Indus3Es Project

New technologies for utilization of heat recovery in large industrial systems

The INDUS3ES technology and its impact on the market

All over the world the energy consumption and its responsible use has been growing as a trend, not only in an industrial approach but also as a social movement. Governments are increasing the incentives and pressure for the industrial processes to be improved in this path and the customers are beginning to perceive the productive process and resources used as a part of the product. In response, the companies are professionalising the energy management and perceive the efficiency not only as an economical variable but also as a duty and a best practice.

In every industry that has the need of a raised temperature stream, the waste heat recovery solutions are a must. With this heat demanding processes being so variable and different, the solutions addressing this issue are too scarce and little varied.

In this framework, the INDUS3ES project is aiming at recovering and revalue non-recovered low-exergy surplus heat in energy intensive industrial processes. Indus3Es System aims to upgrade low temperature waste heat streams to process heat streams at higher temperature levels and then use them in internal industrial process, reducing primary energy consumption of the industry. The project was funded by Horizon 2020 (Topic EE-18-2015: New technologies for utilization of heat recovery in large industrial systems, considering the whole energy cycle from heat production to transformation, delivery and end use); it is a Research and Innovation action, started in October 2015, focusing on new technologies for utilization of heat recovery in large industrial systems.

With the current technologies, the heat reutilisation is generally not feasible or profitable. However, the solution developed in INDUS3ES project, **Absorption Heat Transformers (AHT)**, increase the quality of low temperature stream, converting to useful heat approximately 50% of it. The main difference with other technologies is that AHT systems are thermally activated sorption processes with a **very small electricity demand** for heat recovery only.

INDUS3ES system is capable of raising temperature of low-grade heat (in the range of 70-100°C) by about 50K, yielding a Coefficient of Performance (COP, this is the fraction of recovered heat) of 0.45-0.48.

A pilot plant was installed and demonstrated in an industrial environment in a refinery in Turkey and tested under realistic working conditions . The plant with about 200 kW revalued heat flow is equipped with an innovative non-condensable gasses (NCGs) purge system.

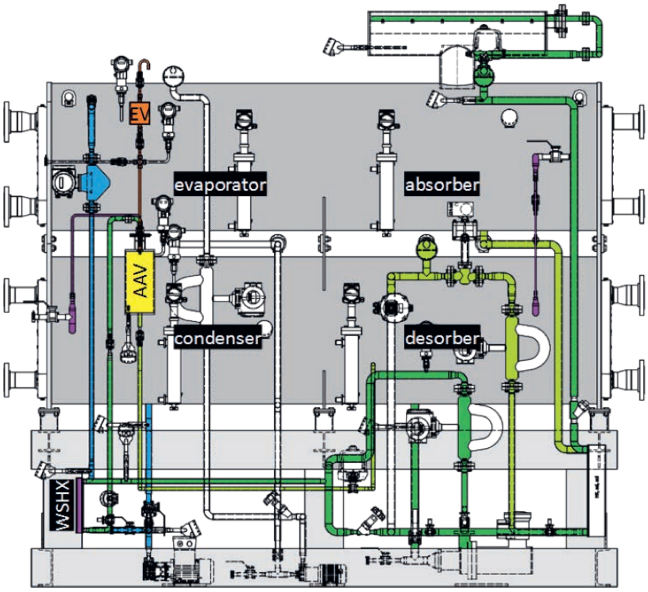

Figure 1 - AHT and purge system overview. Green lines carry solution, light-green lines represents weak solution lines (low LiBr concentration), blue represents refrigerant lines, purple represent the purge system lines.

This system requires no additional equipment, it is fully automated and has a negligible impact on the AHT performance. A very low-flow vapor bleed line delivers vapor and NCGs from the high-pressure vessel to the low-pressure vessel. From there an additional line sucks vapor and NCGs to the adiabatic absorption chamber (AAV). The AAV attains the lowest pressure in the system by using portion of the strong solution, which is subcooled by the water-solution heat exchanger (WSHX). The removed subcooling heat is transferred to the refrigerant, therefore it is internally recuperated and not to be considered a loss. The NCGs which are collected in the AAV are trapped there and are periodically transferred to the evacuation vessel (EV). The EV is then isolated from the AHT, and its NCGs content is discharged into the atmosphere. No special ejectors are use and no vacuum pump is needed. For this procedure, only the opening and closing of valves in the correct sequence and timing is required. This is fully automated by the control system. The control system has been designed considering especially the "Characteristic Equation Method" approach. Apart from the desirable performance automatic adjustment procedures, attention to anti-crystallization procedure has been considered, which is potentially riskier for AHTs, compared to absorption chillers.

By the end of the project, a tested control system was installed and operated for several months. This has demonstrated the successful integration and automation of the technology and its innovations in a real industrial application.

The INDUS3ES market analysis

The market analysis conducted in the project focuses on a comparative analysis made of different solutions that use waste streams and revalorize them, so that they can be reused in industrial processes instead of being lost directly in the atmosphere. Among these solutions, the most common solution is heat pumps. Although the development of new high temperature heat pumps, better in temperature range and performance, is reaching the solution to more markets, yet, its main limitation is still present, as they need an electric contribution that significantly increases their paybacks and lowers their functionality.

In INDUS3ES project AHT has been developed to allow the revalorisation of industrial waste heat streams, by using negligible or even zero primary energy consumption The principle of operation of AHT is based on absorption and evaporation of a refrigerant; so, unlike the electricity-driven heat pumps, AHT is driven by thermal energy, internally generated in the industrial plant.

To analyse the economic viability of AHT, it has been attended the forecasts of the energy prices in Europe. The rising trend of the energy (increasing about 15% from 2008 until 2016), added to the fact that you only need five-year payback, highlights the validity of the strong efforts that countries and companies are performing to minimise the energy consumption and environmental impact using AHT compared to other waste heat recovery technologies.

To provide a deeper analysis of the AHT in the competitive market, an analysis of the energy intensive industrial sectors in Europe was also conducted: Chemical & Pharmaceutical, Pulp & Paper, Food & Beverage, Refineries, Non-metallic mineral, Iron & Steel and Non-ferrous sector. Once the market size, barriers such as profitability, lack of knowledge, lack of interest, lack of specialized entities to support the landing of a new technology, size of device and capacity and scalability have been analysed. However, boosters such as low electricity consumption, reliability, low maintenance, compatible with other technologies, appropriate temperature range and the fact that is fully divorced/unconnected to the industrial process have been reported as strengths. Finally, a benchmark on several product characteristics was set and the market analysis demonstrates the validity of the solution and it encourages further efforts to continue to

improve the solution to help the European industries in their competitiveness and efficiency.

To sum up, the developed AHT system provides an innovative, adaptable and technically competitive system that overcomes the needs of energy-intensive industries. Nonetheless, the main challenges that INDUS3ES face are the standardisation for different capacities. Even when facing these challenges, the solution is suitable, with its biggest attractiveness in its non-intrusive design that will not interact with the established industrial process of the customer, and its small electricity consumption.

The consortium of the Indus3Es Project consists of ten partners: four Research Organisations (TECNALIA, TU Berlin, CIRCE and Technion), three SMEs (Bs Nova, Aiguasol and PNO) and three large industries (Tupras, Repsol and Fertinagro). The Research organisations in charge of the main fundamental research activities related to the envisaged developments are highly experienced on absorption technology and heat transformers systems; the companies are bringing the business spirit and industrial knowledge, while the large companies are key to ensure a successful demonstration and replication of the project results. TECNALIA, one of the main Research & Technology Organizations (RTO) in Europe, is the Coordinator of the project.

For further information about the project, its technology and main results, visit the INDUS3ES website.

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Sustainable Process Industry through Resource and Energy Efficiency