STUDY OF THE UTILIZATION OF FLUID FROM A CONDENSATE POT FOR ESSENTIAL OIL EXTRACTION

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ABSTRACT

The use of waste hotfluid from a condensate pot in ageothermal steam pipe line for the extraction essential oil is studied in this paper. The aim of this study is to replace the current fuel by a non CO_2 producing geothermal energy source in producing essential oil from the *Vetiveria zizanoides* root (Akar Wangi) which is abundant near the condensate pot's fluid location, in West Java, Indonesia.

The accumulation of condensate from a typical steam main pipe line amounts to about 58.4 tons/day with a temperature of 200 ^oC, while the essential oil extraction process needs steam of at least 110 ^oC (usually from fired boiler) with a steam rate of 2 kg/hour/kg of dry *Vetiveria zizanoides* roots (Suwarda, 2009).

The plan is to use condensate collected from condensate pot in a heat exchanger to produce steam at 143.6^{o}C and 4 bara to extract essential oil. It is found that the system proposed in this study will be able to produce about 3.77 kg of *Vetiveria zizanoides* essential oil per day, with 15 hours required for condensate accumulation from the condensate pot and 9 hours for the extraction process.

1. INTRODUCTION

Indonesia has a lot of geothermal power plant with the total estimated resources of 27,189 MWe (Suryadarma *et al*., 2010). Most of the power plants are located in the plantation area where many kind of flora can be easily found. One among the plant is *Vetiveria zizanioides* (Akar Wangi), a variety that contains a good quality essential oil. This plant is abundant in many geothermal power plant regions in West Java (Figure 1) such as Darajat, Kamojang, Wayang Windu, Salak, etc. Usually the essential oil is made in a simple way. Steam at 110 ^oC from small fired boiler is used to distill essential oil from the root of *Vetiveria zizanoides.*

In a typical geothermal power plant, there is a lot of energy wasted to environment or re-injected to the earth i.e. hot brine from the separator or condensate from the main steam pipeline.

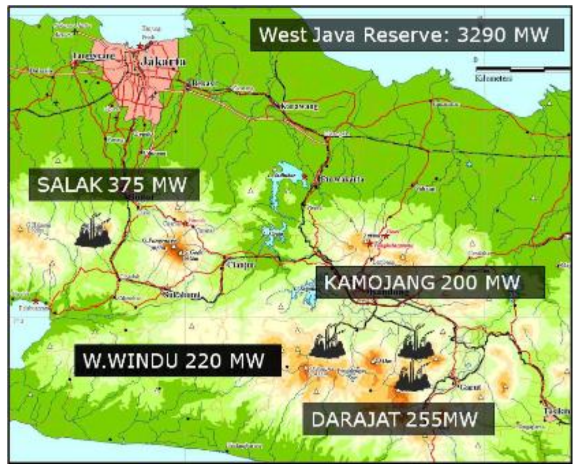

Figure 1 : Geothermal Power Plant in West Java (Agani *et al*., 2010)

A system for extracting essential oil using high temperature condensate rejected from geothermal steam pipe line is proposed in this study.

Normally, the steam pipeline from the wells to the power plant has some condensate pots to collect condensate accumulated along the transmission system. The condensate is released approximately periodically by the steam trap with the mass flow rate of 8.69 kg/s for a duration of 20 seconds every 225 seconds. According to preliminary analysis, the energy from the condensate is sufficient for essential oil extraction process. The proposed system can replace the fuel (such liquid petroleum gas, kerosene, etc.) that is normally used by the people for the extraction of the essential oil and hence will help in reducing CO_2 emission to the atmosphere.

2. ESSENTIAL OIL EXTRACTION PROCESS

Essential oil extraction from crops using a distillation process is categorised as a medium temperature agro-based industry. (Munir and Hensel, 2009). It includes the extraction of oil from roots of vetiver grass such as

Chrysopogon zizanioides (L.) and *Vetiveria zizanioides* (L.) (Danh *et al*., 2010). In West Java, Indonesia, *Vetiveria zizanioides* (L.) is abundant and has been cultivated for the perfumery industry for a long time. This plant has been used also for soil and water conservation (Adams *et al*., 2008), wastewater treatment, land remediation, etc.

In practice, there are many kind of essential oil extraction process, such as cold pressing, solvent extraction, hydro-distillation (Bouaziz *et al*., 2009), direct steam distillation (Tutuarima *et al*., 2009), combined water – steam distillation etc.

In this work, the direct steam distillation method will be considered. The sketch of the system is shown in the Figure 2.

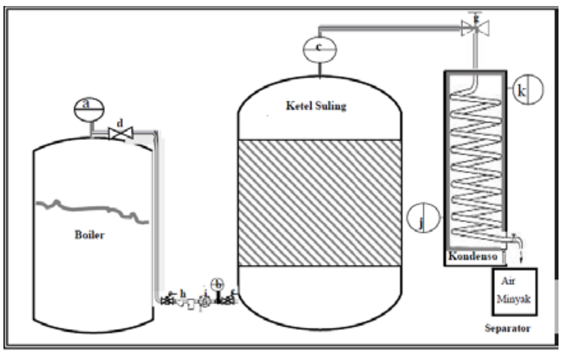

Figure 2: Direct Steam Distillation Process

Commonly, direct steam distillation equipment consists of a heat source, a boiler, a distillation tank, a condenser, piping and an oil receiver. Steam is generated in the boiler using either Liquid Petroleum Gas (LPG) or an electric heater. Vetiver root is placed in the distillation tank while steam from boiler is injected. The upcoming steam carries away oil extracted from vetiver root and flows to the condenser. Hereinafter, those vapors are condensed resulting in the formation of oil and water. Oil and water are then separated in a separator unit (Koul *et al*., 2004). Since the density of oil is lighter than water, the essential oil easily separates from the water and can be collected from the top side of the separator tank. Water can be taken out from bottom of the tank.

3. WASTE HEAT FROM GEOTHERMAL POWER PLANT

Steam from a geothermal well is at saturation conditions. When it flows inside the pipeline, it will lose some heat as result of the temperature difference from ambient air. This means that part of the steam will condense along pipeline and the accumulated water inside pipe line should be rejected. The temperature of the rejected condensate is exactly the same as the saturation temperature at the local pressure in the pipeline.

Normally, the steam pipeline from the wells to the power plant should have some condensate pots to entrap the steam condensate formed along the transmission system. The condensate temperature is high (about 200 ^{o}C). The condensate is collected in the steam trap and released to the atmosphere intermittently. In a typical power plant the mass flow rate is periodic with a discharge of 8.69 kg/s for 20 seconds every 225 seconds.

The waste heat from the condensate can be utilized as a heat source for essential oil extraction. The condensate released from the trap should be collected in a pressurized tank above the steam pressure, to keep the fluid in a liquid phase at a high temperature.

4. THE PROPOSED ESSENTIAL OIL EXTRACTION SYSTEM

As mentioned earlier the hot water from the condensate pot will be used as a heat source for the system. To keep the condensate at a high temperature, the condensate released from the pipe line must be collected in a pressurized tank. The hot water will be used in a heat exchanger to produce steam at 120 ^{o}C for the extraction of essential oil, while the hot water should leave the exchanger at 160 ^{o}C to avoid scaling. The process flow diagram of the proposed system is shown in the Figure 3

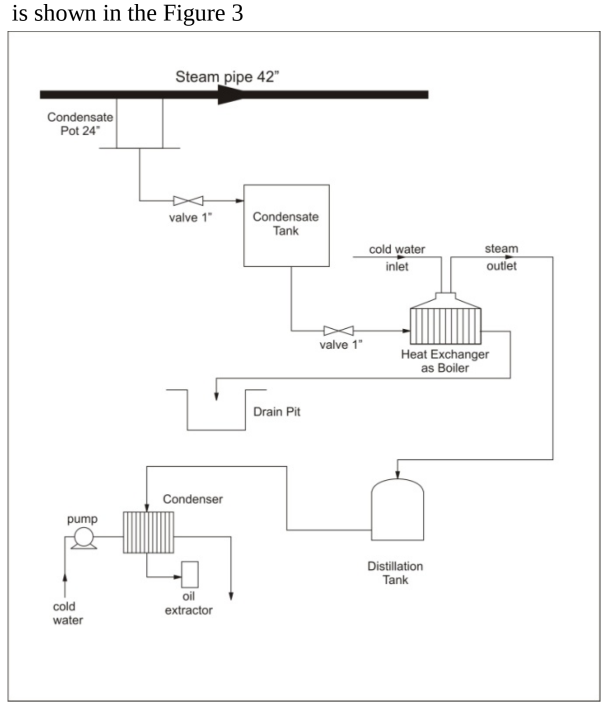

Figure 3: Process Flow Diagram of the Utilization of Waste Heat from Condensate for Essential Oil Extraction

The capacity of the proposed system will be the same as the existing equipment and will have the same configuration except for the fired boiler, which will be replaced by the heat exchanger. The condensate rejected from the steam pipeline will be used as a heat source for the system. The condensate tank should be added to the system to collect the condensate and to keep the condensate at a high pressure.

5. ENERGY BALANCE ANALYSIS

Based on the previous study, the energy needed to extract oil from vetiver root is about 2455.07 MJ/kg vetiver oil produced, while the amount of steam needed for the extraction process is about 2 kg/hour/kg of dry vetiver roots (Suwarda, 2009). The vapor pressure is 4 bara.

For 3.77 kg of essential oil production per day, the process will need 211.57 kg of dry vetiver root and 9 hours of continuous distillation. Since the condensate from condensate pot is released intermittently, the condensate could not be used directly, but should be first collected in the hot water tank. For this purpose the collection time from one condensate pot will be 15 hours, to run a continuous extraction operation of 9 hours. The total condensate collected will be 52.21 tons and the mass flow rate of condensate to the Heat Exchanger will be 1.6 kg/s.

5.1 Energy Calculation of Boiler - Heat Exchanger

To distill essential oil of 3.77 kg/day, heat transfer rate of 285.45 kJ/s is needed. The heat exchanger is used to generate steam using hot water from the condensate tank. Hot water will enter the HE at 207 ^{o}C and leave at 165 ^{o}C (to avoid scaling process along the pipe), while process water will enter the HE at 25 ^{o}C and evaporate at 120 ^{o}C. The Logarithmic Mean Temperature Difference (LMTD) in the heat exchanger is about 96.76 K. According a standard calculation it is found that the overall heat transfer coefficient of the HE is 875 W/m^2.K, and the heat transfer area is about 3.37 m^2.

5.2 Hot Water Reservoir

A hot reservoir tank is provided to allow continuous operation of distillation process. The total amount of condensate needed for producing 3.77 kg/day of essential oil is 52.21 tons. As the flow rate of condensate rejected is 0.86 kg/s for 20 second at intervals of 225 seconds, a hot reservoir tank is needed. The time required hot water collection will be about 15 hours. The total volume of condensate used for the process 61 m^3 and the total volume of the hot water storage tank is about 45 m^3.

6. ECONOMIC CONSIDERATION

The purpose of this work is to analysis the possibility of replacing the energy for extraction of essential oil by waste heat from geothermal power plant. The major items of equipment to be installed are a high pressure condensate tank and a heat exchanger to generate steam.

The traditional method for producing 3.7 kg essential oil consumes 211.57 kg of dry vetiver roots or 634.7 kg of wet vetiver roots, and consumes about 80 liters of fuel (kerosene). The price of wet vetiver roots is USD 0.30 per liters and the price of kerosene is USD 0/57/liter. The price of vetiver essential oil in the market is about US$ 100.00 per kg (Sudarwati, 2011).

The investment for common distillation plant (including distillation, conventional boiler, condenser, and oil extractor) is about US$ 6,650. The stimated cost for modification of the distillation plant to use condensate (including the hot reservoir tank, modification to the boiler incorporating the heat exchanger, and insulation) is about US$ 10,000.00.

Considering the use of condensate will save 80 liters kerosene per day, the Rate of Investment (ROI) of waste heat recovery from condensate will be about 8 months.

CONCLUSIONS

Waste heat recovery from geothermal condensate rejected through condensate pots has been studied for essential oil extraction. The analysis has shown that the proposed system is relatively simple and applicable.

The existing essential oil extraction plant can be modified to use waste heat from condensate with two major additional equipments, i.e. a condensate tank and a heat exchanger, including piping system.

Simple economic analysis has shown that the proposed system will have a ROI of about 8 months.

REFERENCES

Adams, R.P., Sanko N., Dennis A.J., Sunghun P., Tony L., and Mitiku H. 2008. "Comparison of Vetiver Root Essential Oils from Cleansed (Bacteria- and Fungus-Free) vs. Non-Cleansed (Normal) Vetiver Plants". **Journal of Biochemical Systematics and Ecology Vol. 36 : 177 – 182.**

Agani, M., Rozaq K., and Bachrun Z.I. 2010. "Construction and Operation of Kamojang Unit 4, the First Commercial Geothermal Power Plant Built, Owned and Operated by PT Pertamina Geothermal Energy". **Proceedings World Geothermal Congress 2010, Bali, Indonesia**.

Bouaziz, M., Thabet Y., Sami S., and Abdelhafidh D. 2009. "Disinfectant Properties of Essential Oils from *Salvia officinalis L.* Cultivated in Tunisia". **Journal**

of Food and Chemical Toxicology Vol. 47 : 2755 – 2760.

Cassel, E., Vargas R.M.F., Martinez, N., Lorenzo, D., and Dellacassa E. 2009. "Steam Distillation Modeling for Essential Oil Extraction Process". **Journal of Industrial Crops and Products Vol. 29 : 171 – 176**.

Cengel, Y.A. 2002. **Heat Transfer : A Practical Approach, 2nd Edition**. University of Nevado.

Danh, L.T., Paul T., Raffaella M., and Neil F. 2010. "Extraction of Vetiver Essential Oil by Ethanol-Modified Supercritical Carbon Dioxide". **Journal of Chemical Engineering Vol. 165 : 26 – 34**.

Koul, V.K., Gandotra B.M., Koul S., Ghosh S., Tikoo C.L., and Gupta A.K. 2004. "Steam Distillation of Lemon Grass (*Cymbopogon* spp.)". **Indian Journal of Chemical Technology Vol. 11 : 135 - 139**.

Munir, A., and Hensel O. 2009. "Solar Distillation for Essential Oils Extraction – a Decentralised Approach for Rural Development". **International Solar Food Processing Conference**.

Sudarwati, I. 2011. **Cost Analysis of Production Vetiver Root Oil in Garut, West Java**. Graduated Program: Bogor Agricultural Institute, Indonesia.

Suryadarma, Harsoprayitno S., Ibrahim H.D., Effendi A., and Triboesono, A. 2010. "Geothermal in Indonesia : Government Regulations and Power Utilities, Opportunities and Challenges of its Development". **Proceedings World Geothermal Congress 2010, Bali, Indonesia**.

Suwarda, R. 2009. **Energy Analysis of Vetiver Oil Distillation Process with Gradual Increase of Steam Pressure and Flow Rate**. Master Graduate Theses : Bogor Agricultural Institute, Indonesia.

Tutuarima, T., Hari S., Meika S.R., and Erliza N. 2009. **Process Design of Vetiver Oil Distillation by Increase of Pressure and Steam Flow Rate**. Graduated Program: Bogor Agricultural Institute, Indonesia.