ID 1011

Study and Modelling of Milk Fouling in a Vertical Pipe

HARCHE Rima*

Laboratoire des Phénomènes De Transfert (LPDT), Département de Génie Chimique et de Cryogénie, FGMGP. USTHB

*Corresponding author's email: s_r_harchel@yahoo.fr

ABSTRACT

This work focuses on the study and modeling of the fouling phenomenon in a vertical pipe. In a first step, milk is one of the fluids obeying the phenomenon of fouling because of the denaturation of these proteins and especially lactoglobulin which is the active element of milk and to facilitate its use, we chose to study milk as a fouling fluid. In another step, we consider the test section of our installation as a tubular type heat exchanger that works against the current and in closed circuit. A simple mathematical model of Kern & Seaton, based on the kinetics of the fouling resistance, was used to evaluate the influence of the operating parameters (fluid flow velocity and exchange wall temperature) on the fouling resistance. The influence of the variation of the fouling resistance with the operating conditions on the efficiency of the heat exchanger and the importance of the dirty state exchange coefficient as an exchange quality control parameter was discussed and examined. On the other hand, an electronic scanning microscope analysis was performed on the milk deposit in order to obtain its actual image and composition which allowed us to calculate the thickness of this deposit.

Keywords Milk fouling, tubular heat exchanger, fouling resistance.

1. Introduction

For a very long time, fouling has been considered one of the major unresolved problems in the field of heat exchangers. This is particularly true in the agri-food industries; first of all because of the temperature sensitivity of many food constituents [1]. Milk fouling has been studied for a number of years. The composition of the deposit is known and the chemical changes that occur when heating milk are fairly well understood [2]. The literature is now extensive and a number of major contributions have been reported [3], The key role played by proteins and especially b-lactoglobulin has been recognized in most recent milk fouling studies. Were the "rst who investigated the elect of b-lactoglobulin denaturation in milk fouling and showed that heat denaturation of this protein governs the milk deposit formation on the heat transfer area. The kinetics of the b-lactoglobulin reaction to analyse fouling in plate heat exchangers, and found that the amount of deposit could be correlated with protein reaction rates [4].

2. Description of fouling model

The fouling model used in this work relies on the b-lactoglobulin reaction scheme as shown in Fig. 1. It was adopted from Toyoda and Fryer [5] and was "rst proposed by De Jong et al. [4]. When milk is heated above 653C, b-lactoglobulin becomes thermally unstable and it unfolds in molecular denaturation exposing reactive sulphydry (-SH) groups and polymerizes irreversibly to give insoluble particles in aggregation [4]. The key step in studying fouling is to capture the interrelationship between the chemical reactions which give rise to deposition and the fluid mechanics associated with the heat transfer equipment. The reaction scheme is described as follows:

- Proteins react in both the bulk and the thermal boundary layer in the milk. Native protein N is transformed to denaturated protein D, in a "rst-order reaction. The denaturated protein then reacts to give aggregated protein A in a second order reaction.
- Mass transfer between the bulk and the thermal boundary layer takes place for each protein.

DOI: 10.21467/abstracts.169 ISBN: 978-81-970666-4-1 (eBook)

3. Materials and Methods

This study was carried out at the level of the heat transfer phenomena laboratory of the Faculty of Process Engineering of the University of USTHB. For this purpose, a semi-pilot installation was restored as shown in the photograph in Figure 1

Figure 1: Photographie de l'installation semi-pilote

4. Calculation methods

The fouling resistance is related to the operating conditions and can be performed by several parameters such as the temperature of the exchange surface, the flow velocity of the fluid and its temperature.
the experimental Rd value is calculated as:

$$\mathrm{Rd} = \frac{T_{Pi} - T_{Pi0}}{\Phi / A} \qquad (1)$$

T_{pi}= Internal wall temperature of the test section;
T_{pi0}= Initial temperature of the inner wall of the test section.

5. Results and Discussion

Effect of fluid flow to show the influence of fluid flow on the thickness of the deposit, we have shown in Figure (2) the temporal evolution of fouling.

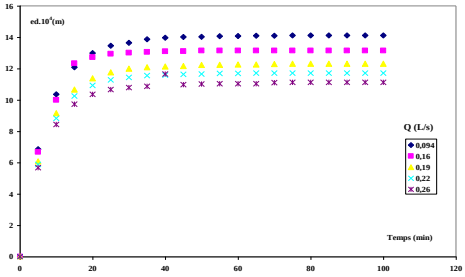

Figure 2: Study of the influence of the flow rate on the thickness of the deposit

5 Conclusions

The objective of this work was to study the phenomenon of fouling by the milk of a tubular heat exchanger in a vertical pipe and this on an installation already tested for the study of this phenomenon in the laboratory of Transfer Phenomenon, team of research of the Faculty of Process Engineering & Mechanical Engineering. In a second place, the study focused on monitoring the fouling resistance over time and the influence of some operating parameters.

References

[1] Belmar-Beiny, M. T., Gotham, S. M., Paterson, W. R., & Fryer, P. J. (1996). The e!ect of Reynolds number and fluid temperature in whey protein fouling. Journal of the Society of Dairy Technology, 19, 119-139.
[2] Lalande, M., Tissier, J. P., & Corrieu, G. (2005). Fouling of heat transfer surfaces related to b-lactoglobulin denaturation during heat processing of milk. Biotechnology Progress, 1, 131-139.
[3] Sandu, C., & Lund, D. (1995). Minimizing fouling in heat exchanger design. Biotechnology Progress, 1, 10-17.
[4] Jong, P. De, Bouman, S., & Van Der Linden, H. J. (1992). Fouling of heat transfer equipment in relation to the denaturation of b-lactoglobulin. Journal of the Society of Dairy Technology, 45, 368.
[5] Toyoda, I., & Fryer, P.J. (1997). A computational model for reaction and mass transfer in fouling from whey protein solutions. In: Fouling mitigation of industrial heat exchange equipment. New York: Begell House.

ISBN: 978-81-970666-4-1
Series: AIJR Abstracts
DOI: 10.21467/abstracts.169