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# ONLINE OIL CONDITION MONITORING OF FOUR STROKE ENGINE

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**Abstract**

In present day practice, the engine oil change period is decided by offline laboratory investigation by the Original Equipment Manufacturers and oil companies. Generally the oil change period is fixed with reference to standard testing conditions. Usually lubricant oil changing is done without knowing the actual condition of the oil as per vehicle manufacturer recommendations. Generally oil changing period recommended by the manufacturer is either at a particular period of time or at a particular Kilo-meter. Due to this, lubricant oils are changed much before using full life of them.

This paper finds solution to this problem. It will enable us to use the lubrication oil to its full life. In this, a temperature sensor gives data for actual temperature of oil to the processing unit, which converts temperature signals into viscosity units. The viscosity of oil is displayed in the display unit. Thus we can easily find out the condition of lubricating oil, which is that it helps to change the lubricating oil at correct time. Also this exact time of oil replacement in an engine, avoids wastage of lubricating property of oil and reduces cost of maintenance. This project displays the condition of lubricating oil to the vehicle user. By extended oil changing periods, the overall lubrication oil consumption may be reduced. It gives positive impact on the economy of any country with reduction of oil imports.

**Keywords** Engine oil, Viscosity, Arduino, Micro processor controller, Buffer.

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## 1. Introduction

Condition monitoring is the process of monitoring a parameter of condition in vehicles (lubricating oil, temperature etc.), in order to identify a significant change which is indicative of a developing fault. It is a major component of predictive maintenance. The use of condition monitoring allows maintenance to be scheduled, or other actions to be taken to prevent failure and avoid its consequences. Condition monitoring has a unique benefit in that conditions that would shorten normal lifespan can be addressed before they develop into a major failure. Condition monitoring techniques are normally used on lubrication oil and other lubricant, while periodic inspection using non-destructive testing techniques and fit for service evaluation are used for stationary plant equipment such as Diesel engines, Petrol engine and all other vehicles.(1)

The following list includes the main condition monitoring techniques applied in the industrial and transportation sectors:

- Vibration Analysis and diagnostics
- Lubricant analysis
- Acoustic emission (Airborne Ultrasound)
- Infrared thermograph
- Ultrasound testing (Material Thickness/Flaw Testing)
- Motor Condition Monitoring and Motor current signature analysis (MCSA)

Most CM technologies are being slowly standardized by ASTM and ISO.

## 2. Functions of Lubricating Oil in an Engine

Lubricating oil with the necessary properties and characteristics will

(1) provide a film of proper thickness between the bearing surfaces under all conditions of operation,

(2) remain stable under changing temperature conditions, and

(3) not corrode the metal surfaces. If the lubricating oil is to meet these requirements, the engine operating temperature must NOT exceed a specified limit.

In internal-combustion engines, lubricating oil serves six functions:

1. Controls friction between load-bearing surfaces

2. Reduces wear by preventing metal-to-metal contact between moving parts
3. Limits the temperature by carrying away heat from fluid friction and combustion of fuel
4. Reduces corrosion by coating metal parts and by flushing debris from between moving parts
5. Dampers mechanical shock in gears
6. Forms a seal on the walls of the cylinders

Some of these functions and characteristics are discussed in the sections that follow.(2)

## 3. Main Challenge with Oil Condition Monitoring

With regard to the initial research objective the following theoretical discussion introduces a novel view about what is identified by the sensor during engine operation. Figure 1 provides a graphically representation of the approach to condition monitoring and outlines the key challenge which will be developed as a theoretical basis to the discussion.

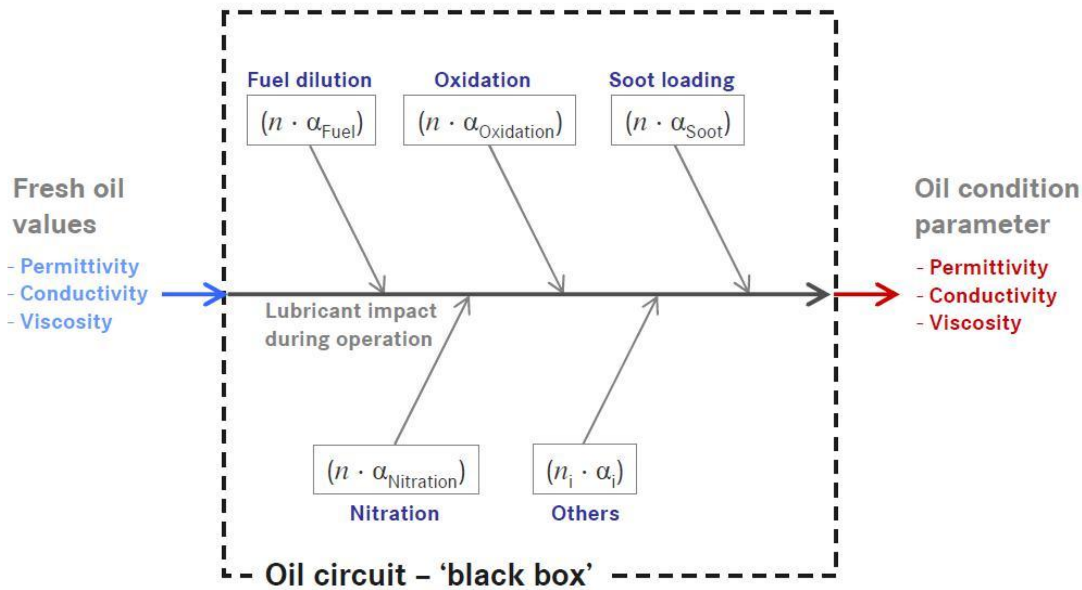



Fig 1 **'Black-box' model of the oil circuit**

The model parameters that we have certain knowledge of are the initial fresh oil value of permittivity, the conductivity and viscosity. Multiple oil contamination occurs during engine operation which affects the oil to an unknown intensity illustrated by each box where *n* indicates the number of molecules.(3) The aim of the condition monitoring and the oil condition parameters measured by the sensor (permittivity, conductivity and viscosity) is to obtain a correlation to the oil condition without having any prior knowledge about the actual oil consistency resulting in any polarisability, conductivity or viscosity. The oil circuit is assumed to be a 'black-box' approach as it is not possible to know the actual condition of the oil without a complete oil analysis. All that is 'seen' by the sensor element is the resulting value of an unknown quantity of influencing parameters which will affect the initial value.

For this model the parameters that we have certain knowledge of are the initial fresh oil value of permittivity, the conductivity and viscosity. As outlined in Chapter 3 multiple oil contamination occurs during engine operation which affects the oil to an unknown intensity. The aim of the condition monitoring and the parameters measured by the sensor is to obtain a correlation to the oil condition without having any prior knowledge about the actual oil consistency resulting in any polarisability, conductivity or viscosity. These effects are illustrated by each box where *n* indicates the number of molecules affecting the oil.(4)

The oil circuit is assumed to be a 'black-box' approach as it is not possible to know the actual condition of the oil without a complete oil analysis. All that is 'seen' by the sensor element is the resulting value of an unknown quantity of influencing parameters which will affect the initial value. In adopting this critical standpoint, the following theoretical considerations support the position of this initial hypothesis. All of the present measurement techniques are 'sum parameters' and a subsequent separation of individual effects with only one value, e.g. permittivity, conductivity or viscosity is not possible.

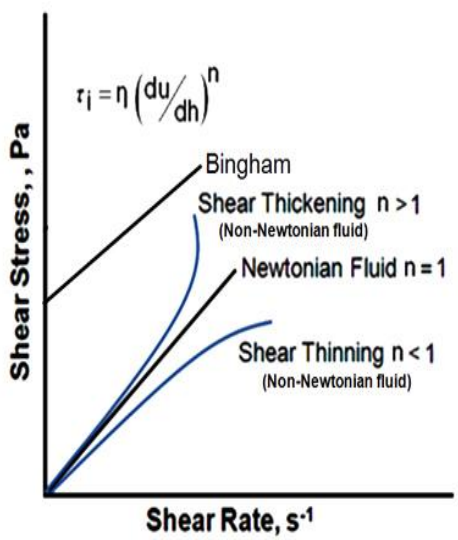



**Fig. 2: Newtonian and non Newtonian fluid.**

## 4. OIL VISCOSITY / GRADE

Viscosity is the most misunderstood aspect of oil and yet it is the most important.

For multi grade oils you will see two numbers (for mono grade oils only one). The first is followed by a “w” and is commonly 0, 5, 10, 15 or 20. The second number is always higher than the first and is commonly 20, 30, 40, 50 or 60. The first and second numbers ARE NOT relate **the “w” number (0, 5, 10, 15 or 20)** When multi grade oils first appeared, a low temperature test called “w” (meaning “winter” not weight) was introduced

Using a “Cold Crank Simulator, the test measures the oils ability to flow at low temperatures.(5)

ALL oils are THICKER at low temperatures than at high temperatures but the lower the “w” number, the quicker the oil will flow at low temperatures

The second number (20, 30, 40, 50 or 60)

This number is known as the SAE (Society of Automotive Engineers) number and is measured in “Centistokes” (cst) at 100oC

Centistokes (cst) is the measure of a fluid's resistance to flow (viscosity). It is calculated in terms of the time required for a standard quantity of fluid at a certain temperature to flow through a standard orifice. The higher the value, the thicker the oil

An oils cst at 100oC determines it’s SAE rating within the following parameters.

- SAE 20 = 5.6 to less than 9.3cst
- SAE 30 = 9.3 to less than 12.5cst
- SAE 40 = 12.5 to less than 16.3cst
- SAE 50 = 16.3 to less than 21.9cst
- SAE 60 = 21.9 to less than 26.0cst

a decent oil always falls in the middle of the spec so an SAE 40 will be around 14cst.

ALL oils labelled 40 must fall within the SAE parameters at 100oC so everything from a mono grade 40 to multi grade 0w-40, 5w-40, 10w-40, 15w-40 are the same thickness at 100degC

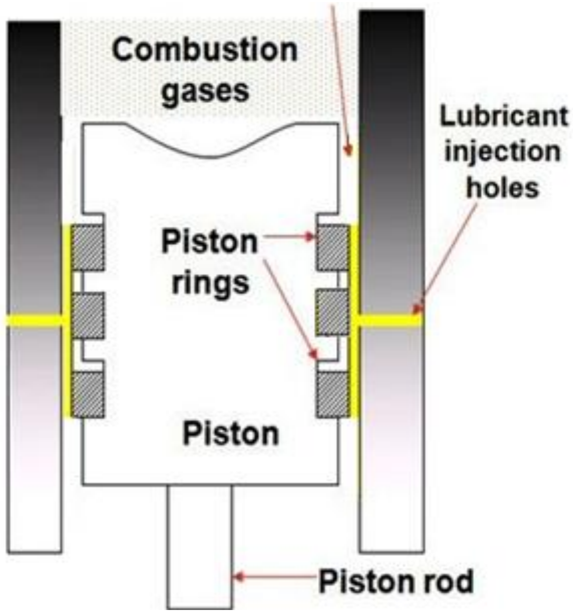



**Fig. 3: Lubricant between cylinder liner and rings.**

## 5. Viscosity Index

Liquids have a tendency to thin out when heated and to thicken when cooled. However, this response of viscosity to temperature changes is more pronounced in some liquids than in others. The property of resisting changes in viscosity due to changes in temperature can be expressed as the viscosity index (V.I.).(6)

Lubricating oils are subjected to wide ranges of temperatures in service. At high temperature, the viscosity of oil may drop to a point where the lubricating film is broken, resulting in metal to metal contact and severe wear. At the other extreme, the oil may become too viscous for proper circulation, or may set up such high viscous forces that proper operation of machinery is difficult. Consequently, many applications require oil with a high viscosity index.(7)In an automobile, for example, the crank case oil must not be so thick at low starting temperatures as to impose excessive drag on the engine and to make cranking difficult. During the warm up period, the oil must flow freely to provide full lubrication to all engine parts. After the oil has reached operating temperature, it must not thin out to the point where consumption is high or where the lubricating film can no longer carry its load.

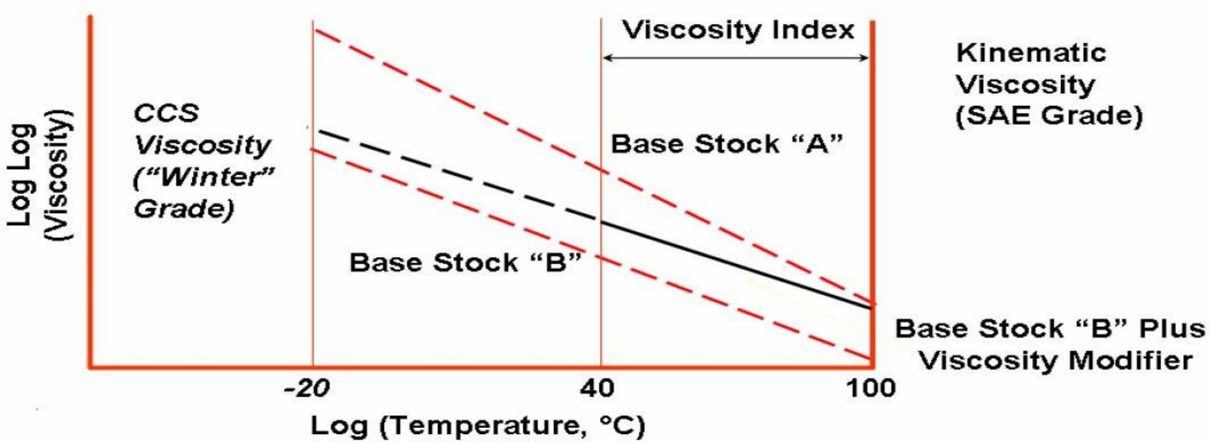



**Fig 4 Viscosity Index**

**6. Temperature Sensor**

A temperature sensor plays an important role in many applications. For example, maintaining a specific temperature is essential for equipment used to fabricate medical drugs, heat liquids, or clean other equipment. For applications like these, the responsiveness and accuracy of the detection circuit can be critical for quality control.

**Fig 5 Temperature Sensor-Thermistor Probe**

7. VISCOSITY OF FRESH OIL.

First take the new fresh lubricating oil (SAE 20W 40). This lubricating oil should be more suitable for four stroke engine in two wheelers. The viscosity of the lubricating oil easily founded by means of the redwood viscometer apparatus. In this apparatus there are two thermometers have been used one for the water and another one for the lubricating oil. The room temperature has taken as $36^0$C. First found the viscosity for room temperature and next found the viscosity value for every $5^o$C and tabulate this reading. By using this values make the following graph.

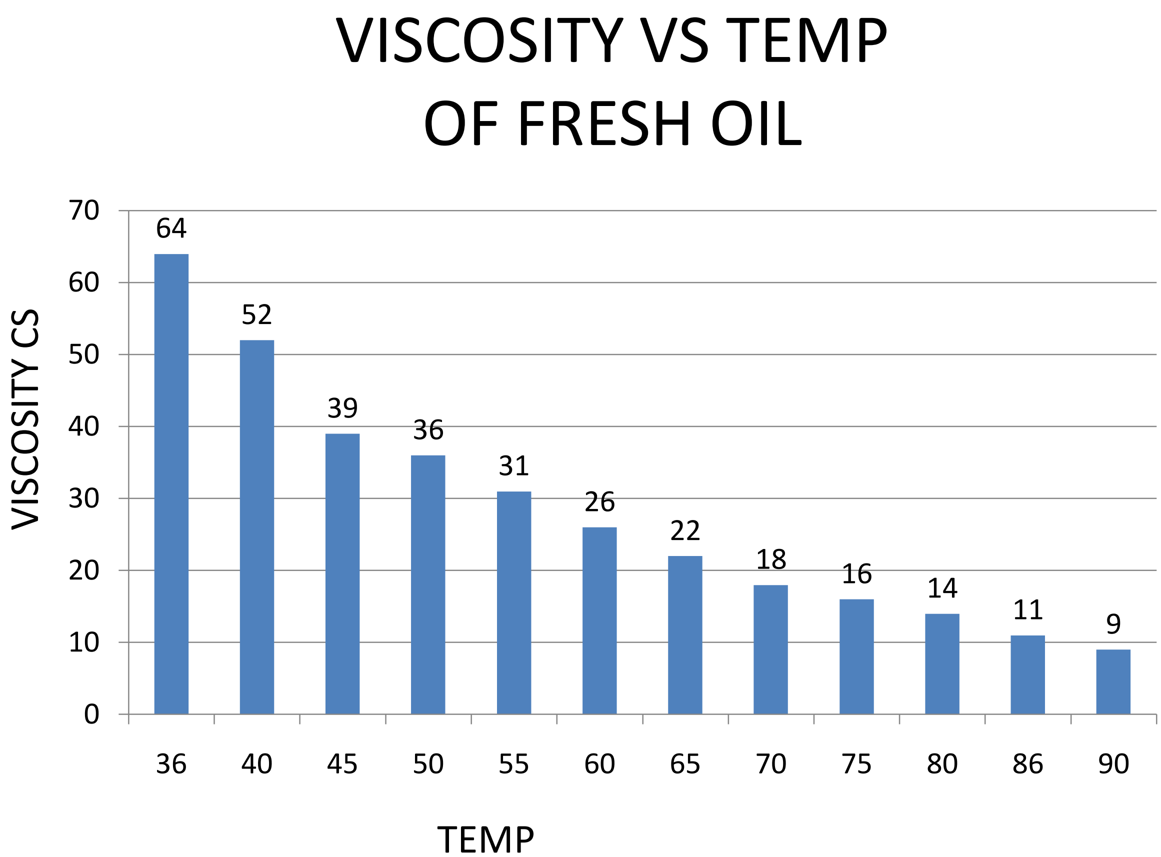



**Fig 6.2 Viscosity vs. temperature of fresh oil**

8. RESULT AND DISCUSSION

The temperature sensor should be placed in oil drainage port of the engine. The temperature sensor senses the temperature of the lubricating oil inside the engine. This signal should be transfer in to the control unit of microprocessor. The microprocessor gets the temperature signals and it should be converted in to the viscosity units by means of the processor by using the following formula.

$$\mu = \mu o\left(\frac{1}{1 + \alpha t + \beta t^2}\right)$$

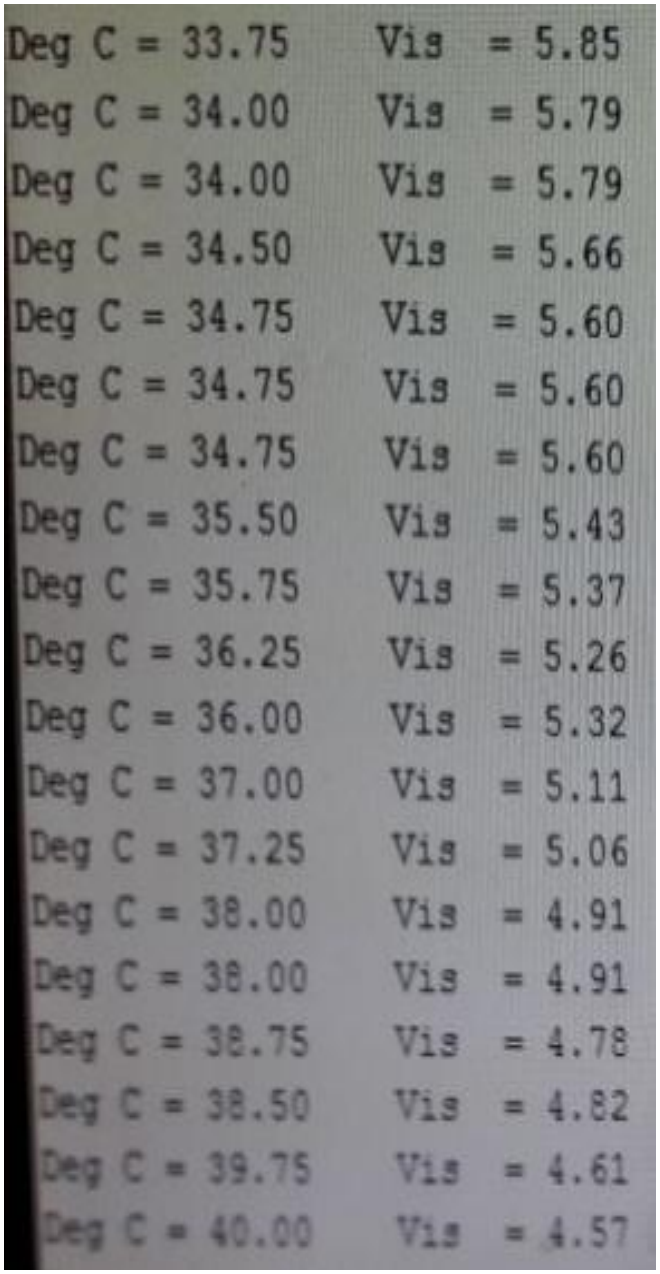
$\mu^o$= 0.0179

α= 0.03368

β= 0.000221

By substituting the above value and the temperature signals, the processor find out the viscosity unit. This viscosity and temperature value should be displayed in the display unit. Consider the SAE 20 W40 fresh lubricating oil. Find out the viscosity of the fresh lubricating oil and next taken the used lubricating oil (5000km). Again find out the viscosity of used lubricating oil, by using this two values first find out the lowest viscosity value of the lubricating oil. This value should be placed in the processor, if the lubricating oil will reach this value suddenly the buffer gets the signals and buffer makes alarm. This indicates the viscosity of lubricating oil has been reduced and we should replace the lubricating oil to avoid the sudden breakdowns.(9,10)

The temperature and viscosity reading has been displayed follow.



| | |
|---|---|
| Deg C = 33.75 | Vis = 5.85 |
| Deg C = 34.00 | Vis = 5.79 |
| Deg C = 34.00 | Vis = 5.79 |
| Deg C = 34.50 | Vis = 5.66 |
| Deg C = 34.75 | Vis = 5.60 |
| Deg C = 34.75 | Vis = 5.60 |
| Deg C = 34.75 | Vis = 5.60 |
| Deg C = 35.50 | Vis = 5.43 |
| Deg C = 35.75 | Vis = 5.37 |
| Deg C = 36.25 | Vis = 5.26 |
| Deg C = 36.00 | Vis = 5.32 |
| Deg C = 37.00 | Vis = 5.11 |
| Deg C = 37.25 | Vis = 5.06 |
| Deg C = 38.00 | Vis = 4.91 |
| Deg C = 38.00 | Vis = 4.91 |
| Deg C = 38.75 | Vis = 4.78 |
| Deg C = 38.50 | Vis = 4.82 |
| Deg C = 39.75 | Vis = 4.61 |
| Deg C = 40.00 | Vis = 4.57 |

```
Deg C = 57.00    Vis = 2.91
Deg C = 57.50    Vis = 2.88
Deg C = 57.75    Vis = 2.87
Deg C = 58.00    Vis = 2.86
Deg C = 57.75    Vis = 2.87
Deg C = 58.00    Vis = 2.86
Deg C = 58.75    Vis = 2.82
Deg C = 59.25    Vis = 2.79
Deg C = 59.25    Vis = 2.79
Deg C = 59.25    Vis = 2.79
Deg C = 59.75    Vis = 2.76
Deg C = 60.25    Vis = 2.74
Deg C = 60.25    Vis = 2.74
Deg C = 57.00    Vis = 2.73
Deg C = 60.50    Vis = 2.73
Deg C = 60.50    Vis = 2.73
Deg C = 61.25    Vis = 2.69
Deg C = 61.25    Vis = 2.69
Deg C = 61.00    Vis = 2.70
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Deg C = 62.00    Vis = 2.66
Deg C = 61.75    Vis = 2.67
Deg C = 62.25    Vis = 2.64
Deg C = 62.50    Vis = 2.63
Deg C = 62.75    Vis = 2.62
Deg C = 62.75    Vis = 2.62
Deg C = 63.25    Vis = 2.60
Deg C = 63.50    Vis = 2.59
Deg C = 63.50    Vis = 2.59
Deg C = 63.50    Vis = 2.59
Deg C = 64.00    Vis = 2.57
Deg C = 64.75    Vis = 2.54
Deg C = 64.25    Vis = 2.56
Deg C = 64.75    Vis = 2.54
Deg C = 65.25    Vis = 2.52
Deg C = 65.25    Vis = 2.52
Deg C = 65.25    Vis = 2.52
Deg C = 65.75    Vis = 2.50
Deg C = 66.00    Vis = 2.49
```

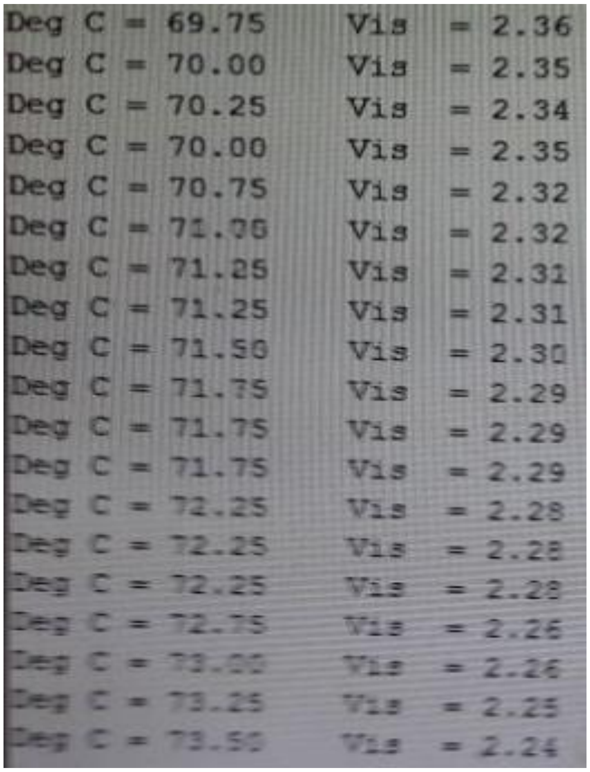


**Table 1SAE Viscosity chart**

| SAE Viscosity Chart (High Temp) 100° C (210° F) | | |
|---|---|---|
| **SAE Viscosity** | **Kinematic (cSt) 100° C Min** | **Kinematic (cSt) 100° C Max** |
| **20** | **5.6** | **<9.3** |
| **30** | **9.3** | **<12.5** |
| **40** | **12.5** | **<16.3** |
| **50** | **16.3** | **<21.9** |
| **60** | **21.9** | **<26.1** |

**8.1 ADVANTAGES**

- It increases the oil changing period.
- It enhances Customer satisfaction.
- It will be more economical.
- It reduces the oil import requirement.
- It prevents failure due to reduction of lubricating properties of oil.
- It can forecast the lubrication between the piston and cylinder.

9. CONCLUSION

When there is a necessity to find out the actual condition of oil, off line methods are being currently used. This method consumes a lot of time in the laboratories. Therefore, there is a need to identify a system which monitors oil at real working time of engine.

This paper involves the following units, they are

- Temperature sensor
- Control unit
- Display unit

In this project, sensor gives the actual temperature of oil to the processing unit where it is converted into viscosity units. The display unit gives us actual viscosity readings. Based on the viscosity readings oil condition can be monitored. By this paper, it is possible to identify the exact life time of the lubricating oil. So that oil change in an engine can be done at correct time.

**REFERENCES**

1. Junda Zhu, David He, Eric Bechhoefer ‘ Survey of Lubrication oil condition monitoring, Diagnostics, and Prognostics Techniques and Systems’ Journal of Chemical Science and Technology, July 2013, vol. 2 Iss. 3, PP. 100-115.

2. Sivarao, Samsudin A.R, Tin S.L, Hasoalan, Taufik, Yuhazry, Abdul Alif, Robert K.M, Sivakumard, C.F Tan, ‘ Promising Techniques of Automotive Engine Lubrication oil Monitoring system – A Critical Review towards Enhancement’, IJES 2012 Vol.1 Iss.2 PP. 228-233.

3. B. Vasanthan, G. Devaradjane, V. Shanmugam, ‘ Online Condition Monitoring of Lubrication Oil on test bench diesel engine & vehicle’, ICRAMET’15, JCHPS Special issue 9: April 2015, 315-320.

4. Lirong QU, Danya HE, ‘ The research and development of Automotive Engine Test platform’, Advanced Materials Research Vols 433-440 (2012) pp 595-599.

5. N.B. Jones, Yu-Hua Li, ‘ A Review of Condition Monitoring and Fault Diagnosis for Diesel Engines’, Tribotest Journal 6-3, March 2000.267-291.

6. Agoston, C. Otsch, B. Jakoby, ’ Viscosity sensors for engine oil condition monitoring – Application and interpretation of results’, Sensors and Actuators A 121 (2005) 327-332.

7. Vojtech Kumbir, Petr Dostil, Jiri Cupera, Arturas Sabaliauskas, ‘kinematic viscosity of four-stroke engine oils’ Advanced Materials Research Vols 433-440 (2013) pp 595-591.

8. X.L Wang, G.N Zhang, J.Y. Zhang, Y.L. Yin, Y. Xu, ‘Failure Analysis and Regeneration Performances Evaluation on Engine Lubricating Oil’ Physics Procedia 50 (2013) 473-479.

9. Gautam Yadav, Pranabesh Ganai, Sudhir Tiwari, Madhuri Maheshwari. ‘Condition Monitoring of Internal Combustion Engine Using Oil Analysis Program’ IJRMET Vol.4, Issue 2, May – October2014.

10. R.K Upadhyay ‘ Microscopic technique to determine various wear modes of used engine oil’ Journals of Microscopy and Ultrastructure 1 (2013) 111- 114.

11. Munirah Abdul Zali, Wan Kamaruzaman Wan Ahmad, Ananthy Retnam, Ng Catrina, ‘Concentration of heavy metal in virgin, used, recovered and waste oil: a spectroscopic study’ Procedia Environmental sciences 30 (2015) 201 – 204.