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FLOW ANALYSIS OF EUCALYPTUS PRODUCTION HEAT EXCHANGER

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Abstract- This study is based on the heat exchanger used in the production of eucalyptus oil. In this study, the heat exchanger required to cool the steam exiting the production process is designed as a boiler. The heat transfer between the steam line and the cold water line is studied using Ansys software. Finally, the velocity of steam and water in the heat exchanger is determined based on velocity, pressure, and temperature. The study is designed to be applicable to both small and large production plants.

Keywords: Eucalyptus, Heat Exchanger, Steam, Water, Velocity, Pressure, Temperature etc.

1. INTRODUCTION

Eucalyptus comes from the Myrtaceae family, widely grown in the world, and commonly used for medicinal plants. There are many species in the world, and one of them is Eucalyptus globulus. The essential oil can be found in Eucalyptus globulus, especially in the leaves.

Eucalypts have been planted on a large scale in India- mainly for fuel wood, pulp, pole, and afforestation purposes- but the dominant species is E. tereticornis ('Mysore hybrid'), which is not suitable for oil production. Both E.globulus (mainly in southern India) and E.citriodora, however, have also been planted, and these two species form the basis for Indian eucalyptus oil production.

1.1 Products and its application

Essential oil is used in many sectors, such as health care, flavoring, perfume, cosmetics, and Pharmaceuticals.

- The bioactive content in essential oil can be used for antioxidant, anti-bacterial, and anti-inflammatory.
- It is an essential ingredient of medicines that are used to provide relief from influenza and colds. In addition to this, it is also used in the preparation of medicines that are used for cough sweets, lozenges, ointments, and inhalants.
- This oil is used in toothpaste flavors and soap fragrances. It is also used by manufacturers of mosquito repellent companies
- Eucalyptus oil is used as a co-solvent component of petrol-ethanol fuel blends.

This study is based on the steam cooling method, changes in steam, and heat transfer. The eucalyptus oil production method is produced in mountainous areas.

Eucalyptus oil is produced by processing the dried leaves of the eucalyptus tree. Boiler, condenser pipe, and separator are used in this process.

The boiler is filled with dry leaves as required or required. The leaves are compressed under high pressure and then piped to the top of the boiler to carry the steam. A condenser is constructed to cool the steam, a condenser is built and cold water is injected at one end. In this method, the pipe is made of steel pipe. As the steam passes through the pipe, its velocity is reduced and as the cold water passes through the upper part of the pipe, the pipe is cooled and the pipe temperature is reduced.

Thus oil and unwanted water are extracted using a dynamic fluid filtration system. The whole purpose of this study is to design a condenser and investigate the changes in it (heat, pressure, velocity).

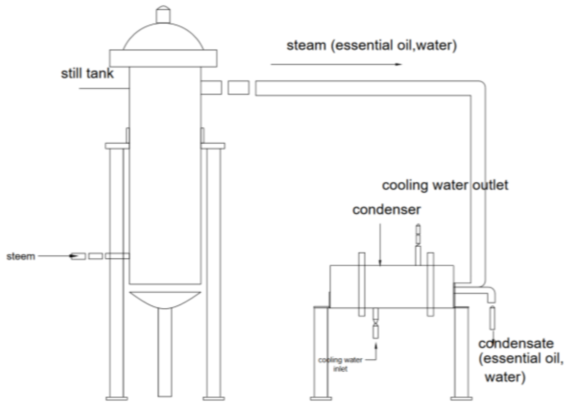

Fig -1: Production of eucalyptus oil

2. MODELLING

The condenser (heat exchanger) is designed using SolidWorks software. The quantities required to manufacture the condenser were taken using the existing mini-factories. SolidWorks software is a 3D design software that uses computer-aided design and we use this software because it is great and easy to use. The required condenser model is designed with the help of this software.

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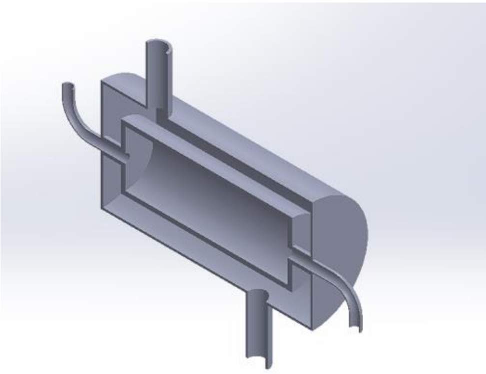

Fig -2: Section view of heat exchange

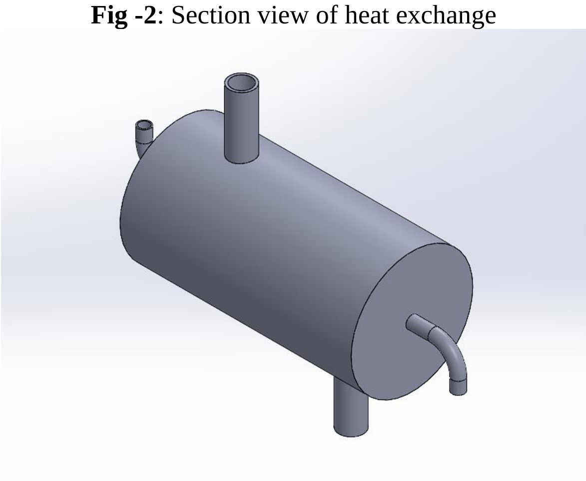

Fig -3: Heat exchange modal

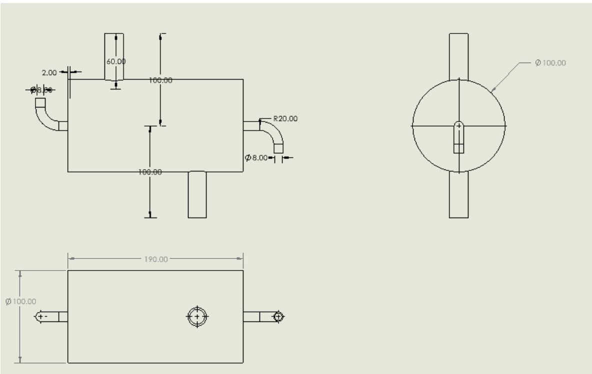

Fig -4: Dimensions of modal

2.1 Heat exchanger

A heat exchanger is a mechanical device that exchanges or transfers heat between two unmixed fluids. All heat exchangers contain different barriers that separate the liquid and transfer heat at the same time. A double-pipe heat exchanger is the most famous type of heat exchanger, which has a very flexible configuration. The simplest type of double-pipe heat exchanger currently available has a small pipe surrounded by another large pipe. This article will mainly explain the double pipe heat exchanger working, types, and applications. A double-tube pipe heat exchanger is a heat exchanger that uses two pipes to exchange heat between two fluids. One pipe has hot fluid, while the other pipe has cold fluid. This heat exchanger is also called a jacketed U-tube, jacketed tube, hairpin, or pipe-in-pipe heat exchanger.

They are most commonly used for transporting heat and air. The double-pipe heat exchanger has a small pipe that is surrounded by another large pipe. One fluid flows inside the small pipe and the other fluid moves by the annulus between the two pipes. The inner wall of the small pipe is the heat transfer surface. The entire heat transfer process takes place in the large tube. In this way, the inner pipe works like a conductive barrier. The external side contains the fluid flow through the tube side or the inside.

This heat exchanger may have one pipe or a bundle of pipes (but lower than 30 pipes). The large pipe is lower than 200 mm in diameter. In some conditions, the inner pipe has vertical fins to improve the heat transfer coefficient between the working fluids. Double-tube pipe heat exchangers are used for small heat transfer areas (e.g., 14 m2). The series connection to raise the heat transfer area needs more space and more accessories, which leads to a higher pressure loss. In addition, it is not possible to increase the number of fluid passages on both sides. This heat exchanger is not suitable for dirty liquids because the dirty liquid will clog it, and cleaning this heat exchanger is very hard. The main advantage of the double-pipe heat exchanger is that it is easy to operate and has a simple design. The construction cost of the double-tube heat exchanger is relatively low and requires minimum maintenance.

These heat exchangers are best suited for sensible cooling or heating in high-pressure and high-temperature applications. Double-tube pipe heat exchangers are used for small heat transfer areas (e.g., 14 m2). The series connection to raise the heat transfer area needs more space and more accessories, which leads to a higher pressure loss. In addition, it is not possible to increase the number of fluid passages on both sides. This heat exchanger is not suitable for dirty liquids because the dirty liquid will clog it, and cleaning this heat exchanger is very hard. The main advantage of the double pipe heat exchanger is that it has easy operation and has a simple design. The construction cost of the double-tube heat exchanger is relatively low and requires minimum maintenance. These heat exchangers are best suited for sensible cooling or heating in high-pressure and high-temperature applications.

2.2 Specification of Double Pipe Heat Exchangers

The double-pipe heat exchanger is one of the simplest types of heat exchanger. The diagram represents this heat exchanger. As shown in the below diagram, one shell or tube is surrounded by another shell or tube. These types of shell and tube heat exchangers have simple and straightforward designs, giving customers a wide variety of options to choose a heat exchanger according to their requirements. There are multiple custom heat exchangers in the market that are designed according to the requirements of different industries and projects. The double-pipe heat exchanger is recommended for use in small applications. They are utilized to transfer heat in small areas (i.e., less than 45 square meters).

To use this exchanger, you must know the types of fluids in your system. Due to the ample flow space on the shell side, you must use only viscous fluids on the shell side. Therefore, when utilizing steam as a working fluid in the heat exchanger, it is best to use pipes for the flow.

Before selecting a suitable heat exchanger, you need to determine the characteristics or conditions of your project. You must also determine the outlet and inlet temperatures as well as the desired heat transfer rate. With this information, it will be easier for you and your seller to present you with the commercially available exchangers and to design the right tube pair for your exchanger. The heat exchanger used in this study was based on the double-pipe heat exchanger model. This system is simple and effective.

2.3 Applications of Double Pipe Heat Exchanger

The application range of double tube heat exchangers is very broad and difficult to cover due to its practical, beautiful, and concise design. Double-pipe heat exchangers are most commonly used in the following applications:

- Solar thermal systems
- The pulp and paper industry
- Pharmaceutical industry
- Wastewater treatment
- Petrochemical industry
- Food and beverage industry
- Refrigeration systems
- Power generation
- Chemical processing
- HVAC systems

3. MANUFACTURING PROCESS

The extraction method can affect the yield and chemical content of the essential oil. The selection of effective extraction methods can produce high quality, maximum yield, and maintain the chemical content. Generally, the extraction methods used are maceration, Ultrasound-Assisted Extraction (UAE), microwave-assisted extraction (MAE), distillation with water or steam, and others.

The effective extraction method can extract essential oil with the best quality and not damage the existence of bioactive compounds. The extraction method of essential oil can be divided into two categories, conventional and modern methods. The conventional method includes hydro-distillation, steam distillation, and extraction using solvents. The modern method includes supercritical fluid extraction, microwave-assisted hydro-distillation, and ultrasound-assisted extraction.

4. ANALYSIS OF HEAT EXCHANGER

The model created in SolidWorks software is saved in IGES format and uploaded into Ansys software. The uploaded Condenser Model is created with the help of ANSYS Fluent and includes the Steam Inlet, Steam Outlet, Water Outlet, and Water Outlet required for the analysis.

Heat exchanger model imported from solid works software ANSYS workbench 2023 R 2 geometry is checked and then the workbench model is meshed. Mesh is a method of dividing an area into small parts. These small parts are triangular shape, quadratic shape, and rectangular shape are divided based on these models.

Out of which 23200 Node and contains 8050 elements. The analysis parameters required for the analysis required for the study are defined in the fluent software. Both pipes are made of steel material. The velocity of the steam is assumed to be 50 m/s based on old research reports and the velocity of the cooling water is assumed to be 10 m/s based on old research reports.

The steam temperature is assumed to be 100°C and the water temperature is assumed to be 28°C. The pressure of the steam is defined as 5 bar and that of the water as 1 bar. In this process, the analysis is based on the iterative method. Heat changes in the condenser are studied separately (cooling and steam), similarly, steam velocity, pressure temperature, etc. are also determined. The velocity of cold water pressure temperature change is also detected the temperature of the steam is reduced inside the condenser and converted into water and oil this phenomenon occurs due to a decrease in temperature. The temperature of the cold water rises and is discharged through the outlet.

As the cold water continuously circulates over the top of the steam pipe, the top of the pipe is cooled and the steam inside the pipe is converted into water and oil. His cold water absorbs heat from the steam pipe and its temperature changes. This constant heat transfer between the cold water and the steam pipe is detected in each area.

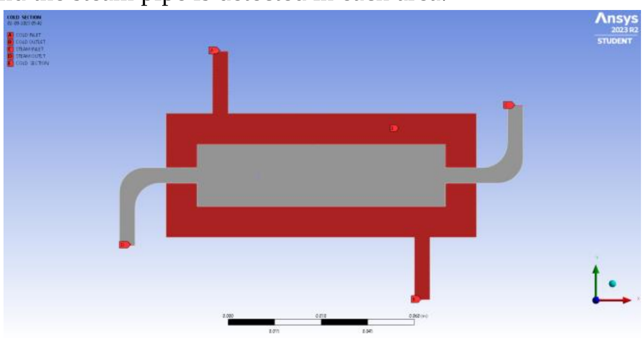

Fig -5: Heat exchanger modal

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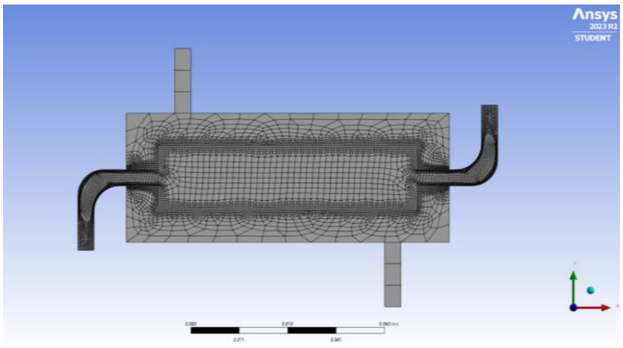

Fig -6: Heat exchanger mesh modal

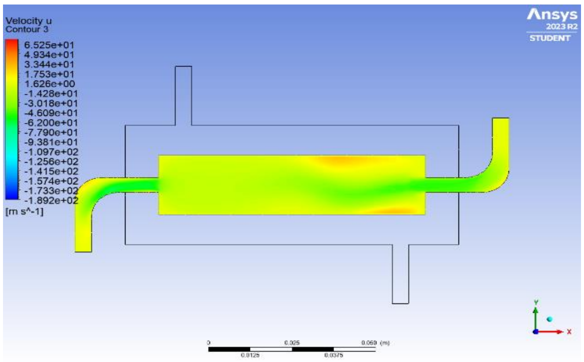

Fig -7: Velocity distribution of steam tank

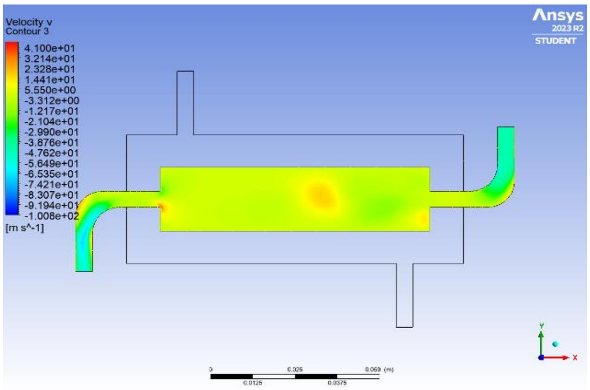

Fig -8: Velocity distribution of steam tank vertical position

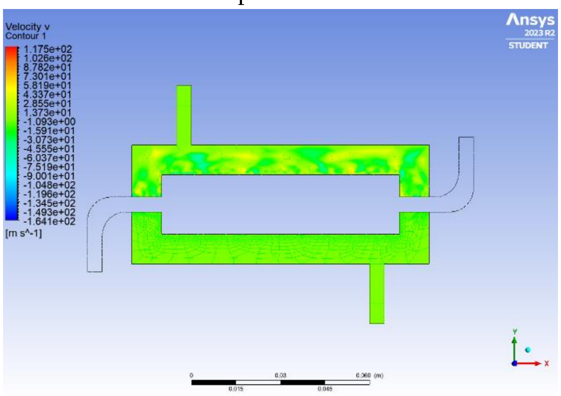

Fig -9: Velocity distribution of water tank

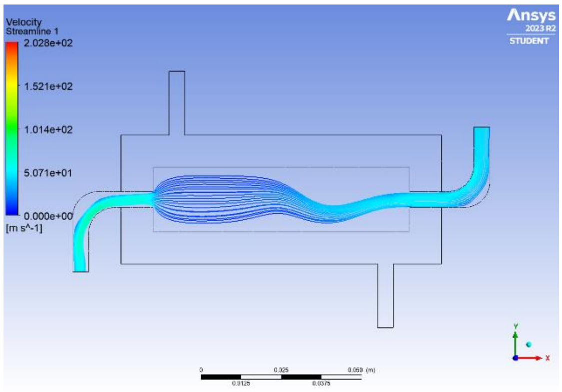

Fig -10: Velocity distribution of steam pipe

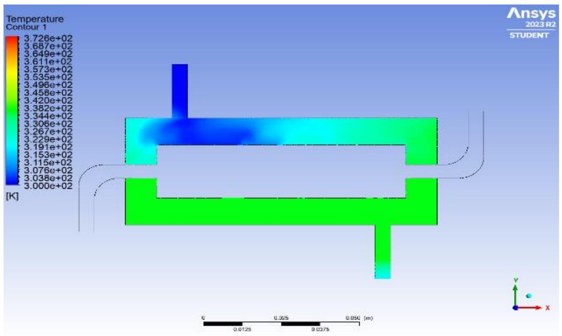

Fig -11: Temperature distribution of water pipe

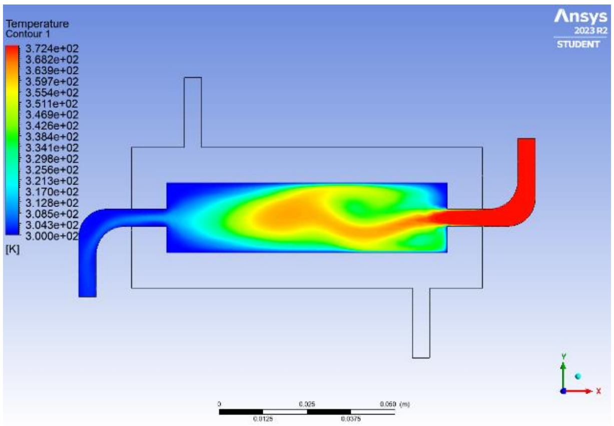

Fig -12: Temperature distribution of steam tank

The boundary conditions of the model are set to solve the conservation of mass, momentum, and the energy equation as well. Table 1 shows the boundary conditions applied for the analysis. The integrated system was simulated in terms of parameters such as the effects of temperature on the species concentration in the stream and water temperature in the heat exchanger.

Table -1: Process boundary conditions used in the simulations.

Fluid domain	Boundary condition values
Coldwater inlet temperature	300 K
Steam temperature	373.15 K
Cold water inlet velocity	20 m/s
Steam inlet velocity	45 m/s
Cold water pressure	1 Bar
Steam pressure	2 Bar

5. RESULTS AND DISCUSSION

The formulated model volume for this study is a combination of a cylindrical steam and heat exchanger tube. After several changes have been chosen, especially in the air inlet in the steam and the cold water inlet in the heat exchanger, a figure mesh was generated between the inlet and outlet temperature range 298–372 K.

The mass fraction variation of species in the gasification temperature, pressure, temperature, and velocity in the heat exchanger is analysed based on the results obtained in the model.

As it can be seen in Figure, a result of the FUENT study model temperature variation has a relation with a mole concentration and mass fraction of species. A greater temperature can be achieved when the mass fraction and mole concentrations of species decrease during the gasification. The temperature of the steam produced in the boiler is 372 K when it reaches the water cool water tank. As the steam passes through each stage in the boiler, the temperature gradually decreases (359 K, 342 K, and 312 K) and finally reaches 312 K. At this stage the steam turns into a liquid. The temperature of the water tank outside the steam tank gradually increases. Finally, the water tank reaches 338 K in the outlet Vapor pressure and vapor velocity decrease gradually inside the section.

6. CONCLUSION

In this study, we learned about the production process of Eucalyptus Oil. The study method enabled accurate detection of changes in heat dissipation. The heat change of the steam pipe and the heat change of the cold pipe were both known in the study. The continuous flow of cold water from the time pipe completely cools the steam pipe thus avoiding unnecessary steam wastage. This study is useful to increase the level of oil production.

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