Steam generation from waste heat with industrial heat pumps

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Introduction

Heat recovery in industrial plants is gaining importance due to decarbonization goals of a large number of industrial companies. In addition to direct heat recovery like heat exchanger networks, industrial heat pumps are increasingly being taken into account for valorizing low-grade waste heat to a temperature level suitable for being fed back into the industrial process.

In industrial energy supply, steam serves as an efficient medium for heat transfer and as a reaction agent. By increasing the utilization temperatures possible with heat pumps, they can also be used for low-pressure steam generation. This article summarizes current developments, shows different types of low-pressure steam generation with heat pumps and gives an outlook on future market volumes.

State of the art of steam generating heat pumps

The utilization temperatures possible with heat pumps have increased significantly in recent years. With the development of these so-called industrial or high-temperature heat pumps to utilization temperatures above 100°C, the generation of saturated steam is obvious. With novel working fluids currently in use, utilization temperatures of up to about 150°C are possible, which corresponds roughly to a saturated steam pressure of 5 bar_a.

Most developments use reciprocating and screw compressors in the power range from a few hundred kilowatts to the low megawatt segment.

Main types of steam generation with heat pumps

In recent developments, two types of steam generation have been established, the so-called direct steam generation and steam generation using a flash tank. In direct

steam generation, the useful heat is transferred directly from the working medium to the water in a steam generator. When using a flash tank, a water-to-water heat pump is used, whereas the hot water is then fed into the flash tank and expanded. Depending on the requirements of the industrial customer, these two types can have their advantages compared to the other type.

Conclusion and market outlook

With steam generating heat pumps, a significant increase in energy efficiency of industrial processes can be achieved. The technology is about to enter the market and is currently at the stage of demonstration in research projects. Products in the range between a few hundred kilowatts and the low megawatt can be found. With turbo compressors, it can be assumed that larger steam outputs will be available in the next few years. However, waste heat streams are often distributed in different parts of plants and can be found easier as one centralized waste heat stream. This paper summarizes the market volume outlook based on studies [1] and the IEA's "Net Zero by 2050" report [2].

References

[1] A. Marina, S. Spoelstra, H.A. Zondag, A.K. Wemmers, An estimation of the European industrial heat pump market potential, Renewable and Sustainable Energy Reviews 139 (2021) 110545.

[2] I.E.A. IEA, Net Zero by 2050 - A Roadmap for the Global Energy Sector, 2021.

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