

Optimization Of Energy Consumption in Geranium Oil Extraction Plant

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Abstract—Excessive energy consumption is a significant challenge for geranium oil extraction plants. To address this, we conducted both theoretical and practical analyses, including a site visit to identify causes of high energy use and to measure current consumption rates. We implemented two engineering solutions: first, integrating condenser hot water into the boiler, which reduced fuel use and increased steam production, achieving a 12.6% energy saving; second, pre-drying geranium leaves before steam distillation, which reduced energy consumption by up to 9%.

Index Terms—Energy consumption, Geranium oil, Cost reduction, Fuel consumption.

I. INTRODUCTION

Geranium oil is a highly prized essential oil known for its sweet, floral scent and numerous therapeutic benefits. Oil is extracted from the stems & leaves of *Pelargonium graveolens* or *Pelargonium roseum* plants through a simple steam distillation process. These stems & leaves are carefully washed to remove impurities and dried. Dried material is placed in a distillation column over a stream of steam. The released essential oil separated from the oil & steam mixture is cooled in a condenser. Collected oil is stored in a dark glass bottle to protect it from light and oxidation. The condensed geranium oil is a pale yellow to greenish in colour with a sweet and floral aroma. Geranium oil is used in aromatherapy and skincare products.

II. LITERATURE REVIEW

Yennam Rajesh, Nabeel M. Khan, & other studied the traditional extraction methods, such as steam, hydro distillation, and solvent extraction, etc. The author used the novel technique, Soxhlet extraction,

for geranium oil extraction from the leaves and stem of the plant using different organic solvents like n-Hexane, Methanol, Chloroform, Toluene, and Water. The result shows that n-Hexane and Toluene give satisfactory results with Soxhlet extraction, with a yield of 0.08-0.1 %. The operating conditions of Soxhlet extraction are Temperature (60-12°C) and time (120-240 min). Also, the author calculated the mass and energy balances of Soxhlet extraction are 6 (V/W) and 75 KW-Hr, whereas for steam distillation, the mass and energy balances are 0.5 (V/W) and 42 KW-Hr. Even though the yield is small compared to steam distillation, this work will be applicable for lab-scale extraction of geranium oil, as well as essential oils, at a lower cost. [1]

The author has studied the investigation of harvesting Geranium plantations. *Pelargonium graveolens* L., also known as rose geranium, rose-scented pelargonium, rose-scented geranium, is a fragrant species of *Pelargonium*. Geranium oil has applications in cosmetics, perfumery, flavor, and medicinal industries. Many authors studied different traditional extraction methods to enhance the yield of geranium oil. Methods like Soxhlet, solvent extraction, and hydro or steam distillation were used to get oil. The author has initially described harvesting conditions of geranium plants and then characterized them using GC-Analysis for varieties of geranium. Recovery of Oil was between 0.3 and 0.6%. [2]

Many small-scale industries use the same unit, i.e., steam distillation, for the extraction of geranium oil. The maximum yield of geranium oil is only up to 0.6 %. Other than reaction engineering, owners of plants also face difficulties while running a geranium oil plant, such as large energy consumption, degradation

of essential components present in the geranium oil, high moisture content in geranium leaves, and a large quantity of solvents is required for the extraction. Due to the minimal yield of production, the cost of oil is higher. Mainly in industries steam distillation method is used for the production of geranium oil. Production was taking place in half an hour with 750-1000 kg per batch. The observations were taken from a nearby small-scale industry of geranium oil production. One ton of geranium leaves produces only 1 liter of oil. The owner also faced problems such as energy consumption of the plant and rapid degradation of essential components present in the geranium oil. Due to the humidity in the air, the moisture content in geranium leaves is increased in the rainy season, and a large quantity of solvent is required for the production. The production cannot be increased significantly due to this limitation, so research work focused on optimizing the energy consumption of the plant.

III. EXPERIMENTATION

The fuel consumption of the plant was 200 kg/hr, & Steam generation was 500 kg/hr with raw materials- Geranium Leaves, Water. The plant has its major equipment as a boiler, a distillation column, Condenser and a separator. Fig. 1 shows the schematic diagram. of the arrangement of equipment.

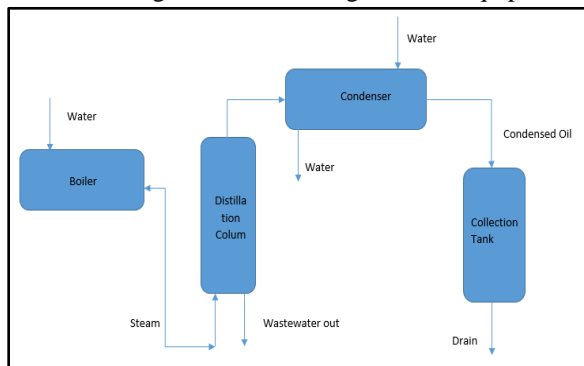


FIG. 1 SCHEMATIC DIA. OF GERANIUM OIL PLANT

The dried geranium leaves were fed to the steam distillation tank. The steam generation is carried out by using a boiler at a temperature of about 100-200 0C and steam is passed into the steam distillation tank for extracting the geranium oil from geranium leaves. After completion of the extraction process,

wastewater was removed from the bottom of the steam distillation tank, and the extracted oil was sent to the condenser to reduce the temperature of the oil. Here, two separate pipes make it possible for hot water to exit and cold water to enter the condenser. This process makes the vapor cool back into liquid form. Steam and oil vapor condensed into liquid in the condenser are collected in the separator. The extracted geranium oil is sent to a collection tank. The waste impurities are separated and drained through the bottom of the collection tank.

To understand energy loss in the plant, we must know the overall material balance & energy balance of the plant. After calculating the same energy required in existing plants, the energy required in modified techniques was calculated by three Methods i.e., by adding a condenser to heat water directly into the boiler, by removing moisture & by applying insulation.

IV. RESULT & DISCUSSION

After calculating the material & energy balance of the existing plant using three different methods, a significant result was found. The addition of condenser-heated water directly into the boiler can save 12.6% of energy in the existing plant.

We also observed that when we fed the wet leaves without drying in the vessel, the fuel required per batch was 200 kg, and when we fed the wet leaves after drying in the vessel, the fuel required per batch was 180 kg. This fuel consumption was considered for the one batch. In the actual practices industry carried out 8 batches per day; if we use dried leaves, then definitely the industry can reduce the fuel consumption up to 9.9%. In addition to this, if insulation were used to avoid the steam heat loss, then energy consumption up to 2% can be reduced.

So, by using hot condensate water, we may reduce 25 kg of fuel consumption, and by using dried geranium leaves reduce 20 kg of fuel consumption. So, we require only 155 kg of fuel consumption as compared to the existing plant fuel consumption of 200kg. So, by all these three methods, we can save 22.5% of energy in the existing plant.

V. CONCLUSION

This work concludes that employing steam distillation to extract geranium oil by using the modified techniques is a promising way for extracting oil using an organic solvent such as water. This work also concludes that for optimization of the geranium oil process, the modified techniques, such as utilization of condenser hot water, removal of water moisture from geranium leaves, are among the best techniques. By using this method, we have achieved a total energy reduction by 22.5%. This research will be very helpful for the large scale of the production of geranium oil. Energy conservation directly affects the quality as well as cost of the product, so due to this, energy conservation plays a very important role in the optimization of the process.

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