Investitionen zur Verminderung von Umweltbelastungen
Programm des Bundesministeriums für Umwelt, Naturschutz
und Reaktorsicherheit

Luftreinhaltung

Summary

Nutzung industrieller Abwärme durch die Stadtwerke Karlsruhe zur
Wärmeversorgung der Stadt Karlsruhe

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Summary

Use of low level temperature process waste heat to support the district heating system in Karlsruhe

**Description** (starting situation and scope, project requirements, strategy and schedule, project achievements in general and in reference to environmental credits)

MiRO and SWK investigated the possibility of recovering waste heat in the refinery and transfer this heat to the community heating system.

*View to the map of north west of Karlsruhe: the two works of refinery MiRO and the transfer pipeline to HKW West of SWK*

The investigations of necessary facilities within the refinery and SWK were basically focused on:

- potential waste heat sources in terms of heat load and temperature at the MiRO Refinery Karlsruhe,
- the possibility of connecting the refinery heat sources and the SWK community heating system by a hot water pipeline
- a rough investment estimate
The resulting business plan convinced both managements to start a more detailed study in order to prove the technical and economical feasibility of the project.

**Principle of the waste heat recovery:**
With additional heat exchangers in the run down paths the waste heat were collected

This study was assigned to the engineering company Arcadis in collaboration with Lauterbach Verfahrenstechnik. The objective of the study was a detailed check of the available heat sources matching economical requirements in temperature, load and mechanical limitations of the pipeline and refinery equipment based on MiRO and SWK standard codes. Finally a costs estimate was generated to judge the benefits and risks of the project. The study by Arcadis/Lauterbach indicated that enough heat at reasonable temperatures is available to justify a heat transfer system between MiRO and SWK. It was shown that from each of the two works of MiRO about 40 MW heat at a temperature of 120°C will be available. According to the study it was recommended to realize the project step wise. The first step involved the heat transfer system between MiRO and SWK and connection of the heat sources in the MiRO operating zone 3 (works 1). It was recommended to verify a reliable operation of step 1 before starting with the realization of step 2 (see the report).

The investment for the first step was estimated to be about 30 Mio Euro. The potential heat transfer from MiRO to SWK was estimated to be approx. 300,000 MWh per year. The potential reduction of CO2 emissions was estimated to be 65,000 tons per year.

**Applicability** (state of the art, constructions, operation, materials, environmental relevance, general requirements like trade mark rights etc., transferability to other areas, cooperation with other divisions.)

The installation of additional heat exchangers in the existing refinery process units as well as the safety considerations was new for all involved parties.

Due to the low pitch between product and hot water temperature, heat exchangers with large heat transfer areas were required. Due to the limited free space in the process areas special heat exchanger types had to be chosen.
Normally Shell and Tube heat exchangers (S&T) were used, covered by a MiRO standard code. Those exchangers are approved and established for many years. These standard S&T were not applicable because of the required high plot area and pressure drop limitations. Special plate heat exchanger had to be used, because they require significantly less plot area compared to S&T with the same efficiency. For safety reasons normal screwed or soldered plate heat exchanger are not applicable so only welded plate packet types, so called parallel plate „shell and tube“ types were feasible. There were only few experiences with these special exchangers in the refinery so extended quality control during manufacturing was necessary.

Two different forms of the special “shell and tube”-types
**Major environmental benefits, significant achieved emissions levels** (Outlining of the innovative solutions with its primary (environmental) issues)

**General aspects** (e.g. additional energy consumption or conservation, CO\textsubscript{2} reduction in tons per year, saving of material, generation or elimination of wastes or waste water, inclusive quantification, as far as possible)

By use of low-temperature waste heat from the refinery in the community heating system, fuelgas as heating medium is replaced. The heat for the community heating system is generated in HKW West, HW Ahaweg and HW Waldstadt. Heat is also imported from the power station Rheinhafendampfkraftwerk unit 7 running on black coal.

Due to the fact that in a combined heat and power process (“cogeneration”) additional fuel is required for heat export the replacement of this heat leads to a reduction of primary energy too.

Under the assumption that the community heat is generated by latest boiler technology, a heat export of 300,000 MWh from MiRO to SWK reduces the CO\textsubscript{2} emissions by 65,000 tons per year.

In addition it should be mentioned that the power saved in refinery air coolers to cool down a process stream nearly compensates the additional power for the circulation pumps to transport the heat from MiRO to HKW West.

**Economics** (Investment and operating costs, cost-benefit relation (reference values))

The original planned investment of 29.7 Mio. EUR was not completely expended: The 14,0 Mio. EUR budget for the installation of the heat exchangers at MiRO was not fully spent. Within the budget for the pipeline and the integration to HKW West and for the emergency cooler some adjustment were necessary, however the total costs for this project part of about 15.7 Mio. EUR were not exceeded either.

*Installation of pipe systems and heat exchangers*
Operational experiences have shown that the forecasts for power costs (circulation pumps) and maintenance cost are close to the projected values. The nitrogen consumption for pressure control of the system was slightly increased.

**Operational Data** (e.g. quality and quantity changes of the involved process streams, changes of the refinery crude slade and throughput)

The available pressure drop may not be exceeded by the the new heat exchangers build into the rundown pathes of the specific unit. In two cases, the pressure on the product side is higher than on the hot water side. For one of these heat exchangers additional process safety measures have to be installed.

*Heat exchanger battery in HKW West*

**Reference Literature** (further technical literature covering the interconnection of community heating systems and industrial plants are not known)

Existing interconnections between community heating system and industrial plants are based on heat export from combined heat and power plants. Export of low temperature waste heat from refinery processes to community heating system is a new way of energy conservation and there is no reference project known by the project partners. The study by Arcadis/Lauterbach is attached in the appendix.