionic surfactants. Also contains: enzymes, perfume.

Water used for both detergents is removed from the water network. The composition of drinking water must correspond with hygienic limits. Very important indicator of drinking water is the size of the pH value, which is expressed by the degree of acidity or alkalinity.

The following table (**Table 1**) is given individual indicators prescribed limits for drinking water and the results of analyse used drinking water.

Table 1 Indicators values of drinking water [1]

Indicator	Unit	Limit values	The measured values
Temperature	°C		5,0
Color	Mg Pt / l	20	1,7
Turbidity	Zf (n)	5	0,8
pH		6,5 - 9,5	7,94
ChSK-Mn	mg / l	3	1,36
Fe	mg / l	0,20	< 0.05
Mn	mg / l	0,050	< 0.030
Al	mg / l	0,20	0.06
Fecal streptococci	KTJ / 100 ml	0	0
Kaliformn bacteria	KTJ / 100 ml	0	0

For measurement purposes were created washing concentrates when the detergent tablet was dissolved in 12 liters of water. The following table (**Table 2**) shows the results of measurement of pH of used water and the mixed detergent concentrate.

Table 2 The measured pH values [1]

	Water	Somat Multi - Perfect + 12 l water	Finish Calgonit + 12 l water
pH - 1st measurement	7,59	10,37	9,94
pH - 2nd measurement	7,64	10,26	9,82
pH - 3th measurement	7,61	10,29	9,89

The results in **Table 2** show the change of pH of the wash concentrate to an alkaline area: pH 10.31 of the detergent Somat Multi-Perfect and pH 9.88 for detergent Finish Calgonit..

The following figure (**Fig. 2**) shows the corrosion behavior of chromium (diagram of the relationship potential E - pH of the environment). If we draw the area in the diagram in which will be corrosion potentials of metals in solutions of sodium carbonate (major compound used detergents), we see that we are in passive area of chromium (green area). The passivity area means that corrosion of the material is suppressed by formation of a passive layer on the surface. The passive layer can fail, for example due to mechanical load, and in the site of the damage is causing corrosion - pitting. Corrosion is further supported by chloride ions contained in the water and macroclimate inside the automatic dishwasher during the wash (spraying, high humidity, elevated temperature).
The figure also shows that the upper area of the sodium carbonate is at the interface between the area of passivity and activity of chromium.

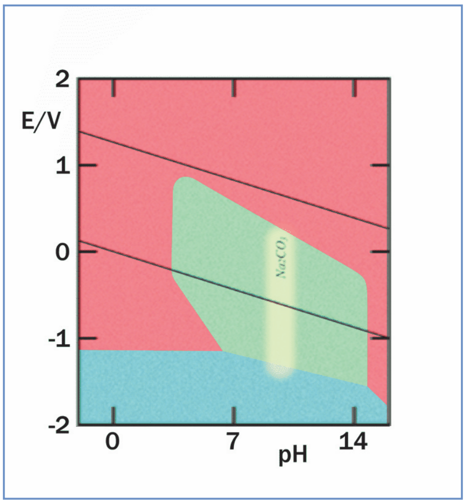

Fig. 2 Corrosion potentials of metals in solutions of sodium carbonate [3]

CONCLUSION

The development of modern technologies in the food industry brings a lot of benefits. One of these technologies is also automatic dishwashers that bring us one major advantage and it is save time. A significant disadvantage of this technology is a very common occurrence of corrosion corrosion-resistant materials used in the food industry for the manufacture of cutlery and dishes. The process of corrosion is undesirable phenomenon and it should be looking for ways to remove it. The article provides a basic overview of the effect of detergents on the corrosion resistance of stainless materials.

REFERENCES

[1] ZÁVADA, A. *Studium povrchové úpravy jídelních příborů.* Ostrava, 2012, 79 s. Diplomová práce. VSB - TU Ostrava. Vedoucí práce doc. Ing. Jitka Podjuklová, CSc.

[2] MOHYLA, M.: *Technologie povrchových úprav kovů*. Učební texty VSB-TU Ostrava, 2006. 3. vydání. 156 s. ISBN 80-248-1217-7.

[3] Diagram potenciál - pH pro chrom. In *VŠCHT* [online]. Vysoká škola chemicko-technologická v Praze. [17.3.2014]. Dostupné z: http://www.vscht.cz/met/stranky/vyuka/labcv/korozni_inzenyrstvi_se/atlas/kapitoly/potencial/obr/o037.htm

[4] ČÍHAL, V. *Mezikrystalová koroze ocelí a slitin.* SNTL Praha, 1984, 355 s.