Corrosion behaviour of stainless steel AISI 321 that comes into contact with food products, during lyophilisation process

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Lyophilisation / freeze drying, microstructure, aliments, stainless steel AISI 321, corrosion.

1. Introduction

During the processes that accompany lyophilisation, food comes in contact with components of the technical system, especially with the tray in which the food is placed. The tray plays a major role in the lyophilisation process, with important effects on the quality of the lyophilized food product. The progress made in the field of industrial equipment construction, for the purpose of freeze-drying food products (such as the mechanical or automated loading option) meant conceiving, designing and manufacturing trays with different shapes, sizes as well as made out of various materials [1,3].

The choice of metallic materials used to make the support of food suitable, optimizing the use as well as for the longest time, first of all, depending on the properties of the chosen material, which must be in accordance with the nature of the food, considered to have an aggressive potential over the food it comes into contact with. Thus, all the materials characteristics, the chemical composition, the structural state, the technological properties and, in general, the properties of the use, must be taken into account.

The materials used must comply with norms from the equipment construction in the food industry, must withstand demands arising from normal operation and maintenance of equipment for lyophilisation, which may be, as the case may be: mechanical friction, corrosion, erosion, thermal effect, penetration adhesion of parasites, bacteria, enzymes, impurities developed in the food environment. Active parts are considered to be those in direct contact with the food material subjected to lyophilisation. They must be harmless to the food material and resistant to stresses that occur during the processes that take place at lyophilisation.

The thermo-physical processes that take place during the freeze-drying process can cause temperature oscillations ranging from -85 to 100° C, and the selected metallic materials must have adequate properties and be resistant to both low and low temperatures [2,7].

2. Materials and methodes

Experimental research has as purpose the study of the metallic materials behaviour, when in contact with food during the lyophilisation process. The metallic material being: Chromium- Nickel Austenitic stainless steel plate, with titanium additions, 1.4541/X 6 CrNiTi 18-10/ DIN EN 10088/ DIN 17440, AISI 321/ BS, 321 S 31/ SIS 2337, thickness of 0.6 – 1.2 mm.

Microscopic analysis was performed using an INSPECT S electronic microscope.

The study of the behaviour of metallic materials in contact with food during freeze-drying lyophilisation process is done considering, both actual conditions in the industrial units as well as the particularities of laboratory facilities where lyophilisation of food has been achieved [4].

In contact with food, metallic materials may undergo certain changes, especially at the surface, largely due to corrosion. Foods can be aggressive to metals.

In general, corrosion is the phenomenon of partial or total destruction of materials following chemical or electrochemical reactions.

3. Results and disscusion

Experimental research was focused on the study of metallic materials in order to build trays used as support for food material during lyophilisation.

Following research on metallic food contact materials, several millions of lyophilisation processes resulted in the AISI 321 / BS stainless steel microstructure, 0.8 mm thick, in contact with various food products (figure 1) [5].

The propagation stage of a micro crater corresponding to the development of this localized corrosion; the attacked area consist of a micro-anode that will undergo a more or less rapid dissolution. Certain material couples are very sensitive to this corrosion: thus AISI 321 steel corrodes by pitting when immersed in an acid chlorinated environment; the additional molybdenum alloy (AISI 316Ti steel) increases the resistance to this attack [6].

4. Conclusions

Because the most frequent negative effect on the metallic material in contact with lyophilized food is corrosion, it has been necessary to analyse all possibilities of corrosion (reflected in the current literature) which can be obtained during lyophilisation. The study of metallic materials corrosion was carried out on theoretical considerations, on the basis of which corrosion assessment is considered. In order to study

the influence of corrosion on the constructive and operating solutions of the trays, we took into the influence factors of corrosion resistance [8].

By microscopic analysis the metal samples, investigated with the high performance equipment, we could notice the presence of corrosion through multiple manifestations, adding some unexpected aspects. In these metallic materials, also punctual corrosion forms have been observed, mainly localized forms of corrosion ("pitting" type). In the case of reusable trays, these forms of corrosion can be primed and / or propagated, thus increasing the degradation of the surface.

As a matter of novelty is the presence of two types of films, the protective film consisting of basic metal oxides, as well as films of biological nature characteristic of each type of food. Biological film is also observed in areas of surface imperfection, previous craters, scratches, and traces from previous machining.

Stronger corrosion status is a threat to re-useable trays, especially when hygiene cannot be achieved with sufficient accuracy. Hence the observation that the maximum accepted number of re-use must be established, as long as contamination of food is due to the danger of reusing trays, quite vulnerable to the aggression of food compositions, at the intimate level

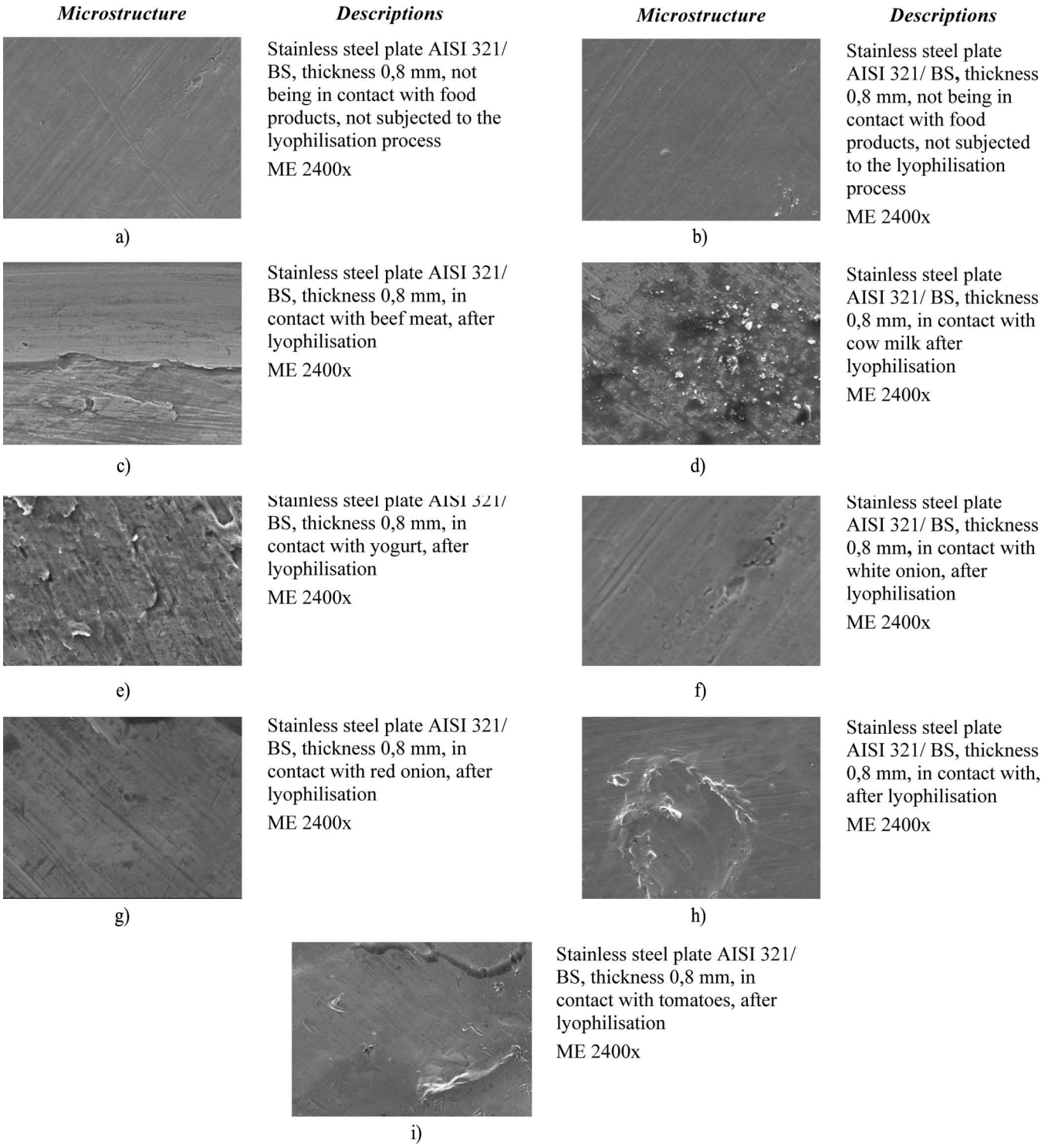

Figure 1. Stainless steel plate in contact with food at lyophilization

of the material, leading to the risk of altering the quality of lyophilized food [9].

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Calendar of International and National Events

2019			
February 20	Digitalisation in Vocational Training and Further Education	Essen, Germany	www.dvs-ev.de/digitalisation2019
March 20 - 22	8th Asia Pacific IIW International Congress	Bangkok, Thailand	https://iiwap2019.com/
April 10 - 11	Beam technologies	Halle, Germany	http://www.slv-halle.de/tagungen/beamtec-2019
June 05-07	ICWAM 2019-International Congress on Welding, Additive Manufacturing	Metz, France	http://www.icwam.com
July 07 - 12	72nd IIW Annual Assembly and International Conference	Bratislava, Slovakia	http://www.iiw2019.com
November 07 - 08	10th International conference "Innovative technologies for joining advanced materials"	Timişoara, Romania	http://www.isim.ro/tima
December 09 - 12	17th International Symposium on Tubular Structures (ISTS17) in National University of Singapore	SINGAPORE	http://ists17-singapore.org/index.html