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Pilot plant designing and implementation for biodiesel production

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Abstract: Environmental constraints and public awareness of concerns such as pollution and sustainable development have garnered considerable attention in recent decades. The move away from fossil fuels and toward alternative energy is of the utmost importance, despite the difficulty of meeting the Paris agreement's targets. Biodiesel is an exciting alternative fuel that is being extensively researched for usage in transportation and industrial power generation. To get the maximum possible yield, the catalysts, production technique, and any other relevant parameters are carefully fine-tuned. The design and construction of the pilot plant were based on the most efficient operating conditions discovered.

Index Terms: Biodiesel, Pilot plant. Process flow diagram, Renewable energy

1. INTRODUCTION

The crisis in the energy industry is one of the most difficult and significant problems facing today [1]. Due to the fact that our daily lives are dependent on a range of energies and power sources, this raises an essential topic for discussion. Nonetheless, one of the most significant causes of air pollution is the combustion of fossil fuels to generate energy [2]. Many governments are under pressure from environmentalists and scientists to transition away from the use of fossil fuels and toward the usage of renewable energy sources. This modification is vital to prevent the predicted devastating effects of climate change. Biodiesel is one of the prospective alternative fuels that could one day replace fossil fuels when it comes to power generation and transportation [3]. The biodiesel production method known as transesterification has been the subject of research [4, 5].

In addition, the role of the catalyst and the impacts of several catalyst types were examined [6]. The previous study has investigated the consequences of comparing the physicochemical parameters of biodiesel and blended diesel to those of regular diesel, as well as the effects of these properties on the vehicle [7]. In the past, researchers have explored the impact of co-solvents on biodiesel manufacturing yield [8]. Based on experimental results, acetone was shown to be the most effective co-solvent for the transesterification process [8]. To assess the blending quality, research has been conducted on the properties of blended diesel, such as diesel combined with biodiesel and bioethanol. This was done so that the blend's quality could be determined. The addition of even a small amount of bioethanol to a diesel and biodiesel blend dramatically enhanced the fuels' physical properties. This was true regardless of the bioethanol-adding ratio. It is plausible to conclude that the switch from diesel vehicles powered by fossil fuels to bioethanol-powered vehicles reduced harmful emissions significantly [9]. To evaluate the influence of mixing on the transesterification process, a comparative analysis of numerous types of stirrers has been done [10]. This experiment was conducted to investigate the influence mixing had on the process. However, the commercialization of biodiesel in Sri Lanka will not occur unless the necessary governmental adjustments are made [11]. In the past, the author has recommended that immediate action be taken to promote this as an alternative fuel source.

The installation of a pilot plant has boosted the amount of biodiesel that can be produced on a large scale for commercial use. The appropriate operating parameters and mixing qualities for the design have been found as a result of laboratory research and evaluations.

2. PILOT PLANT DESIGN

The design of the pilot plant was not a simple process because it had to reflect the actual operating conditions of the facility. Consequently, the process flow diagram depicted in Fig. 1 served as the starting point for the initial phase.

The four components of a typical biodiesel production process are the biodiesel storage tank, the main reactor, a separation unit, and the biodiesel purification section. However, neither the system for recovering raw materials nor the product recovery steps are included in the conventional technique. Due to evaporation losses that occur during the reaction, it is crucial to add additional methanol for the optimal manufacturing process. In addition, the glycerine produced as a byproduct is not reclaimed since it does not satisfy the purity requirements of several other industrial applications. The highly efficient biodiesel manufacturing facility is created with raw material recoveries, such as the section for the condensation of methanol, and the byproduct purification unit, which has sections for the purification of glycerine and other byproducts. In addition, biodiesel washing, and drying machines are added at the end of the process to enhance the amount of biodiesel purity attained.

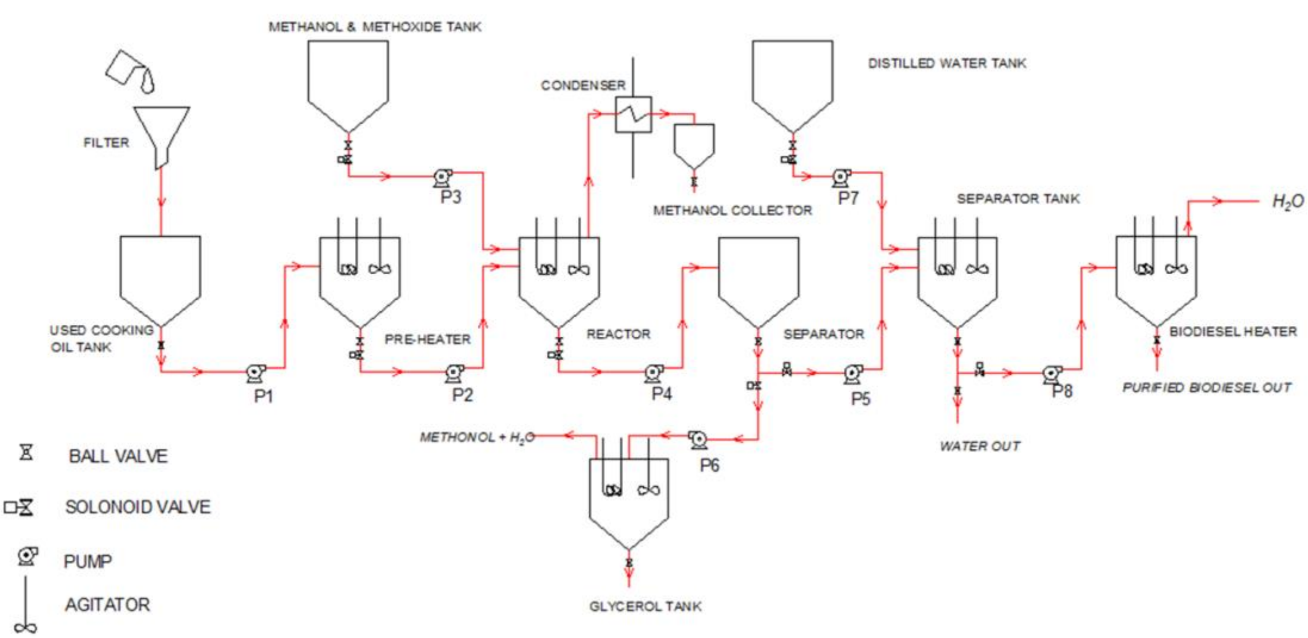

Fig. 1. Process Flow Diagram

Fig. 2 illustrates the isometric view of the 3D drawing. It represents the valves, solenoid valves, pumps, and heating units.

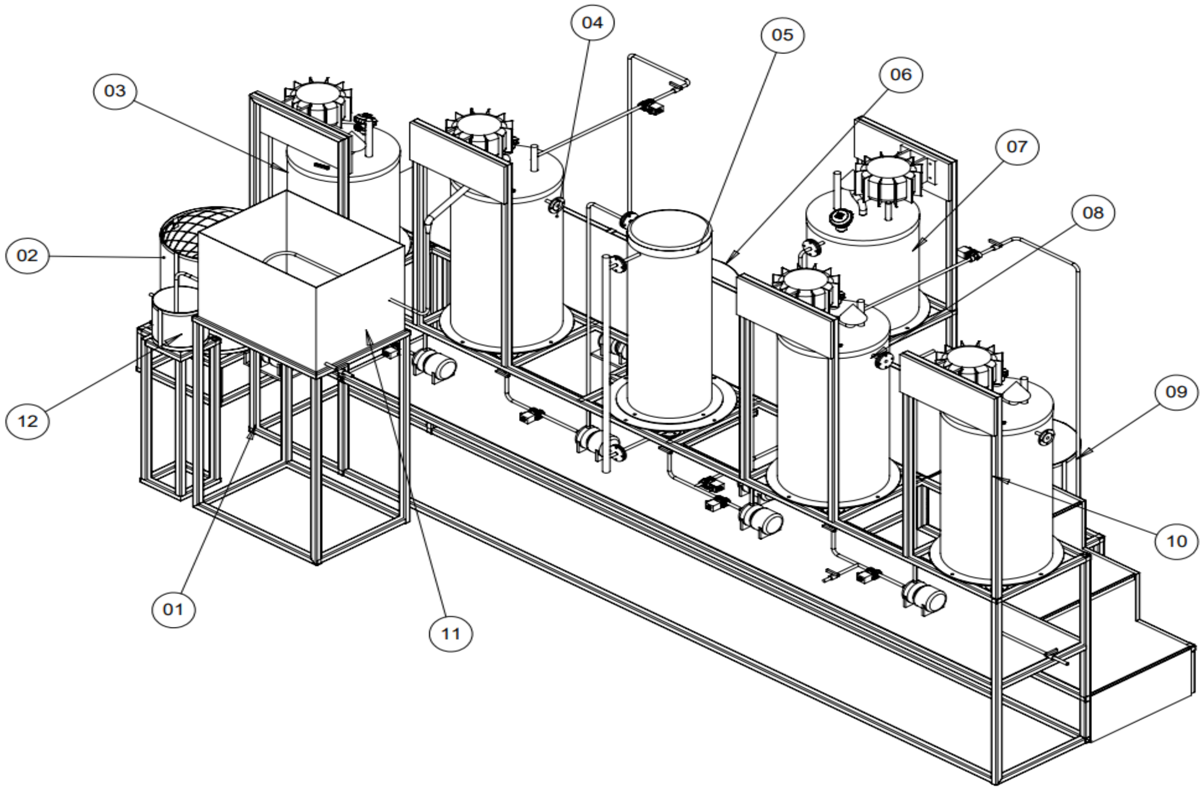

Fig. 2. The isometric view of the 3D

1- MAIN FRAME
2- OIL TANK
3- HEATER UNIT
4- MAIN REACTOR
5- SEPARATOR
6- METHANOL+METHOXIDE TANK
7- GLYCEROL TANK
8- WASHING UNIT
9- DISTILLED WATER TANK
10- BIODIESEL HEATER
11- CONDESOR UNIT
12- METHANOL COLLECTOR

The side view of the three-directional efficient stirrer unit is depicted in Fig. 3. There are three sets of blades within the stirrer's shaft. The angles between the blades are 90° for the lower blades, 60° to 120° for the middle blades, and 30° to 150° for the top blades. These three-blade devices are linked to the shaft by an adjustable sliding clip. It is able to ascend and descend to adjust the distance between two sets of blades. The blades themselves are angled differently from the blades' connecting portion.

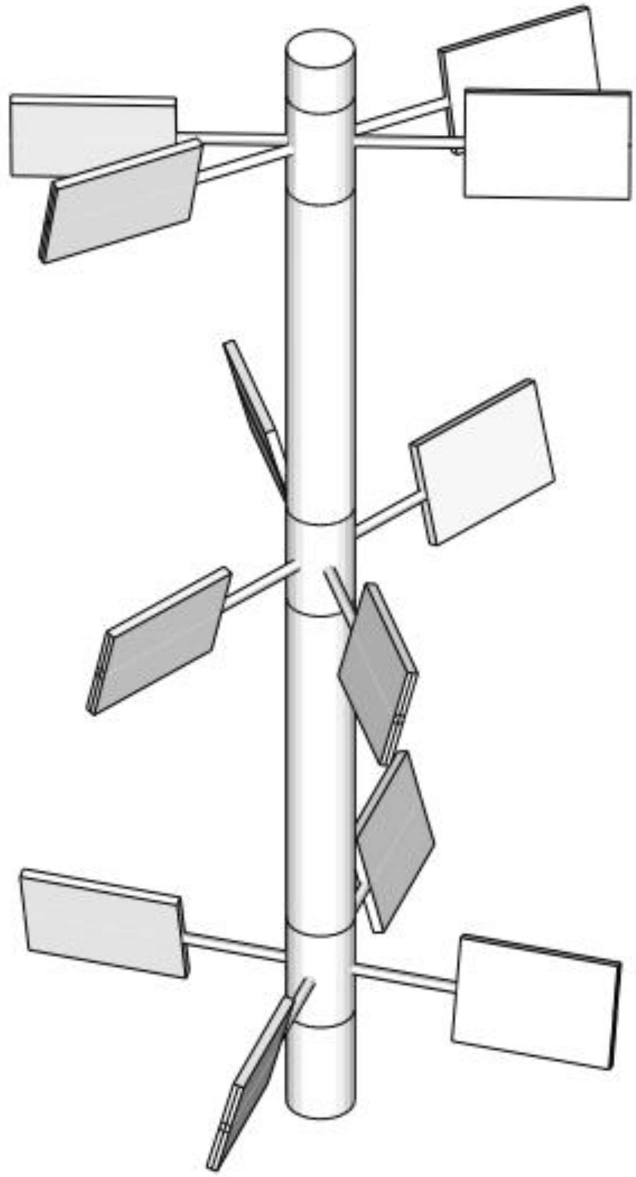

Fig. 3. Side view of the three directional efficient stirrer unit

Fig. 4 illustrates the 3-dimensional view of the stirrer with the measurements.

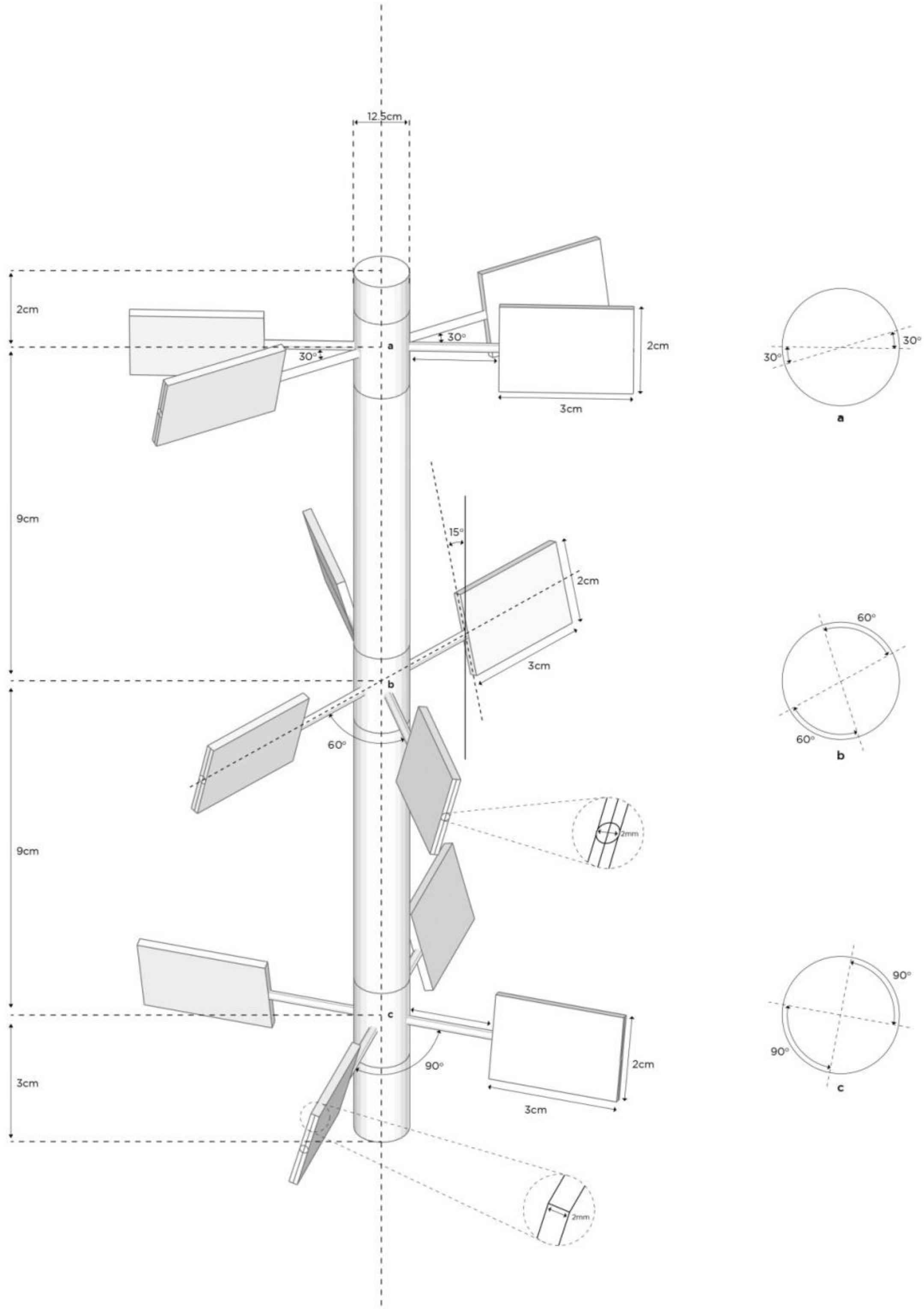

Fig. 4. Three-dimensional view of the stirrer

There are available and tested baffle reactors for chemical processes. In contrast, this unique reactor has 10 nozzles in addition to the baffle to provide transitional flow while stirring. Therefore, transitional flow develops and boosts the mixing capacity closer to the reactor wall than overall smooth flow. Moreover, these nozzles are manufactured in a thin baffle plate with an embossed hole to boost the pressure of the fluid (Fig. 5).

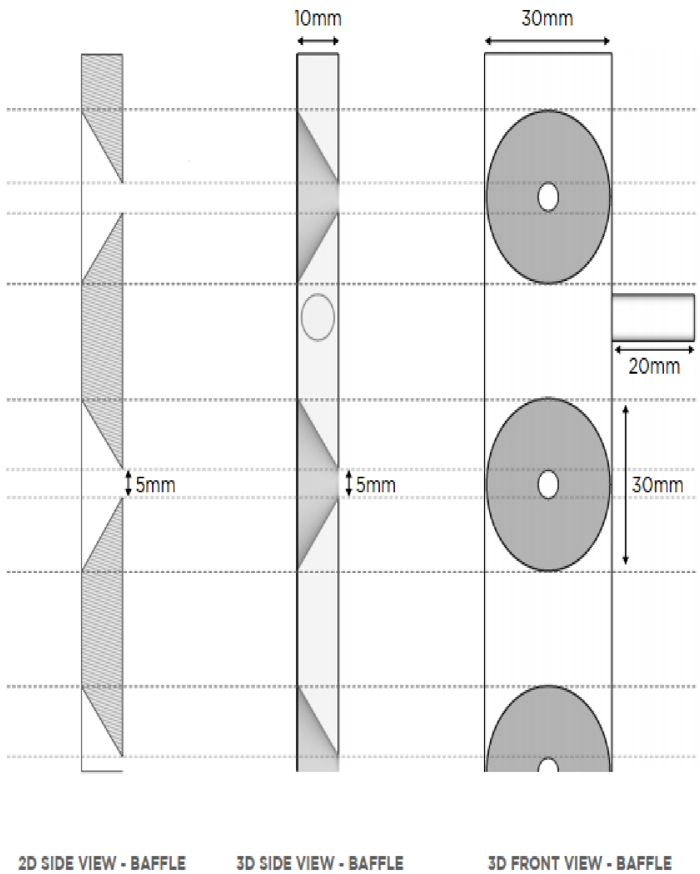

Fig. 5. Nozzles

The center stirring unit's three directional shafts, which rotate in three distinct directions, also play an important function. Consequently, distinct vortices emerge throughout the process of mixing. At the bottom of the reactor, four sharpened blades for the impeller unit provide an additional vortex for optimum mixing; as a result of these highly efficient reactor enhancements, the biodiesel generating reaction time has been decreased from 90 minutes to 4 minutes (Fig. 6).

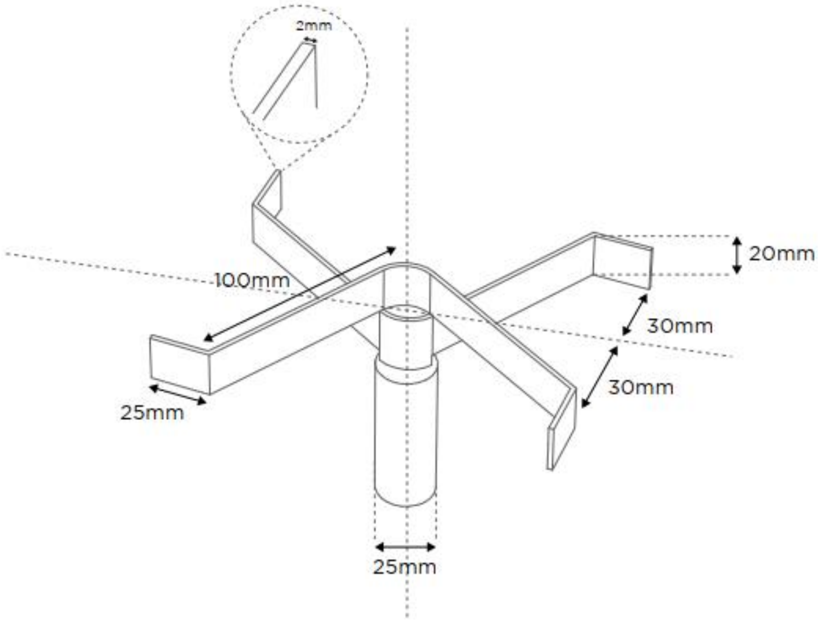

Fig. 6. Four sharpened blades at the bottom

In addition, unlike the conventional technique of biodiesel production, additional heating is not required to proceed with the transesterification reaction. This will significantly reduce the amount of energy necessary for the transesterification process.

Because of the relatively high viscosity and the high density of the resultant glycerol, the glycerol accumulates at the bottom of the reaction medium. This is because of the nature of glycerol. Because of this, the molecular collisions that occur in the aggregate mixture are disrupted. Therefore, to prevent the reaction from slowing down, the impeller, which has four blades (12), pushes the glycerol downwards and lifts it. This procedure is broken down into two distinct stages. In the first stage, the mixture is propelled upward by the impeller's lower propellers (10) to the impeller's upper propellers (11). Then the mixture is propelled upward by the upper propellers to the lower blade (13) of the central stirrer. The propellers in the central stirrer are arranged in three levels, with each layer's propellers (15) attached at three different angles to the metal rod (13) in the center. Due to the angles between the separated propellers, the mixture in the reactor (reactant-product mixture) rotates at various speeds in different layers, increasing the molecular collision of the mixture and consequently lowering the overall reaction time and increasing yield.

Because of the ten identical nozzles (6) in each baffle (5), which is coupled to a flange (4), the fluid flow is transitioning to transitional flow. There are four baffles to raise the fluid's pressure as it flows. A central stirring unit is mounted to the reactor's upper lid (1) to generate vortices for effective fluid mixing. The central stirrer's blades are attached to the middle shaft by a separate metal shaft (14). At the bottom, a stationary flange connects a four-bladed propeller to the reactor (9). The reactor's base is embossed upward (3) to create a passage (8) for collecting the glycerol and biodiesel.

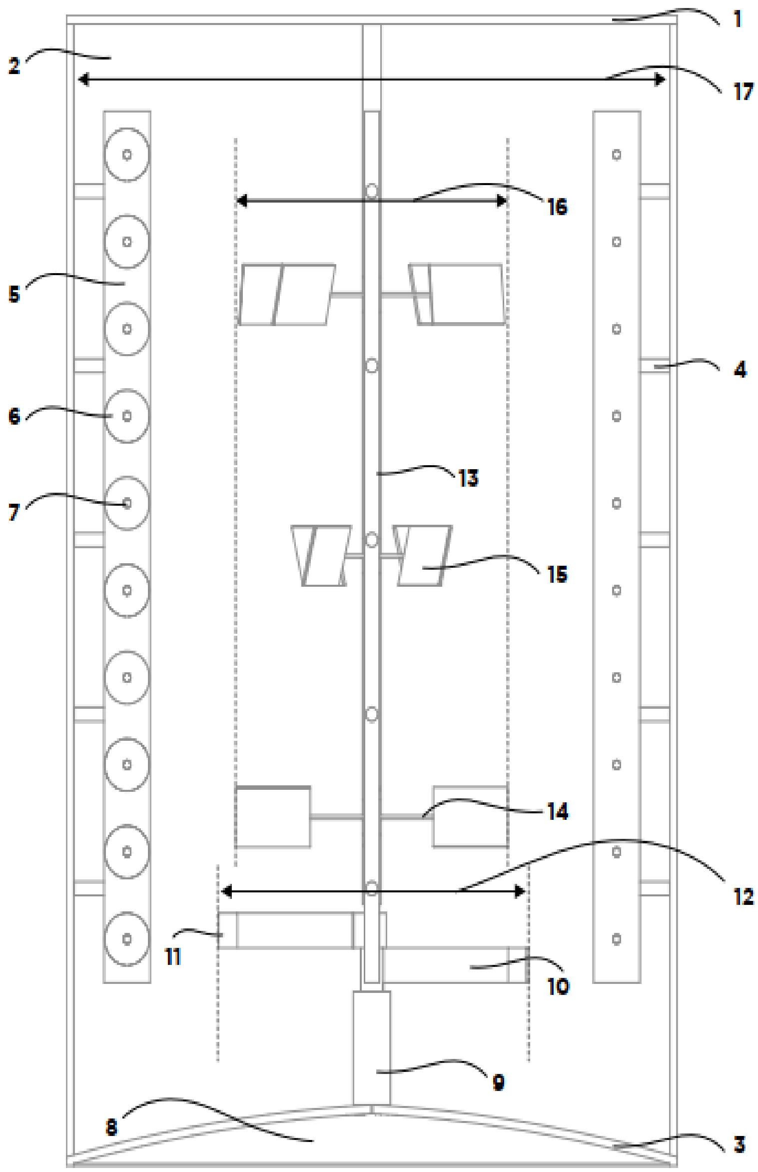

Fig. 7. Illustrates the Front view of the reactor unit

The pilot plant of the biodiesel production process is given in Fig. 8. To get a corrosion-free environment, stainless steel was used as the raw material for construction.

Fig. 8. Biodiesel production Pilot plant at the laboratory

3. CONCLUSION

Pilot plant can be used to produce biodiesel with optimized operating conditions. Moreover, it can be used as an ideal model for the industrial partners to motivate them for alternative fuel production. At the same time, optimum yield can be analyzed by varying operating conditions. That information will be useful for simulation studies before implementing industrial scale biodiesel production plant.

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