

CASE PROMMING IN CROATIA

Background

This study is part of an IEE (Intelligent Energy Europe) project called Woodheat Solutions (IEE/07/726/SI2.499568). Woodheat Solutions (WhS) aims to inspire investment in wood-based heat (and CHP) generation particularly from undermanaged forest. The project plans to transfer best practise from experinced EU Member States, namely Finland and Austria, through demonstration of case studies, training, engagement events and one to one support. The project will establish a network for long-term co-operation on biomass energy, offering tools and support that can be applied across the EU.

Promming Ltd. was founded in 1990 as a small metal workshop. In about 20 years it has grown into a leading manufacturer of equipment in Croatia for shops, warehouses and stores. Currently the company employs 120 workers of which more than 100 directly in manufacturing processes.

Manufacturing of the products demands a lot of heat and power, e.g. for painting and drying of metal products. Due to rapid increase of fossil fuel prices Promming Ltd. invested in a thermal oil boiler mainly using wood chips and grinding dust as fuels. Wood chips are made of wood residues from own furniture manufacturing and roundwood available in the area.



Picture 1: Experts visiting Promming Ltd.

Existing boiler and its connection to ORC cycle for power generation

The company has acquired 1.6 MW thermal oil boiler (KARA KTO 1350, made in the Netherlands) for heat production. The inlet and outlet temperatures of the thermal oil are 235 and 250 °C, respectively. Its maximum temperature is about 300 °C. The boiler output is clearly higher than what is normally needed for the production process. The boiler output is typically 0.6

– 0.7 MW. Therefore the Promming company is considering to buy an ORC system for generating electricity in addition to heat production.

In order to calculate first how much energy can be transferred in thermal oil if the boiler is working within 235 – 250 °C range, the oil flow rate has to be known. According to the information from an oil pump manufacturer, pump capacity is 71 m³/h. On the other hand, a typical density and heat capacity of thermal oil are ~ 750 kg/m³ and 2.7 kJ/kg °C in the temperatures in question. On this basis it is possible to calculate that the thermal oil boiler could produce heat:



Picture 2: The heating system of Promming.

$$P = 71 * 750 * 2.7 (250 - 235) / 3600 = 600 \text{ kW} = \mathbf{0.6 \text{ MW}}$$

This is practically the same output at which the boiler is normally working. If the boiler is working at its maximum output 1.6 MW using 71 m³/h oil flow rate, the temperature rise in the boiler for transferring 1.6 MW heat would be:

$$\Delta T = (1.6 / 0.6) * (250 - 235) = \mathbf{40 \text{ }^\circ\text{C}}$$

Since the maximum temperature of the thermal oil should not exceed 300 °C, the process with ORC could work within the temperature range 250 – 290 °C, for instance.

Figure 1 shows an example where a thermal oil boiler runs ORC cycle using silicon oil as work fluid. Thermal oil temperature drops from 300 to 250 °C in the evaporator and silicon oil evaporates and heats up to almost 300 °C. Silicon oil temperature after the condenser is about 100 °C.

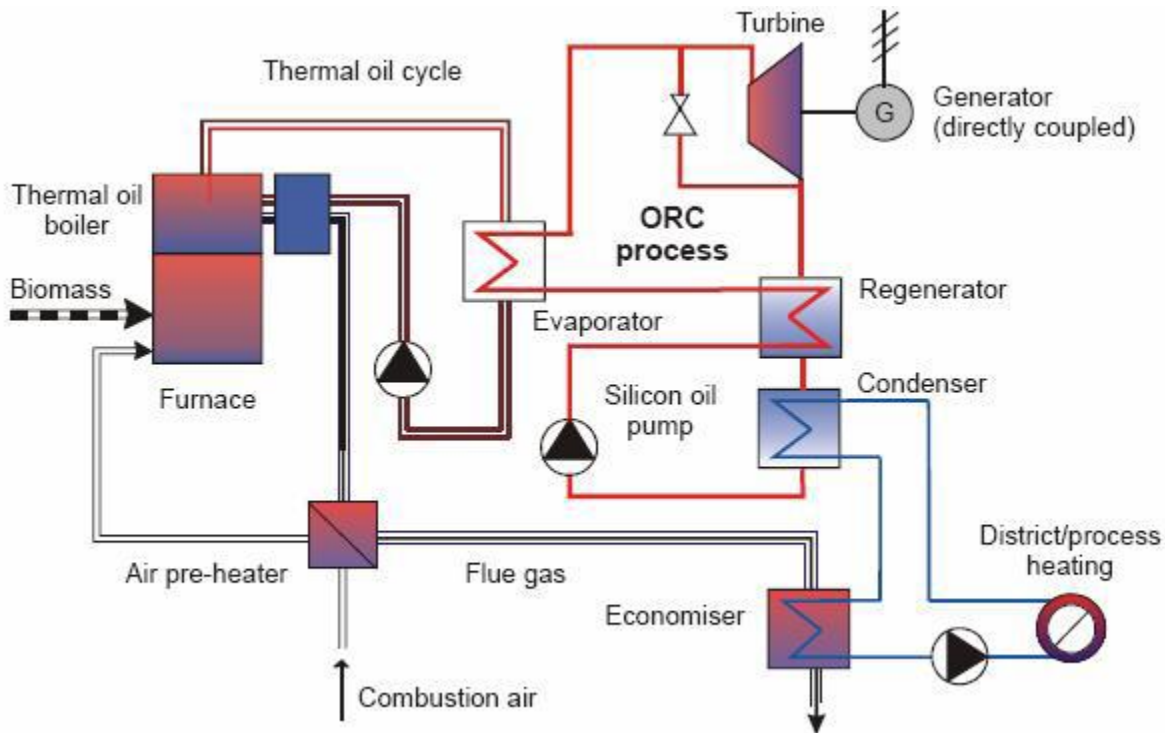


Figure 1. A schematic picture of an ORC system..

The process in Figure 1 could be applied with some modifications to the Promming case. The evaporator of the ORC system would be placed in the thermal oil cycle before the present boiler load 0.6 MW. In such a case the thermal oil would enter the evaporator in its maximum temperature 290 °C. The temperature drop in that stage would be 25 °C from 290 to 265 °C. The temperature drop to enable the present load should be 15 °C from 265 to 250 °C. The temperature drop in the evaporator would correspond to about 1.0 MW in terms of energy and the temperature drop for the present load would correspond to 0.6 MW. Taking into account that the power generation efficiency of ORC systems is typically 15 – 18%, it implies that about 0.15 – 0.18 MW of electricity could be generated and in addition to that, about 0.80 MW of heat in the condenser taking into account the losses in the cycle. This heat could be used for example for drying wood before pelletising it.

Wood drying capacity after ORC installation

If the excess heat 0.80 MW will be used for drying wood in order to produce pellets for instance, following amount of energy is required for every tonne of wood:

$$E = (1000 - (1000 - f_i * 1000/100)/((100 - f_d)/100)) * 2.44 \text{ MJ}$$

Where f_i and f_d are moisture contents of wood before and after drying.

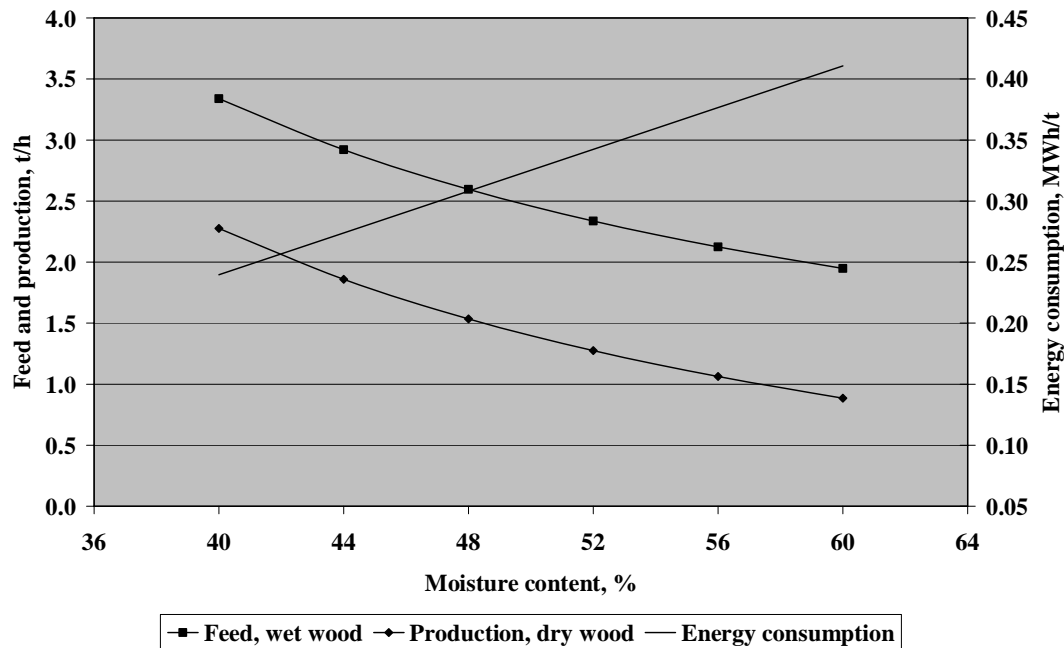


Figure 2. Feed, production and energy consumption in wood drying.

Figure 2 shows how much wet wood could be dried in an hour with 0.80 MW heat input and how much dry wood (moisture 12%) would be obtained. In addition, Figure 2 shows heat consumption per every wet tonne of wood. The overall efficiency in drying has been assumed to be 90%. If the fuel moisture would be 50% for instance, Figure 2 indicates that about 2.4 t/h of wet wood could be dried, yielding about 1.3 t/h of dried wood. Energy consumption would be correspondingly almost 0.33 MWh per every wet tonne. Figure 2 indicates also how strong effect the fuel moisture has on the yield. If the moisture is 60% instead of 40%, the yields are about 0.9 and 2.3 tonnes/h, respectively. Therefore it is extremely important to let the wood dry as much as possible in the forest or whatever place where it is stored.

If the dried wood will be pelletised, it would use electricity approximately 130 kWh/tonne, which accounts for 2.8% of the product's energy content. Further on, if the moisture content of the wet wood would be 50% for instance, its production rate would be 1.3 t/h (see Figure 2) and the corresponding power consumption $1.3 * 130 \text{ kW} \sim 170 \text{ kW}$. In such case, the pellet production would consume practically all the electricity that ORC system generates.

Conclusions

If Promming Ltd. decides to install an ORC power generation to its existing thermal oil boiler, the ORC system can generate 150 – 180 kW of electricity. In addition, about 0.80 MW of excess heat will be produced. This heat can be used for drying saw dust in order to manufacture pellets after drying it. The excess heat enables 0.9 – 2.3 t/h pellet production depending on the moisture content of the wet wood entering the drier system. In addition, pellet production would consume 120 – 300 kW of electricity depending again on the moisture content of the wet wood and consequent production rate of pellets.

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