BAB V
KESIMPULAN DAN SARAN

5.1 Kesimpulan

Kesimpulan yang dapat diambil dari hasil penelitian ini adalah:

1. Pendekatan matematis dengan *computational fluid dynamics* dapat dilakukan untuk mensimulasikan terjadinya *fouling* pada pasteurisasi susu di heat exchanger.
2. *Deposit* yang terbentuk pada *heat exchanger* cenderung semakin tebal pada daerah yang semakin jauh dari masukan dan pembentukannya cenderung melambat seiring waktu.
3. Laju *fouling* paling dipengaruhi temperatur susu dekat dinding *heat exchanger*.
4. Untuk meminimalisasi *fouling*, harus dibuat rancangan *heat exchanger* yang dapat mengakomodasi temperatur fluida pemanas yang rendah, caranya dengan menurunkan kecepatan alir serta meningkatkan temperatur masukan.
5. *Shell and tube heat exchanger* kurang cocok digunakan untuk pemanasan susu.

5.2 Saran

Saran yang dapat diberikan adalah:

1. Dilakukan kompromi supaya *fouling* relatif kecil tetapi biaya kapital tidak terlalu tinggi untuk mendapatkan proses yang optimal secara ekonomi.
2. Dapat dirancang *heat exchanger* yang masukan dan keluarannya bisa dipertukarkan untuk memanfaatkan sisi yang belum terbentuk banyak *fouling* sebagai akhir pemanasan untuk memperpanjang waktu kerja *heat exchanger* sebelum pembersihan.

DAFTAR PUSTAKA

Ardsomang, T., Hines, J. W., & Upadhyaya, B. R. (2013). Heat Exchanger Fouling and Estimation of Remaining Useful Life. *Annual Conference of Prognostics and Health Management Society*, 1-9.

Awad, M. M. (2011). *Fouling of Heat Trasfers Surfaces, Heat Transfers - Theorical Analysis.* Rijeka: InTech.

Baldocchi, D. (2010). *Leaf Boundary Layers and their Resistances and Mass and Momentum.* Berkeley: University of California.

Bansal, B., & Chen, X. D. (2005). Fouling of Heat Exchangers by Dairy Fluids - a Review. *ECI Symposium Series, Volume RP2: Proceeding of 6th International Conference on Heat Exchanger Fouling and Cleaning - Challenges and Opportinities*, 150-157.

Beek, W. J., & Muttzal, l. K. (1980). *Transport Phenomena.* Chichester: Wiley.

Belmer-Beiny, M., Gotham, S., Paterson, W., Fryer, P., & Pritchard, A. (1993). The Effects of Reynolds Number and Fluid Temperature in Whey Protein Fouling. *Journal of Food Engineering 19*, 119-139.

Bezerra, M. A., Santelli, R. E., Oliveira, E. P., Villar, L. S., & E. L. (2008). Response surface methodology (RSM) as a tool for optimization in analytical chemistry. *Talanta*, 965-977.

Bezerra, M. A., Santelli, R. E., Oliveira, E. P., Villar, L. S., & Escaleira, L. A. (2008). Response surface methodology (RSM) as a tool for optimization in analytical chemistry. *Talanta*, 965-977.

Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2001). *Transport Phenomena.* New York: John Wiley & Sons, Inc.

Bott, T. R. (1994). *Fouling of Heat Exchangers.* Amsterdam: Elsevier Science & Technology Book.

Burton, H. (1968). Deposit from Whole Milk in Heat Treatment Plant - a Review and Discussion. *Journal of Dairy Research*, 137-143.

Cengel, Y. A. (2008). *Introduction to Thermodynamics and Heat Transfers.* Dubuque, IA: McGnaw-Hill.

Chanapai, A. (2010). *Modelling of Crystallization Fouling in Shell-and-Tube Heat Exchangers.* London.

Changani, S., Belmar-Beiny, M., & Fryer, P. (1997). Engineering and Chemical Factors Associated with Fouling and Cleaning in Milk Processing. *Experimental Thermal and Fluid Science 14*, 392-406.

Christholm, D. (1980). *Developments in Heat Exchanger Technology.* London: Applied Science Publishers.

Coimbra, J. S., & Teixeira, J. A. (2009). *Engineering Aspects of Milk and Dairy Products.* CRC Press.

de Jong, P. (1997). Impact and Control of Fouling in Milk Processing. *Trends in Food Science & Technology*, 401-405.

de Jong, P., Bouman, S., & Van Der Liden, H. J. (1992). Fouling of heat treatment equipment in relation to the denaturation of beta-lactoglobulin. *Journal of rhe Society of Dairy Technology*, 3-8.

De Jong, P., Bouman, S., & Van Der Liden, H. J. (1992). Fouling of heat treatment equipment in relation to the denaturation of beta-lactoglobulin. *Journal of rhe Society of Dairy Technology*, 3-8.

de Wit, J., & Klarenbeek, G. (1989). Tecnhological and Functional Aspects of Milk Proteins. *Milk Proteins*, 211-222.

Douglas, J. F., Greenberg, R., Farrel, J. H., & Edmonson, L. F. (1981). Effects of Ultra-High-Temperature Pasteurization on Milk Proteins. *J. Agric. Food Chem.*, 11-15.

Earle, R. (1983). *Operations in Food Processing - the Web Edition.* New Zealand Institute of Food Science.

Eigel, W. (1984). Nomenclature of Protein of Cow's Milk. *Journal of Dairy Science 67*, 1599-1631.

Epstein, N. (1982). *Fundamentals of Heat Transfers Surface Fouling: With Emphasis on Laminar Flow.* Washington: Hemisphere.

Epstein, N. (1983). *Fouling of Heat Exchangers.* New York: McGnaw-Hill.

Fondation de technologie laitière du Québec. (1985). *Dairy Science and Technology: Principles and Applications.* Presses Université Laval.

Food Standards Agency. (2002). *McCance and Widdowson's The Composition of Food.* Cambridge: Royal Society of Chemistry.

Fryer, P. J., Robbins, P. T., & Asteriadou, K. (2011). Current knowledge in Hygienic Design: Can We Minimize Fouling ang Speed Cleaning? *Procedia Food Science*, 1753-1760.

Fryer, P., & Slater, N. (1985). A Direct Simulation Procedure for Chemical Reaction Fouling in Heat Exchangers. *Chemical Engineering Journal 31.*

Georgiadis, M. P., Rotstein, G. E., & Macchietto, S. (1998). Modelling and Simulation of Shell and Tube Heat Exchanger Under Fouling. *AlChe Journal* , 959-971.

Gillham, C. R., Fryer, P. J., Hasting, A. P., & Wilson, D. I. (2000). Enhanced Cleaning of Whey Protein Soils Using Pulsed Flows. *Journal of Food Engineering*, 199-209.

Gut, J. A., & Pinto, J. M. (2003). Selecting Optimal Configurations for Multisection Plate Heat. *Industrial & Engineering Chemistry Research*, 6112-6124.

Hagsten, C., Loren, N., Hamberg, L., Wiklund, J., Innings, F., Nillson, L., . . . Nylander, T. (2013). A Novel Fouling And Cleaning Set-Up For Studying The Removal of Milk Deposits Produced During UIIT-Treatment. *Proceedings of International Conference*

on Heat Exchanger Fouling and Cleaning (hal. 457-464). Budapest: www.heaexchanger-fouling.com.

Jeurnink, T., Walstra, P., & de Kruif, C. (1996). Mechanisms of fouling in dairy processing. *Milk Fouling in Heat Exchanger*, 115-133.

Kern, D., & Seaton, R. (1959). A Theoretical Analysis of Thermal Surface Fouling. *British Chemical Engineering*, 258.

Kuppan, T. (2000). *Heat Exchanger Design Handbook.* New York: Marcel Dekker, Inc.

Lalande, M., Tissier, J., & Corrieu, G. (1985). Fouling of Heat Transfers Surfaces Related to Beta-Lactoglobulin Denaturation During Heat Processing of Milk. *Biotechnology Progress 1*, 131.

Lean, M. E. (2006). *Fox and Cameron's Food Science, Nutrition & Health, 7th Edition.* CRC Press.

Lewis, R. M., Torczon, V., & Trosset, M. W. (2000). Direct Search Methods: then and now. *Journal of Computational and Applied Mathematics*, 191-207.

Lucas-Clements, R. H. (1981). Use of skimmed milk in human foods in developing countries. *Journal of the Society of Dairy Technology*, 67-69.

Mahdi, Y., Mouheb, A., & Oufer, L. (2009). A Dynamic Model for Milk Fouling in a Plate Heat Exchanger. *Applied Mahematical Modelling*, 648-662.

Merian, T., & Goddard, J. (2012). Advances in Nonfouling Materials: Perspective for the Food Industry. *Journal of Agricultural Food Chemistry 60*, 2943-2957.

Muller-Steinhagen, H. (1998). Mitigation of Process Heat Exchanger Fouling: an Integral Approach. *Chemical Engineering Research and Design, 76*, 97-107.

Myers, R. H., Montgomery, D. C., & Anderson-Cook, C. M. (2009). *Response Surface Methodology: Process and Product Optimization Using Designed Experiments 3rd Edition.* John Wiley & Sons Inc.

Papiz, M. Z., Sawyer, L., Eliopoulos, E. E., North, A. C., Findlay, J. B., Sivapredadarao, R., . . . Kraulis, P. J. (1986). The Structure of Beta-LG and Its Similarity to Plasma Retinol-Binding Protein. *Nature*, 383-385.

Perry, R. H., & Green, D. (1985). *Perry's Chemical Engineer's Handbook.* New York: McGraw-Hill.

Rahman, M. S. (2007). *Handbook of Food Preservation, Second Edition.* CRC Press.

Ranken, M. D. (2012). *Food Industries Manual.* Springer Science & Business Media.

Rosmaninho, R., Santos, O., Nylander, T., Paulsson, M., Beuf, M., Benezech, T., . . . Melo, L. F. (2007). Modified Stainless Steel Surfaces Targeted to Reduce Fouling - Evaluation of Fouling by Milk Components. *Journal of Food Engineering 80*, 1176-1187.

Sherwood, T., Pigford, R., & Wilke, C. (1975). *Mass Transfer.* New York: McGnaw-Hill.

Steinhagen, R., Muller-Steinhagen, H., & Maani, K. (1993). Problems and Costs due to Heat Exchanger Fouling in New Zealand Industries. *Heat Transfer Engineering*, 19-30.

Taborek, J., Aoki, T., Ritter, R., Palen, J., & Knudsen, J. (1972). Predictive Methods for Fouling Behavior. *Chemical Engineering Progress. 68*, 69-78.

Toyoda, I., & Fryer, P. (1997). A Computational Model for Reaction and Mass Transfer in Fouling from Whey Protein Solutions. *Fouling Mitigation of Industrial Heat Exchanger Equipment.*

Toyoda, I., Schreier, P., & F. P. (1994). A Computational Model for Reaction Fouling from Whey Protein Solutions. *Proceeding of Fouling Cleaning in Food Processing*, 222-229.

van Asselt, A., Visser, M., Smit, F., & de Jong, P. (2005). In-line Control of Fouling Proceedings of Heat Exchangers Fouling and Cleaning - Challenges and Opportunities. *Engineering Conferences International.* Kloster Irsee.

Visser, J., & Jeurnink, T. J. (1997). Fouling of Heat Exchangers in the Dairy Industry. *Experimental Thermal and Fluid Science*, 407-424.

Wallhauber, E., Hussein, M., & Becker, T. (2012). Detection Methods of Fouling in Heat Exchangers in the Food Industry. *Food Control 27*, 1-10.

Watkinson, A. (1980). Process Heat Transfer: Some Practical Problems. *Canadian Journal of Chemical Engineering*, 553-559.

Yang, M., Young, A., & Niyetkaliyev, A. (2009). MODELLING THE FOULING INDUCTION PERIOD. *Proceedings of International Conference on Heat Exchanger Fouling and Cleaning VIII* (hal. 69-75). Schladming: www.heatexchanger-fouling.com.