IONIC LIQUIDS AS THERMAL FLUIDS: FEASIBILITY STUDY OF ITS APPLICATION ON A HEAT EXCHANGER OF A PLASTIC PRODUCTION MACHINE

T.I.L. Antunes[1], L.M.L. Mendes[1], C. A. Nieto de Castro[2,3] and V. M. B. Nunes[1,3*]

[1]Escola Superior de Tecnologia, Instituto Politécnico de Tomar, Campus da Quinta do Contador, 2300-313 Tomar, Portugal

[2]Departamento de Química e Bioquímica Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal

[3]Centro de Ciências Moleculares e Materiais, Faculdade de Ciências - Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal

[*]Corresponding author: valentim@ipt.pt

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Introduction: The objective of this work was to evaluate the viability of replacing the conventional thermal oil used in a heat exchanger of a plastic production machine, by an ionic liquid of known properties. Thermal fluids have many industrial applications covering all aspects from unit operations to chemical processes. The main utilization consists on the heat transfer from (or to) chemical process equipment, petrochemical or others, like reactors, heat exchangers, dryers, evaporators, and also presses for lamination or moulding.

Ionic liquids (ILs) are liquids whose melting point are lower than 100ºC, composed exclusively by ions and possessing an array of physical properties that caused the increasing of interest during the last years, proved by the significant raise in the number of publications. The ionic liquids have several physicochemical properties that are unique and that allow them to be adequate for many applications where conventional solvents are not applicable or non sufficient effective. Those properties include [1]: Extremely low volatility, low melting point, chemical and thermal stability, no flammability, high heat capacity per unit volume, high thermal and ionic conductivity and a wide electrochemical potential window. Comparing with the properties of synthetic compounds (based on hydrocarbons, aromatics or syloxanes) the heat capacity of imidazolium systems have a higher heat capacity per unit volume in all the applicable temperature ranges [2]. As a result, they have several applications in various domains of science. However, the application of ionic fluids as thermal fluids it is not very well known, and a few information is published [3-5].

Feasibility Study: The fieldwork, mainly in the industry unit, consisted in analyzing the technical characteristics of the equipment, dimensioning, selection of the ionic liquid and viability of the project. The study was focused on an equipment (heat exchanger) existing in a machine for the extrusion of thermoplastic elastomers, from ICMA (http://www.icmasangiorgio.it). The objective of this machine is to incorporate all the additives into the polymeric matrix. This involves the fusion of the polymeric phase and at the same time de mixture of the components due to the shear stress caused by the rotation of the extrusion spindles. To obtain the fused polymers it's necessary to apply heat from electric resistances that are in contact with the external surface of the extrusion machine. However, after some period of operation a significant amount of heat is generated due to the friction in the interior of the machine and also due to the friction of the polymer with the metallic surfaces and collision between the molecules itself. To control the temperature at a given set-point heat must be removed. This is achieved by cooling cycles. In the studied equipment the cooling is done by the circulation of thermal oil between the interior and external wall of the extrusion machine, trough a heat exchanger. This process is schematized in figure 1.

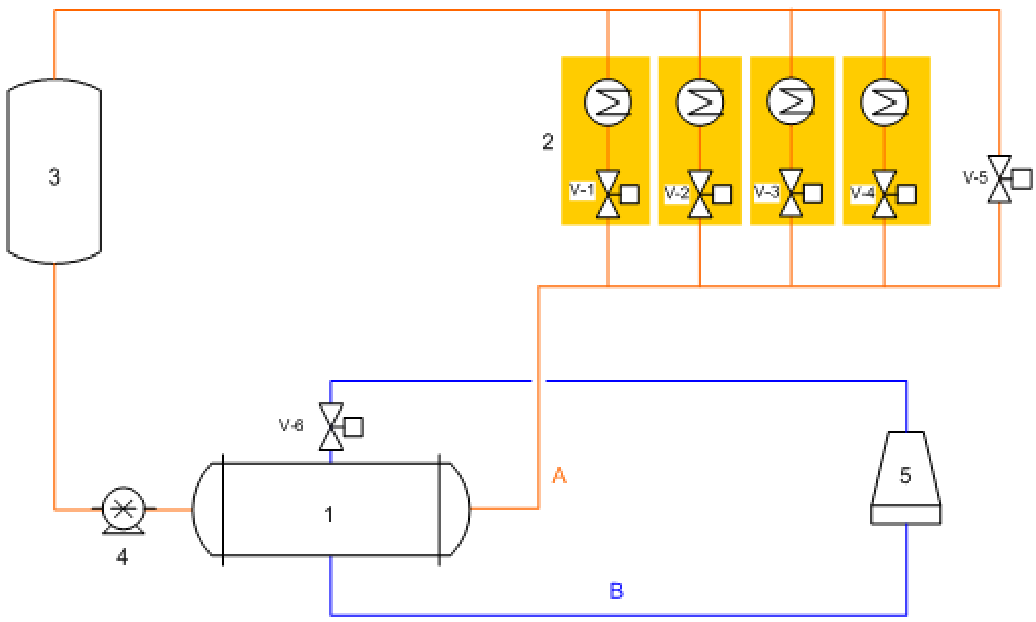

Figure 1. Scheme of the cooling system of the machine. (1) Heat Exchanger; (2) Heating blocks; (3) Oil reservoir; (4) Pump; (5) Refrigeration tower; (A) Oil current; (B) Water current.

The extrusion machine is segmented in several parts, and each part has a heating zone. Each one of these has an electro valve (V1 to V4) connected to the oil exit and that are actuated by the temperature controller. All the oil entries are connected to a common collector and the oil exits are connected to the exit collector. The exit collector, transporting the heated oil, is connected to the shell part of a shell and tubes heat exchanger (number 1 in figure), while the exit of the heat exchanger with the cooled oil is connected to heating blocks. Once the controller opens an electro valve the oil circulates to cool the heated zone.

The extremes of the entry and exit collector are connected through the valve V5 that controls the oil flux between the two collectors, creating a closed circuit that enables the circulation of oil even when all the other valves are closed. This system allows also the control of the cooling oil temperature (A). When the oil temperature raises above a given *set-point* the valve V6 is open, allowing the admission of cold water (B) to the heat exchanger. To the correct functioning of the entire system a oil reservoir is needed (number 3 in figure) to serve as lung for the oil pump (number 4), that assures the oil circulation through the system. The water leaving the heat exchanger is send to 3 *chillers* composing the general system of cooling of the entire plant (number 5). The temperatures of the several currents were measured using an IR pyrometer. The oil flow was also measured. All the relevant parameters for dimensioning the heat exchanger were calculated by an iterative procedure until a convergence value was obtained. The final area for the heat transfer area was A_0 = 13.58 m^2.

Keeping in mind the objective of this work, we repeated the calculations with some selected ionic liquids using the same equations and the thermophysical properties availabel at the ILThermo Database (http://ilthermo.boulder.nist.gov). On the basis of the obtained results, we verified that the ionic liquid with the lower heat transfer area was [BMIM][BF4] (1-butil-3-metilimidazolium tetrafluoroborate), with A_0 = 11,28 m^2. Comparing with the area needed with the thermal oil we found that it is lower for the ionic liquid and the correspondent number of tubes will be also lower.

Nevertheless from the economical point of view it must be also considered, besides the cost of equipment and installation, the cost of the ionic liquid itself. Compared with the thermal oils available in the market, the price of the ionic liquids is still prohibitive. The increasing demand of ionic liquids and the commercialization in higher quantities will certainly change the actual situation at a medium term. It must also be emphasized that the ionic liquids can be included in the field of "Green Chemistry" an aspect of great concern both for the chemical and environmental community. As a final remark we can say that the ionic liquids have the necessary physical and chemical properties to be used as thermal fluids, being the main disadvantage, at this moment, the economical aspects.

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