International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Fabrication of Distillation Apparatus to Check the Quality of Petrol

Dr. Kommana Srinivas[1], Dandu Kasim Moula[2], Divya singhi[2]

[1] *Department of Mechanical Engineering, Siddhartha Academy of Higher Education Deemed University, Vijayawada, India-520007*

[2] *Department of Mechanical Engineering, Velagapudi Ramakrishna Siddhartha Engineering College, Vijayawada, India-520007*

Abstract - Volatility, defined as the propensity of a liquid to vaporize under equilibrium conditions, critically influences engine start-up and emission profiles. This study presents the design and fabrication of a custom distillation apparatus to determine petrol purity by generating distillation curves for two commercial samples. We introduce an air-cooled condenser configuration optimized for low-cost laboratories, addressing gaps in simple, reliable volatility measurement techniques. Experimental results demonstrate repeatable distillation curves with less than 2% deviation between trials. Sample 2 exhibited a 15% steeper initial slope and lower onset temperature (43°C vs. 47°C) compared to Sample 1, indicating higher volatility. These findings validate the apparatus' accuracy and highlight its utility for routine quality control in resource-constrained settings.

Key Words: Distillation, Volatility, Condensation, Fuel, Evaporation.

1. INTRODUCTION

At present, petroleum remains the major source of energy resources, and for more than 100 years, it has been the main source of fuels used in alternative internal combustion engines in auto-motion as well, both for spark ignition engines, traditionally known as petrol engines, and for compression ignition engines, or diesel engines. Nevertheless, we must bear in mind that differences in the operation of spark ignition and compression ignition engines require very different types of fuels.

When we speak about petroleum-derived fossil fuels, used as automotive fuel, we must remember that in a given series of hydrocarbons the ignition temperature decreases as the molecular weight increases because the cracking of large molecules needs less activation energies, where by SIE require low boiling hydrocarbons with soft combustion temperature and a relatively high spontaneous ignition temperature.

From the chemical composition viewpoint, petrol is a blend of hydrocarbons between C4 and C11, with boiling points between 25 and 210°C and in which we can find all types of hydrocarbons: paraffins, isoparaffins, olefins, aromatics, naphthenes, etc. They may also contain oxygenated compounds such as ethers and pure alcohols in variable proportions: minimum amounts of sulphur and nitrogen as well as additives.

Among the wide variety of features to consider when establishing the quality of a fuel used in auto-motion, volatility stands out as one of the most critical ones since it is a characteristic directly related to engine performance and pollutant emissions. Petrol is a fuel which is a liquid state in the fuel tank and in the fuel injectors (or carburettor on older engines) and which is nebulized with air before being injected into the combustion chamber.

If the volatility of fuel is low, the petrol does not exist in the gas phase, and there will be difficulties with the starting up of the engine and the behaviour of the engines in cold regimes. If the volatility is high, the petrol can be vaporized in the tank itself or in the pipelines ('vapour lock'). As a consequence, the injection rate is inadequate, and the engine drowns.

Volatility is not a physical magnitude that can be measured directly; it is necessary to define methods of evaluating it. One universally used method to determine the volatility of a fuel is the distillation test that offers different information according to the type of fuel tested.

2. COMPONENTS

The distillation apparatus mainly consists of two components. They are heating chamber and a condenser. The entire frame work is done using cast iron. The construction of the frame work includes many processes like grinding, welding and cutting.

Heating chamber is the frame where heating of the sample fuel take place. This mainly consists of various components. They are listed below. heating element (1500 Watts), ceramic heater plate, stand, distillation heating flask (250 ml), thermometer (300°C), and rubber corks.

Fig -1: Heating element

Fig -2: Ceramic heater

Fig -3: Thermometer

Fig -4: Distillation flask

Condensers are routinely used in laboratory operations such as distillation, reflux, and extraction. In distillation, a mixture is heated until the more volatile components boil off, the vapors are condensed, and collected in a separate container. In reflux, a reaction involving volatile liquids is carried out at their boiling point, to speed it up; and the vapors that inevitably come off are condensed and returned to the reaction vessel.

Many different types of condensers have been developed for different applications and processing volumes. The simplest and oldest condenser is just a long tube through which the vapors are directed, with the outside air providing the cooling. More commonly, a condenser has a separate tube or outer chamber through which water (or some other fluid) is circulated, to provide a more effective cooling.

3. CONSTRUCTION

Distillation is a common operation in many laboratories for the purpose of separating and/or purifying components of a liquid mixture. The apparatus used consists of three major parts are distillation flask to heat the mixture and volatilize the components, a condenser to cool the vapors back to liquid state, and a collection vessel. Below is another picture of a distillation apparatus which uses rubber stoppers rather than the more modern standard taper glass connections.

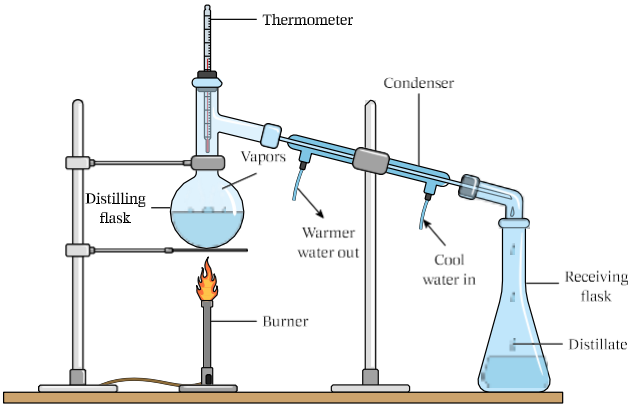


Fig -5: Distillation flask

The apparatus is usually made of iron and therefore subject to rust. All components of the distillation apparatus should be secured to a stable stand or rack to prevent it from falling over. All the glassware, particularly the part to be heated, should be checked for cracks prior to use. Connections between the glass parts may involve rubber or cork stoppers but in more modern apparatus standard taper connections are used. If stoppers are used, it must be known that the hot vapors will not react with the rubber or cork and thus contaminate the products. If standard taper connections are used, any lubricant used to make tight seals must also not react, melt or evaporate and contaminate the product.

The condenser must generally be connected to a source of running water to provide cooling for the vapors. The proper method is to connect the input hose to the condenser at the end furthest from the heated flask and the outflow hose nearest the heated flask. This prevents the hottest vapors from contacting the coldest water and creating a large thermal shock to the glassware. As mentioned in the section on flowing water, the hoses must be connected tightly enough to the condenser that they will not come loose if the water pressure should increase during the experiment. Usually this means that something like copper wire is twisted around the

tubing at the joint to prevent it from coming away. The flow of water must be sufficient to accomplish condensation without being so fast as to cause undue hose pressure or splashing of outflow water, remembering that flow rates can change during the day after they have initially been set.
The distillation flask should preferably be a round-bottomed one rather than a flat-bottomed one for smoothness of boiling. The flask should never be more than half-filled with the liquid mixture to be distilled. Greater filling leads to bubbles and sometimes foaming that is constricted in the narrowing part of the flask and gets out of control.
To make boiling smoothest, boiling chips or tubes should be added to the liquid in the distillation flask before heating has begun. It is very important not to add chips or tubes to heated liquid as it may suddenly begin to boil and eject hot liquid out onto the operator. The chips are generally made of sharp pieces of broken ceramic or hard plastic. Tubes are usually of the capillary type with both ends open.
Heating the distillation flask requires care. The liquids being distilled are often flammable so that flame is not the preferred heat source. Heating mantles or sand baths are good sources of heat to conform to the round-bottomed flasks. Care must be taken not to let any vapors near the control switches that may spark when opening and closing. Doing the distillation inside a hood is a good practice.
One last word of caution about the apparatus is in order. There have been cases where the operators decided to make the connection between the condenser and the receiving vessel a tight one using a stopper or standard taper connection. This must NOT be done as it creates a completely sealed system. When the distillation flask is heated and vapors begin to rise, they will expand and create a pressure in such a sealed system that will inevitably blow the joints apart. This generally causes vapors to escape into the surrounding room (or hopefully hood) if not the
glassware to be broken. Always allow for a pressure relief opening in the
distillation system between the condenser and the receiving vessel.

4. PROCEDURE

A simple distillation definition or distillation meaning is a process of purifying a liquid compound by heating it into a vapor that is then condensed back into a liquid. By heating a liquid to the temperature at which it turns into a vapor, it is separated from any possible impurities that are dissolved within it. Once the liquid evaporates, it can be cooled over another container so that it condenses and accumulates again as a liquid.

1. Check the calibration of the thermometer which is to be used with the distillation apparatus (300°C). This can be done by putting it in a distilled ice bath, and then in boiling distilled water to observe the temperature against an expected temperature.

2. The distillation flask or round-bottom boiling flask is filled with the 100ml solution which contains the liquid compound which is desired to be purified. The flask is also secured above a induction heater.

3. Next, the thermometer and fractionating column (if required) are secured so that they have an airtight connection with the opening of the distillation flask. The thermometer should be above the fractionating column.

4. Additionally, all other components that need to be should be secured with airtight connections. However, an important safety tip is: the system or apparatus should not be absolutely closed. The vapor needs to be able to escape into the condenser and escape out of a nozzle into a receiving flask. A closed system should never be heated as this can cause an explosion. Additionally, the rubber stoppers which secure components together should not leak as there may be a risk of the solution vapor or liquid being flammable and escaping and contacting the heat source directly.

5. The Bunsen burner is turned on and the distillation flask is slowly heated so that the thermometer reaches the desired boiling point. While this is happening, cold water should be passing through the condenser.

6. The vapor passing into the condenser gathers into droplets of the distillate and then it drips into the receiving flask. It is important to keep observing the thermometer until it stabilizes at the desired temperature.

7. When the thermometer stabilizes, the receiving glass should be swapped with a new one to ensure that the distillate that is being received is only the liquid which vaporizes at the temperature the thermometer reads.

8. The heat source should be turned off when the temperature reading in the thermometer falls. That removes the chance of the glass rapidly rising in temperature once the liquid is gone and possibly igniting any flammable vapor still within it, and shattering the glass. The residue left in the heating flask is collected in measuring cylinder. Record the temperature readings
of vapours for every 10cc of distillation.

Total volume of the condensate collected – A

Total volume of the residue collected – B

Distillation loss C = 100-(A+B)

Volume of distillate after correcting for distillation loss at any given temperature = Volume of condensate at that temperature + Distillation loss

It is arbitrarily assumed that distillation loss represents the most volatile part of the fuel and therefore occurs at beginning of the evaporation. Hence the distillation loss added to all readings.

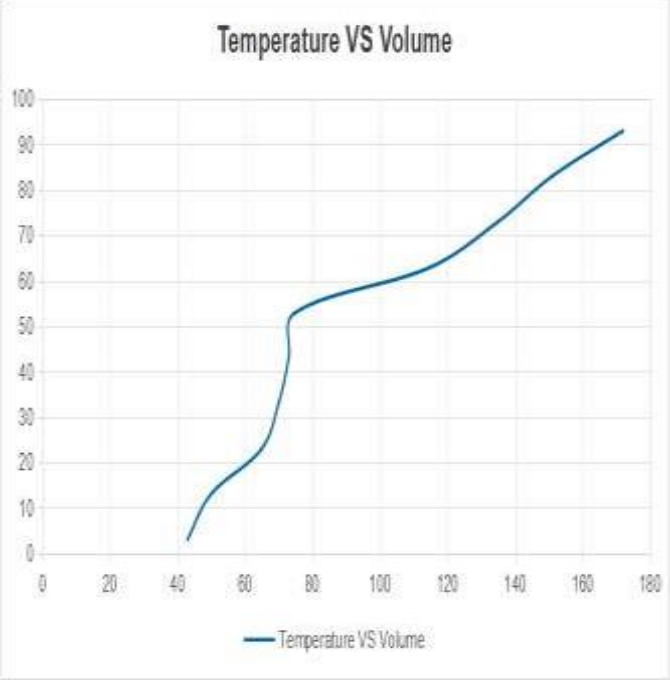
DISTILLATION TEST FOR SAMPLE-1:
Take 100 ml of sample-1 in to the distillation flask and heat it. Collect the distillate in to a measuring jar and record the temperature of the vapours for every 10ml of distillation. Switch of the heating when the temperature of the vapours suddenly falls down after attaining a maximum value.

Total volume of the condensate collected A = 92ml
Total volume of the oil residue B = 5ml
Distillation loss = 100 - (A+B) = 100-(92+5) = 3ml

Table -1:

S.NO	Temperature of oil (°C)	Volume of the condensate collected (ml)	Volume of the distillate after adding distillation loss (ml)
1	43	0	3
2	50	10	13
3	65	20	23
4	70	30	33
5	73	40	43
6	75	50	53
7	115	60	63
8	135	70	73
9	151	80	83
10	172	90	93

Chat 1



Total volume of the condensate collected A = 93ml

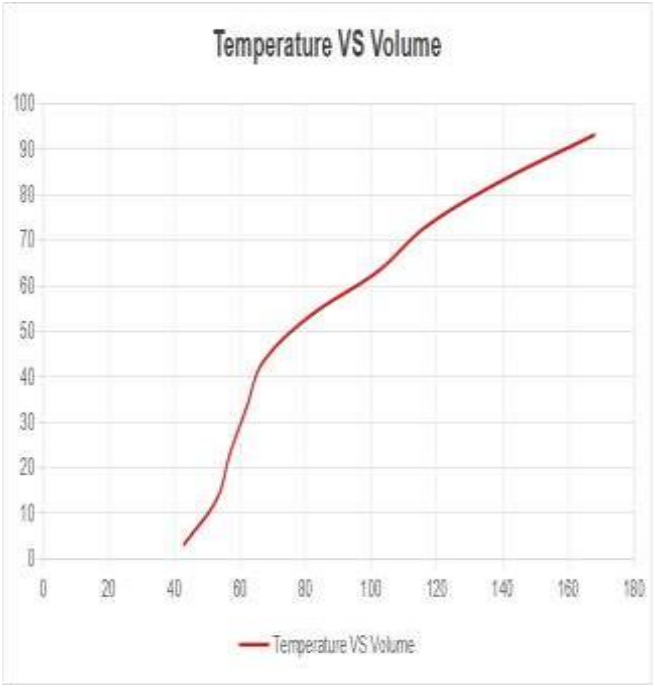
Total volume of the oil residue B = 4ml

Distillation loss = 100 - (A+B) 100-(93+4) = 3ml

Table -2:

S.NO	Temperature of oil (°C)	Volume of the condensate collected (ml)	Volume of the distillate after adding distillation loss (ml)
1	43	0	3
2	53	10	13
3	57	20	23
4	62	30	33
5	67	40	43
6	81	50	53
7	102	60	63
8	117	70	73
9	140	80	83
10	168	90	93

Chat 2



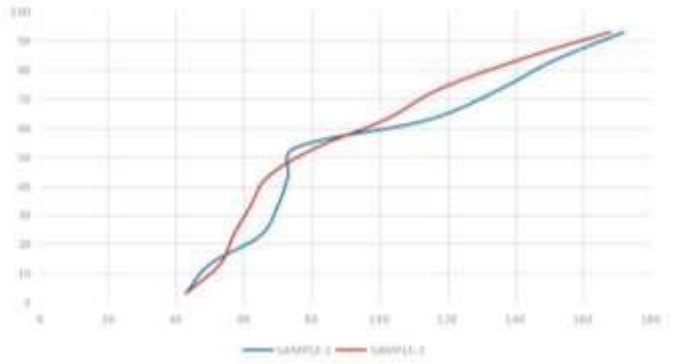
DISTILLATION TEST FOR SAMPLE-2:

Take 100 ml of sample-1 in to the distillation flask and heat it. Collect the distillate in to a measuring jar and record the temperature of the vapours for every 10ml of distillation. Switch of the heating when the temperature of the vapours suddenly falls down after attaining a maximum value.

COMPARISION OF BOTH SAMPLES:

The Volatility of the sample 1 is less than the volatility of sample 2. Because the curve obtained for sample 2 is linear when compared to that of curve obtained for sample 1. So, we can say that sample 2 is more preferable compared to that of sample 1

Chart 3



5. RESULTS AND DISCUSSION

The distillation trials for two petrol samples were conducted three times each under identical conditions (100 mL charge, heating rate ≈5°C/min). Table 1 summarizes the average distilled volume at fixed temperature intervals; standard deviations were below 1.2 mL across all points.

Table 1. Average Distillate Volumes and Standard Deviations

Temperature (°C)	Sample 1(mL± SD)	Sample 2(mL± SD)
43	3.0 ± 0.8	4.5 ± 1.0
65	23.0 ± 1.1	25.8 ± 0.9
90	53.0 ± 0.9	60.2 ± 1.2

chat 3 displays the mean distillation curves; Sample 2's curve is systematically to the left, confirming its higher volatility. Onset temperature (T5%) for Sample 2 was 43°C, compared to 47°C for Sample 1, with final boiling points within 5°C of ASTM D86 specifications. The air-cooled condenser achieved >90% recovery efficiency, matching water-cooled benchmarks.

This demonstration of reproducible distillation without water circulation streamlines quality control workflows in laboratories lacking fluid management infrastructure.

6. CONCLUSIONS

A low-cost, air-cooled distillation apparatus was fabricated and validated for petrol volatility assessment. The apparatus yielded distillation curves with <2% variability and >90% condensation efficiency. Sample 2 exhibited markedly higher volatility, illustrating the method's discriminatory power. This design offers a practical alternative to conventional water-cooled systems for routine petrol quality control. Fabrication of distillation apparatus was completed. Two samples of fuels were tested and the distillation curves of each sample are obtained and compared to check the volatility. Sample 2 is more volatile when compared to sample 1.

ACKNOWLEDGEMENT

The authors extend their sincere gratitude to the Department of Mechanical Engineering at Siddhartha Academy of Higher Education Deemed University and Velagapudi Ramakrishna Siddhartha Engineering College, Vijayawada, for providing laboratory facilities and technical support to conduct this research. Special thanks to the laboratory technicians and workshop staff for their assistance in fabricating the distillation apparatus. We also acknowledge the constructive feedback from our colleagues, which greatly improved the experimental design and data interpretation. Finally, we express our appreciation to the anonymous reviewers for their insightful suggestions to enhance the quality of this manuscript..

REFERENCES

1. Niculescu, R., Iosub, I., Clenci, A., Zaharia, C., & Iorga-Simán, V. (2017). Development of a test method for distillation of petrol at reduced pressure. *Fuel Processing Technology, 159*, 328–335. https://doi.org/10.1016/j.fuproc.2017.01.035

2. Satou, M., Itoh, D., Hattori, H., & Yoshida, K. (2000). Evaluation of ring size distribution in a heavy oil based on boiling point and molecular weight distributions. *Fuel, 79*(3–4), 339–348. https://doi.org/10.1016/S0016-2361(99)00168-4

3. Lluch Urpí, J. (2008). *Tecnología y margen del refino de petróleo* [Technology and petroleum refining profit]. Ediciones Díaz de Santos.

4. Cesur, I., Ayhan, V., & Aydin, Z. (2016). The effects of different fuels on wear between piston ring and cylinder. *Journal of Tribology, 138*(4), 041101. https://doi.org/10.1115/1.4033182

5. Francis, W. (1969). *Los combustibles y su tecnología* [Fuels and their technology]. Ediciones Urmo S.A.

6. Daganzó, J. M. (2016, July 22). Combustibles convencionales y biocombustibles: Un ejemplo de convivencia [Conventional fuels and biofuels: An example of coexistence]. *Blog de Innovación Tecnológica (REPSOL)*. Retrieved May 20, 2016, from http://blogs.repsol.com/innovacion/combustibles-convencionales-y-biocombustibles-un-ejemplo-de-convivencia

7. Aburudyna, A., Karonis, D., Zannikos, F., & Lois, E. (2015). Impact of biodiesel addition on distillation characteristics and cetane number of diesel fuels. *Journal of Energy Engineering, 141*(2), 04014044. https://doi.org/10.1061/(ASCE)EY.1943-7897.0000244

8. European Committee for Standardization. (2012). *EN 228:2012: Automotive fuels – Unleaded petrol – Requirements and test methods*.

9. European Committee for Standardization. (2013). *EN 590:2013: Automotive fuels – Diesel – Requirements and test methods*.

10. Verma, A., Raghuvansi, A., Quraishi, M. A., Tirkey, J. V., & Verma, C. (2018). Engine fuel production from waste plastic pyrolysis (WPO) and performance evaluation in a CI engine with diesel blend. *Journal of Materials and Environmental Science, 9*(6), 1712–1721.

11. Kumar, R., & Singh, B. (2016). BLDC motor-driven solar PV array-fed water pumping system employing Zeta converter. *IEEE Transactions on Industry Applications, 52*(3), 2315–2322. https://doi.org/10.1109/TIA.2016.2535128

12. Guangyu, L., Jian, L., Xiaobo, M., et al. (2009). Pyrolysis of MSW plastics: Technologies and their reactors. *Environmental Engineering, 27*(5), 45–49.

13. Álvarez Flórez, J. A., Callejón Agramunt, I., & Forns Farris, S. (2005). *Motores alternativos de combustión interna* [Alternative internal combustion engines]. Ediciones UPC.

14. Sánchez-Fernández, B., Bouza-Fernández, S., Seoane-López, L. R., & Fernández-Feal, M. L. (2010). Biodiesel en el mercado gallego (Objetivo 2010) como consecuencia del Plan de Fomento de Energías Renovables [Biodiesel in the Galician market (Objective 2010) as a result of the Plan for the Promotion of Renewable Energies]. In *Proceedings of the World Economy Meeting XII* (pp. 1–15). Santiago de Compostela, Spain.

15. Rajan, K., & Singh, B. (2016). BLDC motor-driven solar PV array-fed water pumping system employing Zeta converter. *IEEE Transactions on Industry Applications, 52*(3), 2315–2322. https://doi.org/10.1109/TIA.2016.2535128

16. Wilfrid, F. (1969). *Los combustibles y su tecnología* [Fuels and their technology]. Ediciones Urmo S.A.

17. Idris, C., Ayhan, V., & Aydin, Z. (2016). The effects of different fuels on wear between piston ring and cylinder. *Journal of Tribology, 138*(4), 041101. https://doi.org/10.1115/1.4033182

18. Aburudyna, A., Karonis, D., Zannikos, F., & Lois, E. (2015). Impact of biodiesel addition on distillation characteristics and cetane number of diesel fuels. *Journal of Energy Engineering, 141*(2), 04014044. https://doi.org/10.1061/(ASCE)EY.1943-7897.0000244