Project 68 | **Industrial High-Temperature Heat Pumps**

https://heatpumpingtechnologies.org/project68/

March 2026

Task 2 – Sector Collaboration: Integration possibilities of HTHPs

[Pulp & Paper] - Ajin P&P in Daegu, Republic of Korea

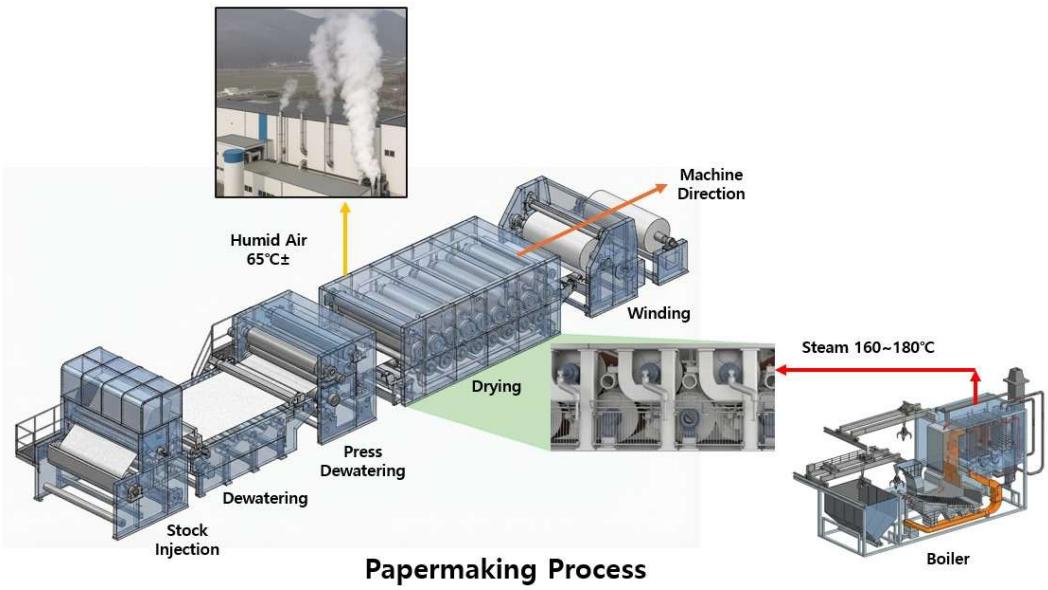

Figure 1: Process Flow of Paper Manufacturing Using Recovered Steam from Incineration Boilers

Overview of Key Production Processes

Ajin P&P Co., Ltd. is a leading Korean manufacturer of corrugating medium with nearly five decades of industrial experience since its establishment in 1975. Located at a single production site in Daegu, the company accounts for approximately 10% of the domestic market and represents a notable model of the circular economy by recovering hundreds of thousands of tons of paper resources (wastepaper) annually and converting them into high-quality packaging paper. With strategic goals of digital transformation by 2030 and carbon neutrality by 2050, Ajin P&P is promoting a fundamental transition in the energy structure of the paper industry, which is known for its high energy intensity.

The pulp and paper industry is a highly energy-intensive sector, and approximately 60-70% of the total thermal energy demand in paper production is consumed in the drying process.

- **Process Flow:** Moist paper sheets pass through multiple dryer cylinders for moisture removal. High-temperature steam, typically at 160-180°C, is supplied inside the cylinders to heat and dry the paper web.
- **Energy Intensity:** In general, approximately 1.2 tons of steam are required to produce 1 ton of paper, corresponding to roughly 1.2-1.5 MWh of thermal energy. At present, the steam used in the process is mainly generated by waste-fueled and LNG-fired boilers.
- **Waste Heat Opportunity:** During the drying process, a large volume of hot and moisture-laden exhaust air is generated as water evaporates from the paper. This exhaust air, typically at around 60-70°C, contains a substantial amount of latent heat. In the existing process, most of this stream is discharged to the atmosphere after passing through an air-to-air heat exchanger, while the recovered portion is used to maintain the high-temperature drying environment inside the hood through supply air.
- **Heat Sources and Sinks:** This demonstration project implements an energy recycling concept in which the temperature of discarded waste heat is upgraded by a heat pump and returned to the production process as useful steam.
- **Existing System (Baseline):** In the conventional paper production system, steam at temperatures above 160°C generated by fossil-fuel boilers is supplied to the dryers. After transferring heat, the exhaust is discharged externally, and condensate is returned to the boiler. Because this

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configuration relies entirely on external fuel input, it is vulnerable to fuel price fluctuations and results in substantial carbon emissions.

Summary of heat sources and sinks.

Category	Detailed Item	Specifications	Characteristics
Heat Source	Fluid type	Hot and humid exhaust air	Continuous generation
	Temperature level	Inlet 70-80℃ / Outlet 45-55℃	High latent heat source
Heat sink	Fluid type	Low-pressure saturated process steam	Direct process integration
	Temperature level	Target above 120℃	High-temperature lift required
System Gap	Temperature difference (ΔT)	Large temperature lift of approximately 70 K or more	High technical complexity

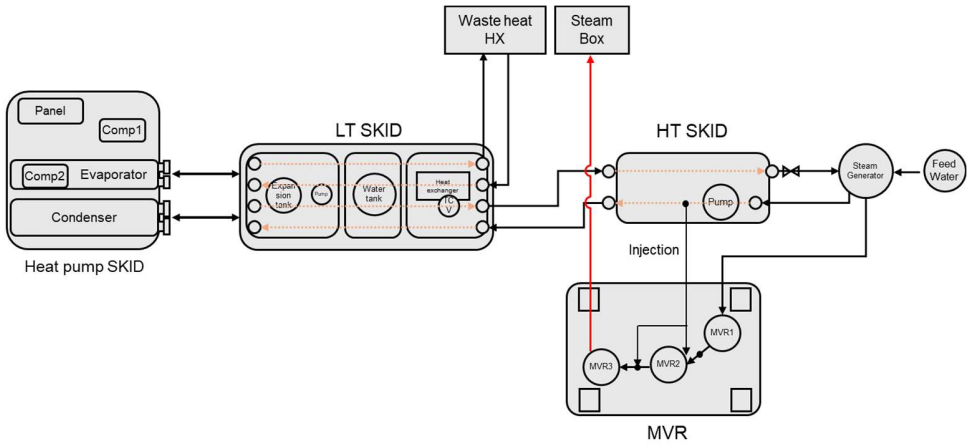

Figure 2: Conceptual Layout of an HTHP and MVR Hybrid System

Integration concept system/process

The core of this demonstration project is a hybrid system in which a large-capacity, high-temperature-lift heat pump (HTHP) is connected in series with a mechanical vapor recompression (MVR) unit.

- **Waste Heat Recovery (HTHP):** Heat is recovered from the dryer exhaust air by means of an air-to-water heat exchange process and supplied to the evaporator of the heat pump. Using a four-stage compression system with a low-GWP refrigerant (global warming potential below 10), the recovered heat is upgraded to hot water at approximately 108°C, which is then used in a steam generator to produce low-pressure steam at around 103°C.
- **Vapor Recompression (MVR):** The low-pressure steam generated by the heat pump is mechanically compressed in the MVR unit. During compression, both pressure and temperature increase simultaneously, and the steam is finally upgraded to saturated steam above 120°C, which can be directly utilized in the paper production process.
- **Operation Logic:** The system is designed to detect fluctuations in exhaust heat load in real time according to paper grade changes and production speed. The integrated control algorithm is structured to maximize the heat pump COP while minimizing the use of the existing boiler when supplementary steam is required.

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FACTS ABOUT THE CONCEPT

Heat Sink: 120~130℃ Production of 120-130°C saturated steam for supply to the drying process

Heat Source: Exhaust air from the paper drying process (60-70°C, humid air)

Heat Pump Concepts: Large-scale 1000 RT class four-stage oil-free turbo-compression heat pump integrated with MVR-based steam upgrading, using a low-GWP refrigerant; integrated system efficiency above 2.5 under a temperature lift of 70 K

Pattern: Continuous operation system designed to match the characteristics of a paper production line operating 24 hours per day

Main advantages: Reduced fossil fuel consumption and lower carbon dioxide emissions; large-capacity design suitable for large-scale industrial processes

Main challenges: Control optimization under varying exhaust conditions caused by paper grade changes and load fluctuations

Maturity: TRL 7

Demonstration cases: On-site demonstration at Ajin P&P in Daegu, Republic of Korea (2023-2027)