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IEA District Heating and Cooling

Programme of Research, Development and Demonstration on District Heating and Cooling

ADVANCED ENERGY TRANSMISSION FLUIDS FOR DISTRICT HEATING AND COOLING

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ANNEX IV

ADVANCED ENERGY TRANSMISSION FLUIDS

Final Report of Research

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Submitted to:

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Introduction

The application of drag reducing additives in district heating networks is a promising technology to improve the competition conditions of those systems. The pressure loss and therefore, the pumping costs of existing networks can be reduced or their capacity can be increased. The pipes and fittings of new planned networks can be designed in smaller diameters. Other possibilities to use the drag reducing effect are the decrease of the supply temperature due to an increasing mass flow while keeping the capacity constant or the integration of further (far away) heat sources which becomes only economic due to decreasing pumping costs. Resources can be saved and the pollution of the environment can be reduced.

During the last 13 years, lots of investigations concerning the application of cationic surfactants as drag reducing additives have been carried out in Canada, Denmark, Finland, Germany, Korea, the Netherlands, Sweden and the United States. Experiments with different kinds of cationic surfactants such as Ethoquate, Habon(-G), Obon(-G), Dobon(-G), C_{16}TASal etc. have been carried out. The effects on pressure drop behaviour in straight pipes, helical tubes as well as the heat transfer behaviour in those geometries have been investigated. The heat transfer of shell and tube, helical tube and plate heat exchangers has been examined. Furthermore, heat meters, fittings, pumps, the corrosion behaviour, environmental aspects and water hammering have been investiggated when using drag reducing surfactants.

In laboratory tests and full scale investigations in Denmark, Germany and the Netherlands, the general suitability of cationic surfactants - especially of Habon-G and Dobon-G in combination with Sodiumsalicylate - as drag reducing substances for district heating systems was proven. Based on those results, strategies to apply surfactants in real district heating systems have been developed.

The International Energy Agency (IEA) also undertook research, development and testing of advanced energy transmission fluids for district heating and cooling. An Experts Group made up of member countries respresentatives was formed 1987 to guide and to support research in this field. Nations participating in this cooperative research programme include Canada, Denmark, Finland, Germany, Korea, the Netherlands, Norway, Sweden, United Kingdom and the United States.

In addition to IEA-sponsored activities a number of government agencies are sponsoring independent research and testing efforts on advanced energy transmission fluids for district heating and cooling. The interest in this R & D-work is apparent from this that in many cases chemical manufactors, engineering firms and DHC-systems operators participate to share one’s experiences.

In the meantime - starting 1983 - four working programmes (called Annex I, II, III andIV) were established, which essentially are attend with the development of additives capable of reducing friction losses and increasing the capacity of district heating and cooling distribution systems.

The first three Annex-programmes with important subjects, such as environmental aspects, operational aspects, corrosion behaviour, simulation etc., have been finished (Annex I (1986), Annex II (1989), Annex III (1992). The results of the projects-activities have been published and disseminated in the participating countries.

In 1993 a further working-programme, so called Annex IV, with a new three-year period was established. Under Annex IV, four projects concerning the field of research „Advanced Transmission Fluids for District Heating and Cooling“, have been supported for which several institutes and companies of different countries have been carried out alone and in cooperation with various partners theoretical and experimental work:

- Project A: „Modelling of the Location and Requirements for Heat Exchangers in District Heating Networks Using Friction Reduction Additives“,
- Project B: „Experiments on the Effects of Friction Reduction Additives on Substations“,
- Project C: „Survey of Environmental Restrictions to the Use of Additives in District Heating and Cooling Systems“ and
- Project D: „Improving of the Heat Transmission Properties of Tube Bundle Heat Exchangers by Installing Obstacles inside the Pipes“.

The project A is dealing with the simulation of the behaviour of comprehensive transport networks with special consideration of heat exchangers which separate the transport system from the distribution network. With this a network simulation program for transport systems with a graphical user interface and a CAD-like function for network design was developed. With the simulation tool the modifications of a district heating network, which are necessary when applying drag reducing additives can be worked out. These are mainly the heat exchangers for the hydraulic separation in a transportation-system containing surfactant solution and several distribution-systems operating with district heating water, the pressure maintenance and the treatment and supply of water for the distribution system. Simulation results for the application of surfactants in a real system are given. Within the context of project A, economic calculations hve been carried out. These calculations consider general models and give an overview of the savings in costs which can be expected under certain conditions.

In project B the influence of drag reducing additives in small domestic heat exchangers and on flow meters which are installed in small consumer stations has been determined. Four different kinds of heat exchangers (single wall plate HE, helix shaped multiple double HE, spiral double pipe HE and double wall plate HE) and four different flow meters (magnetic-inductive, mechanical-inductive and mechanical meters) have been investigated under technical conditions (primary and secondary circuit temperatures for summer and winter).

This investigations show the following results:

- No significant changes concerning the pressure drop of the investigated heat exchangers ,
- minor decreases in heat transmission capacity of the investigated heat exchangers when using Habon-G (by that the influence for tertiary heat exchanger is smaller than for secondary),
- the magnetic-inductive and one mechanical heat meter are low influenced by the use of Habon-G. The accuracy of the two other mechanic heat meters decreases strongly with increasing surfactant concentration.

Aim of project C was the collecting of data and information about commercially available drag reducing surfactants and of regulations of different countries concerning the approval of drag reducing additives in district heating systems. Therefore, a questionnaire has been developed, which was handed to all members of the Experts Group „Advanced Transmission Fluids for District Heating and Cooling“ to register the state of conditions of the different IEA member countries.

The questionnaire was answered from nearly all member countries (Canada, Denmark, Finland, Germany, Korea,the Netherlands, Sweden and the United States). The analysis results that an unambiguous conclusion covering the situation in all countries cannot be drawn. In most countries there are no concrete rules related to this new technology. It seems to be clear that a certain reluctancy towards the introduction of new additives in general is a common attitude. The technology has not been declined in any of the countries.

When using drag reducing additives inside pipes, the heat transfer from the fluid tothe inner pipe area is reduced significantly. Therefore, the last project D has been carried out, in which the improvement of the heat transmission conditions in tube bundle heat exchangers by installing turbulence increasing obstacles (spiral springs) inside the pipes was investigated.

These investigations in laboratory scale (University of Dortmund) have been carried out with water and surfactant solutions at different flow velocities, concentrations and temperatures. The results with pure water agree quite well with literature values. With obstacles a strong improvement of the inner heat transfer coefficient is reached. When using obstacles (prestressed helical springs of stainless steel wire with defined pitches) the heat transfer with surfactant solutions is - under certain conditions - even better than in case of using water without obstacles. On the other hand, measurements of the pressure drop inside the tubes show a significant increase. Compared to water without obstacles an increase of 200 to 800 % can occur, depending on the pitch of the spring.

In full scale tests in district heating exchangers (CHP plant in Herning) pipes containing spiral springs (both conventional and stainless steel) were in operation for one year . The spirals caused no difficulties during operation, slight corrosion in the conventional steel and no sign of corrosion in the stainless material.

The conclusion shows, that to the use of obstacles, the total heat transfer is improved, that the steam in the CHP-plant can be expanded to a lower level. This implies a higher electricity generations with which the increased pumping demand through the heat exchanger can be compensated. Herewith the installing of optimized obstacles inside the pipes of condensers represents an experimentally supported measures with which the use of suitable drag reducing additives in district heating systems will be economically possible.

The reports and the results of the several projects are presented as independent parts of the total report. They have an independent table of contents and therefore, an independent numbering of pages.

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However the following reports are the result of the knowledge, expertise and work of the particular principal authors and project leaders.

December 1996

Artur Steiff

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