The Wide Fuel and its Characteristics

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***Abstract*—**.Water in diesel emulsion is an optional fuel, has a potential to reduce the formation of both nitrogen oxides, carbon dioxides and particulate matters in diesel engine. Thus the performance of this emulsified fuel strongly depends on the type of emulsion, stability of emulsion, amount of surfactant and the physio-chemical properties. In this study, water in diesel emulsion fuels of 5%, 10%, 20%, 25% water by volume was prepared by a mechanical stirrer. Physical and chemical properties of emulsion were examined as this properties could influence the spray characteristic of the emulsion which can affect the ignition delay and flame propagation, the carbon contents for emulsified fuel with 10% and 20% were low droplet size of the emulsion was found to be less than 2 μm. The water content in the emulsified fuel also include the amount of surfactant density and viscosity was found to be higher for all of the water in diesel emulsion the pure diesel.

Keywords-*Emulsified fuel, surfactant, droplet size, emulsion properties flash and fire point, viscosity, density, calorific value*.

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I. INTRODUCTION

In spite of preferable advantages of diesel engines, they are one of the major pollution contributors to present time. Such primary pollutants exhausted from diesel engines are particulate matters (PM), nitrogen oxides (NOx), Sulphur oxides (SO_X), unburnt hydrocarbon (HC), carbon monoxide (CO), and carbon dioxide (CO_2) [1]. Emulsion of diesel and water are often promoted as being able to overcome the difficulty of simultaneously reducing emissions of both NO_X and PM from the diesel engines [2]. The main mechanism causing the reduction in NOx emissions seems to be the decrease in the temperature of the combustion products as a result of vaporization of the liquid water and consequent dilution of the gas phase species. As for PM emissions, the presence of water during the intensive formation of soot particles seems to reduce the rate of formation of soot particles and enhance their burnout by increased concentration of oxidation species such as OH [3]. The aim of the present study is to obtain stable water in diesel emulsion (WiDE) which is stabilized with surfactants, in order to reduce operating costs, emissions and fuel consumptions of any internal-combustion engine. Primary step before using WiDE as a fuel is to characterize their properties as it will influence certain operating parameter of the engine such as injection timing and mixing process [4]. Besides that, it was found that physical and chemical kinetics of the combustion is influenced by the presence of water vapor in fuel [5].

II. METHODOLOGY

Two-phase water in diesel emulsion (WiDE) as shown in figure 1. It was prepared using mechanical stirrer, with above 1200 RPM. Four blends of WiDE with 5%, 10%, 20%, 25% water by volume very prepared. The flash point and fire point were measure by pensky martens apparatus. Calorific value of the fuel were obtained using digital bomb calorimeter. Chemical characteristic were analyzed using CHNSanalyzer. Stability of the WiDE was visually observed. Water droplet and distribution was captured by using microscope and measurement of droplet size done using software toupview-3.7.

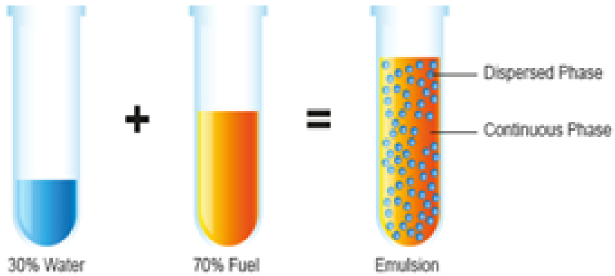

Fig.1 concept of two phase water-in-diesel

III. RESULTS AND DISCUSSIONS

The most important factor in the preparation of emulsion is the selection of suitable surfactants or blend of surfactants which can satisfactory emulsify the chosen ingredients at a specific temperature. Emulsification is greatly influenced by hydrophile-lipophile balance (HLB) of any surfactants [7]. Percentage of water in emulsion, stirring speed and duration, types of surfactants are the parameters that affect the stability of an emulsion. The current study was observed for more than 40 days. Since it was emulsified and found to be stable as shown in figure 2.1 and 2.2. It was observed that the larger the amount of water content in the emulsion, the brighter milky emulsion is produced. The 20% and 25% emulsion samples are more brighter milky then 5% and 10% sample.

Fig.2.1 Before Fig.2.2 After
Fig.2.1 & 2.2 Stable WiDE samples with 5% to 25% water

A. *Water content of WiDE*

The water content of WiDE is sum of amount of water and surfactants shown in table 1 for 100 ml emulsion sample.

SAMPLE	DIESEL (ML)	WATER (ML)	SURFACTANTS (ML)
WiDE-5	95	3	2
WiDE-10	90	8	2
WiDE-20	80	18	2
WiDE-25	75	23	2

Table:-1 Water Content of WiDE

The amount of water content varies where the amount of surfactants used are same for the study. The presence of water in WiDE is a key issue to be addressed. Since it will affect the ignition delay timing [8, 9].

B. *Flash point and Fire point of WiDE Samples*

The flash point and fire point analysis of WiDE samples are very important parameters for understanding fuel characteristics and for pure diesel fuel. Flash points very between 40°C to 96°C. The fuel must have a high auto ignition temperature. The flash and fire point of 100ml emulsion samples are shown in below table 1.1.

SAMPLE	SURFACTANTS		MIXING TIME	FLASH POINT	FIRE POINT
	S-1	*S-2*			
Pure Diesel	0ml	0ml	0min	41°C	47°C
WiDE-5	0.5 ml	1.5 ml	10min	43°C	52°C
WiDE-10	0.5 ml	1.5 ml	10min	47°C	56°C
WiDE-15	0.5 ml	1.5 ml	10min	49°C	60°C
WiDE-20	0.5 ml	1.5 ml	10min	50°C	63°C
WiDE-25	0.5 ml	1.5 ml	10min	55°C	66°C
WiDE-30	0.5 ml	1.5 ml	10min	59°C	71°C
WiDE-35	0.5 ml	1.5 ml	10min	67°C	77°C
WiDE-40	0.5 ml	1.5 ml	10min	73°C	83°C

*S-1 =surfactant 1, *S-2=surfactant 2

Table:-1.1 Flash And Fire Point Analysis

The water percentage increase the flash point and fire point. Difference between flash point and fire point is approx 10°C.

C. *Calorific Value Analysis*

The gross calorific value of WiDE was decreased with increase in water content as shown in table 1.2. The amount of water leads to lower heating value of WiDE and can be attributed to slight reduction in engine power when used as fuel.

SAMPLE	CALORIFIC VALUE (CAL/GM)
WiDE-5	6610
WiDE-10	6250
WiDE-15	5582
WiDE-20	5520
WiDE-25	4500

Table:-1.2 calorific Analysis

D. *Density Analysis*

The density of WiDE sample increases with increase in water content as shown in graph.The density of samples increases around 0.006 to 0.008 when increase in water percentage is 5%.

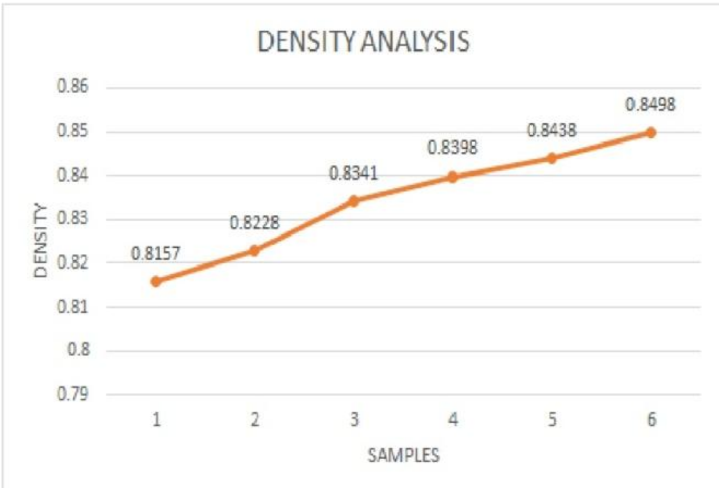

Figure 3-density analysis chart

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E. Stability Check of WiDE Samples

Stability of the WiDE samples is affected mainly by the fraction of water, stirring speed and concentration of surfactants. The stability of samples varies around 40 to 56 days which is shown in fig 2.1 & 2.2.

F. CHNS Analysis

Carbon content was higher in diesel compare to WiDE with 5% water. Which can be attributed to the influence of surfactant along with lesser water. Also carbon content in WiDE with 10% and 20% water were less compared to diesel. Hydrogen percentage was higher inWiDE of 5% and 10% compare to pure diesel. The surfactants used are easily burn with no soot and free of Sulphur and nitrogen [10]. All the CHNS analysis data are shown in table 1.4.

SAMPLE	CARBON (W/W)%	HYDROGEN (W/W)%	NITROGEN (W/W)%	SULPHUR (W/W)%
Pure Diesel	81.36	11.83	0.1012	0.1255
WiDE-5	86.30	16.316	0.1124	0.1023
WiDE-10	78.60	12.401	0.191	0.0679
WiDE-15	73.80	11.067	0.207	0.0589
WiDE-20	68.89	9.731	0.223	0.0479

Table:-1.4 CHNS Analysis

G. Viscosity Analysis

Engler viscometer used to find viscosity of WiDE and diesel for the temperature range as shown in table 1.5. for analysis water bath temperature taken between 50°C to 60°C where WiDE and diesel temperature is taken around 40°C to 42°C.

SAMPLE	TEMPERATURE	TIME (sec)	KINEMATIC VISCOSITY (cm^2/sec)	ABSOLUTE VISCOSITY (kg/m.sec)
Pure Diesel	29°C	64	0.1382	$1.1273*10^{-5}$
	41°C	56	0.1134	$0.925*10^{-5}$
WiDE-5	29°C	70	0.1563	$1.2858*10^{-5}$
	41°C	60	0.1260	$1.0367*10^{-5}$
WiDE-10	29°C	76	0.1739	$1.4504*10^{-5}$
	41°C	64	0.1383	$1.1535*10^{-5}$
WiDE-15	29°C	78	0.1797	$1.5091*10^{-5}$
	41°C	71	0.1592	$1.3369*10^{-5}$
WiDE-20	29°C	103	0.2503	$2.1120*10^{-5}$
	41°C	97	0.2336	$1.9711*10^{-5}$

IV. Calculation Equation

Kinematic viscosity

$$\mathbf{V = (A*t) - (B/t)}$$

Where A=0.0026 cm^2/sec^2

B =1.8 cm^2

Absolute viscosity

$$\mathbf{N = V * \rho \ (kg/(m.sec))}$$

The viscosity difference between WiDE-5 and WiDE-10 is small. Viscosity and density variation between WiDE-5 and WiDE-10 are significant and is due to the reduction in actual water content in the mixture which was not maintained.

V. Water Distribution and Droplet Diameter

The distribution of water in WiDE of 10% and 20% are shown in figure 4(a) and 4(b). The images were captured by microscope with 400X magnification. It was concluded that droplet diameter of the micro-emulsion would not vary beyond 0.1 to 20 µm. the smaller droplets evaporate more quickly and form a better air-fuel mixture. Hence the reduction in soot when the mixture burns [11-13]. Figures show that means droplet diameters are in acceptable range for all the two WiDE sample.

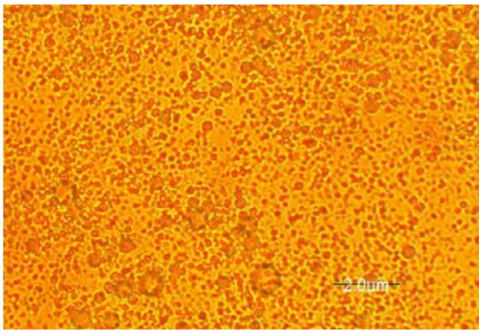

Figure 4(a) WiDE-5

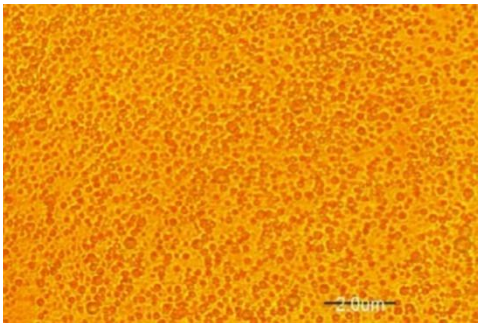

Figure 4(b) WiDE-10

VI. Torque Analysis of WiDE

The torque data analysis of WiDE is done in Tata diesel engine with 1500 R.P.M capacity. The torque of pure diesel is measured 45-50 kg. Compare to torque of pure diesel the torque of WiDE is 65-70 kg. The torque of WiDE-10 is measured around 75-80 kg.

VII. Conclusion

Two-phase stable water in diesel emulsion (WiDE) with 5%, 10% ,20% and 25% water were successfully prepared using mechanical stirrer and their physical and chemical properties were examined and discussed in detail.Droplet sizes of less than 2µm were achieved. We concluded that Increase in water

% increases the flash point and fire point.Difference between flash point and fire is approx 10 °c.

Stability of the diesel emulsion is affected mainly by the fraction of water, stirring speed and conc. of surfactant. We concluded that adding emulsifier increases the stability of emulsion. Also we concluded that calorific value of samples decreases by increase in water percentage

We concluded that density of sample increases around 0.006 to 0.008 when increase in water percentage is 5%.Also we concluded that the engine torque increases by use of WiDE samples. We concluded that CO_2 emission decreases by increase in water percentage. Also according to WiDE sample use and type we have to change nozzle spray in diesel engine.

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