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# Performance Analysis of Four Stroke Compression Ignition Engine using Water Diesel Emulsion

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**Abstract:** Increase in air pollution level causes too many health problems which increase concern of many researchers and scientists to find alternative fuel which reduce pollutant level and also give better thermal efficiency. In this regard a research has been carried out using water diesel emulsion which gives a better thermal efficiency with respect to diesel and also from heat balance sheet it has been found that less amount of heat is liberated from exhaust

**Keywords:** Diesel, Emulsion, Brake thermal efficiency, fuel consumption, brake power

## I. INTRODUCTION

Emulsion is colloid of two or more immiscible liquids where one is in dispersed phase and another is in dispersion phase. Emulsified fuels are example of fuels which contain water mixed with combustible liquid for example water mixed with diesel or vice versa. Emulsified fuels can be further classified into two category micro emulsion and microemulsion. The property which differentiate both emulsion are their colloidal size and stability of emulsion.

Stabilizing agent of an emulsion is called emulsifier. Generally surfactant are used to provide stability to emulsion. Surfactants are basically surface active agents. There are three kind surfactant anionics cationics, nonionics and amphoterics.

Objective of this research is to find out comparison of diesel with that of water diesel emulsion according to their performance like brake thermal efficiency, specific fuel consumption and brake specific fuel consumption apart from this heat losses by engine have been also discussed when using diesel and emulsion.

## II. EXPERIMENTAL SETUP

Table 1 Apparatus specifications

|                |                      |
|----------------|----------------------|
| Cylinder       | Four stroke          |
| No. of stroke  | 4                    |
| Speed          | 1500RPM              |
| Bore           | 85mm                 |
| Stroke         | 110mm                |
| Cooling system | Water cooling system |

Table 2 Fuel specification

| S.No. | Fuel   | Notation | C.V.  | Density |
|-------|--|----------|-------|---------|
| 1.    | Diesel   | K1       | 42360 | 742.100 |
| 2.    | 85%Diesel + 10% water + 5% (TWEEN 80 + SPAN 80)      | K2       | 36281 | 788.226 |
| 3.    | 88%Diesel + 10% water + 0.7% TWEEN 80 + 1.3% SPAN 80 | K3       | 36942 | 785     |
| 4.    | 78%Diesel + 20% water + 0.7% TWEEN 80 + 1.3% SPAN 80 | K4       | 32481 | 752.166 |
| 5.    | 93%Diesel + 5% water + 0.7% TWEEN 80 + 1.3% SPAN 80  | K5       | 37460 | 727.833 |

Where C.V. is calorific value of fuel in kJ/kg and density in kg/m<sup>3</sup>.

### III. METHODOLOGY

Preparation of emulsion requires mixing of water in diesel with calculated amount of surfactants. Firstly 90% of diesel with 9.5% of water and 0.5 % of surfactant tween 80 is mixed with the help of magnetic stirrer with about 1000rpm and then after it is kept for one hour to check the stability of emulsion but after one hour water settles down due to its high density. So first attempt was failed then after surfactant with 1% of total tween 80 and span 80 was taken with mixture of 90 % diesel and 9% water and again to test its stability it is kept for one hour and after one hour it was found that the emulsion was stable. Now for performance evaluation purpose surfactant ratio were taken as 2% and 5% and quantity of water and diesel was altered. Variation in water content as 5% 10% and 20%. In above process water that was used was demineralized water. Figure 1 below shows water diesel emulsion of different combination. K2 contains 85%diesel with 10% water and 5% emulsion. K3 contains 88%diesel with 10% water and 2% surfactant. K4 contains 78% diesel with 20% water and 2% surfactant. K5 contains 93%diesel with 5% water and 2% surfactant.



Fig. 1 showing emulsions made by mixing different ratio of water, diesel and surfactant K3 K2

### IV. RESULTS AND DISCUSSION

#### A. Result In Tables

TABLE 3 PERFORMANCE VALUES OF K1

| Load (W) | BP (kW) | $m_f$ (kg/hr) | BSFC (kg/kW-h) | BTE (%) |
|----------|---------|---------------|----------------|---------|
| 0        | 0       | 0.61891       | -              | 0       |
| 1        | 0.5084  | 0.62158       | 1.222446       | 6.9521  |
| 2        | 1.0169  | 0.62336       | 0.612975       | 13.864  |
| 3        | 1.5254  | 0.62959       | 0.412736       | 20.590  |
| 4        | 2.0338  | 0.64295       | 0.31612        | 26.884  |

Table 4 Performance values of K2

| Load (kg) | BP (kW) | $m_f$ (kg/hr) | BSFC (kg/kW-h) | Brake thermal efficiency (%) |
|-----------|---------|---------------|----------------|------------------------------|
| 0         | 0       | 0.43699       | -              | 0                            |
| 1         | 0.5139  | 0.44267       | 0.86139        | 11.5192                      |
| 2         | 1.02712 | 0.45023       | 0.43835        | 22.6363                      |
| 3         | 1.53966 | 0.46064       | 0.29918        | 33.1656                      |
| 4         | 2.05017 | 0.47199       | 0.23022        | 43.1003                      |

Table 5 Performance values of K3

| Load (kg) | BP (kW) | $m_f$ (kg/hr) | BSFC (kg/kW-h) | Brake thermal efficiency (%) |
|-----------|---------|---------------|----------------|------------------------------|
| 0         | 0       | 0.40318       | -              | 0                            |
| 1         | 0.5139  | 0.406         | 0.79004        | 12.3348                      |
| 2         | 1.02712 | 0.42013       | 0.40904        | 23.8241                      |
| 3         | 1.53966 | 0.42673       | 0.27716        | 35.1607                      |
| 4         | 2.05017 | 0.45122       | 0.22009        | 44.2777                      |

Table 6 Performance values of K4

| Load (kg) | BP (kW) | $m_f$ (kg/hr) | BSFC (kg/kW-h) | Brake thermal efficiency (%) |
|-----------|---------|---------------|----------------|------------------------------|
| 0         | 0       | 0.47296       | -              | 0                            |
| 1         | 0.5139  | 0.4856        | 0.94493        | 11.7293                      |
| 2         | 1.02712 | 0.49733       | 0.4842         | 22.8901                      |
| 3         | 1.53966 | 0.50907       | 0.33064        | 33.5216                      |
| 4         | 2.05017 | 0.51719       | 0.25227        | 43.9353                      |

Table 7 Performance values of K5

| Load (kg) | BP (kW) | $m_f$ (kg/hr) | BSFC (kg/kW-h) | Brake thermal efficiency (%) |
|-----------|---------|---------------|----------------|------------------------------|
| 0         | 0       | 0.44893       | -              | 0                            |
| 1         | 0.5139  | 0.45242       | 0.88037        | 10.9161                      |
| 2         | 1.02712 | 0.45941       | 0.44728        | 21.4861                      |
| 3         | 1.53966 | 0.46378       | 0.31022        | 31.9045                      |
| 4         | 2.05017 | 0.46389       | 0.2292         | 41.9304                      |

Table 8 Heat balance sheet for fuel K1

| Load | T1   | T2   | T3   | T4    | T5   | $t_1$ | $t_2$ | Heat loss by radiation and uncounted loss (kJ/kg) |
|------|------|------|------|-------|------|-------|-------|---|
| 0    | 33.5 | 35.0 | 38.4 | 168.4 | 40.4 | 301   | 3.2   | 3197.96   |
| 1    | 33.6 | 36.5 | 37.6 | 174.5 | 4.7  | 280.2 | 2.9   | 3670.34   |
| 2    | 33.4 | 36.4 | 37.0 | 185.3 | 44.8 | 273   | 2.8   | 3305.35   |
| 3    | 33.5 | 36.5 | 36.8 | 191.4 | 47.7 | 366.8 | 2.8   | 3337.02   |
| 4    | 33.5 | 36.1 | 36.9 | 195.3 | 50.8 | 259.2 | 2.8   | 1554.03   |

Table 9 Heat balance sheet for fuel K2

| Load | T1 | T2   | T3   | T4    | T5   | $t_1$ | $t_2$ | Heat loss by radiation and uncounted loss (kJ/kg) |
|------|----|------|------|-------|------|-------|-------|---|
| 0    | 34 | 35.1 | 36.2 | 121.2 | 51   | 25.2  | 2.2   | 64.8068   |
| 1    | 34 | 35.6 | 35.9 | 122.2 | 50.6 | 25.3  | 2.2   | 110.778   |
| 2    | 34 | 34.4 | 35.8 | 133.6 | 52.3 | 25.3  | 2.2   | 90.9014   |
| 3    | 34 | 35.9 | 35.4 | 108.2 | 55.2 | 25.2  | 2.2   | 62.9746   |
| 4    | 34 | 34.7 | 35.3 | 113.8 | 54.3 | 25.2  | 2.2   | 335.656   |

Table 10 Heat balance sheet for fuel K3

| Load | T1   | T2   | T3   | T4    | T5   | $t_1$ | $t_2$ | Heat loss by radiation and uncounted loss (kJ/kg) |
|------|------|------|------|-------|------|-------|-------|---|
| 0    | 39.5 | 41.2 | 41.5 | 121.2 | 52.3 | 25.2  | 2.2   | 82.3838   |
| 1    | 39.5 | 42.7 | 41.1 | 122.2 | 52.3 | 25.3  | 2.2   | 22.8785   |
| 2    | 39.5 | 43.8 | 40.8 | 133.6 | 51.2 | 25.3  | 2.2   | 77.9224   |
| 3    | 39.5 | 42.3 | 40.7 | 108.2 | 50.2 | 25.2  | 2.2   | 88.4007   |
| 4    | 39.5 | 45.8 | 40.2 | 113.8 | 51.0 | 25.2  | 2.2   | 114.0700  |

Table 11 Heat balance sheet for fuel K4

| Load | T1   | T2   | T3   | T4    | T5   | t <sub>1</sub> | t <sub>2</sub> | Heat loss by radiation and uncounted loss (kJ/kg) |
|------|------|------|------|-------|------|----------------|----------------|---|
| 0    | 36.1 | 53.4 | 36.3 | 135.7 | 58.3 | 25.2           | 2.2            | 836.971   |
| 1    | 36.1 | 47.3 | 37.0 | 136.5 | 47.2 | 25.3           | 2.2            | 377.573   |
| 2    | 36.1 | 47.8 | 36.5 | 127.7 | 47.6 | 25.3           | 2.2            | 1852.19   |
| 3    | 36.1 | 42.1 | 36.9 | 127.6 | 57.4 | 25.2           | 2.2            | 920.07  |
| 4    | 36.1 | 44.1 | 36.5 | 122.9 | 45.2 | 25.2           | 2.2            | 1409.93   |

Table 12 Heat balance sheet for fuel K5

| Load | T1 | T2   | T3   | T4    | T5   | t <sub>1</sub> | t <sub>2</sub> | Heat loss by radiation and uncounted loss (kJ/kg) |
|------|----|------|------|-------|------|----------------|----------------|---|
| 0    | 34 | 35.1 | 36.2 | 121.2 | 51   | 25.2           | 2.2            | 1027.1  |
| 1    | 34 | 35.6 | 35.9 | 122.2 | 50.6 | 25.3           | 2.2            | 998.041   |
| 2    | 34 | 35.2 | 35.8 | 133.6 | 52.3 | 25.3           | 2.2            | 388.149   |
| 3    | 34 | 36.3 | 35.4 | 108.2 | 55.2 | 25.2           | 2.2            | 392.417   |
| 4    | 34 | 36.8 | 34.9 | 113.8 | 54.3 | 25.2           | 2.2            | 1872.05   |

Note: From table 8 to 12 unit of load and temperature is in kilogram and degree Celsius respectively.

## B. Graphical Analysis

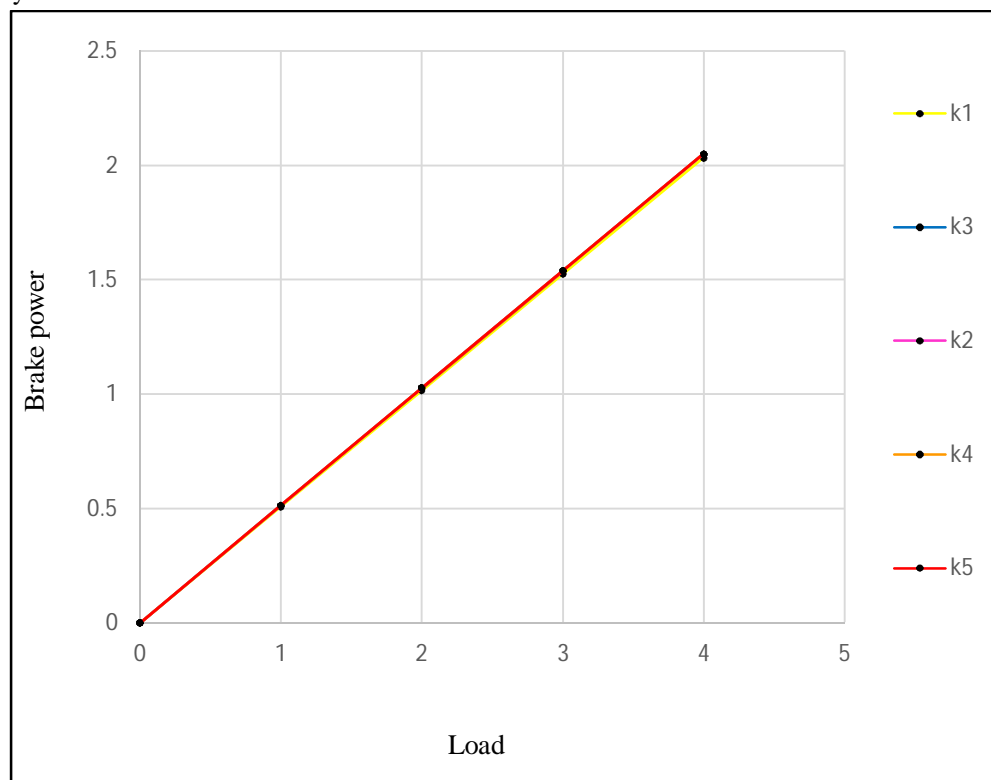


Fig.2 Variation between brake power and load

Figure 2 shows variation between brake power and load for diesel and different emulsions. As according to the graph above it is clearly visible that brake power is directly proportional to applied load. As the value of load increases brake power also increases.



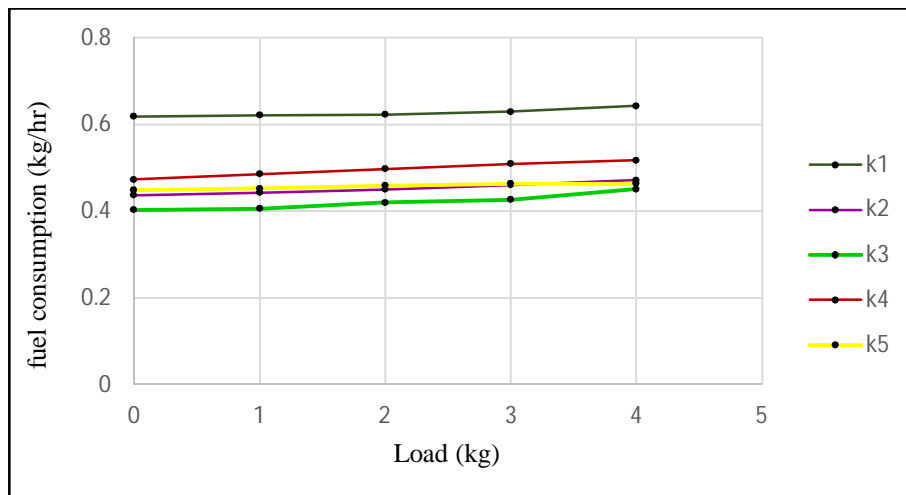


Fig. 3 Variation between fuel consumption and load

Figure 3 shows variation between fuel consumption and load for diesel (K1) and emulsions (K2 to K5). Diesel require more fuel as compare to emulsion which can be seen from above graph. Fuel K3 requires less fuel as compare to all other fuels. Apart from this as the load increases fuel consumption also increases as at higher load throttling power of engine increases.

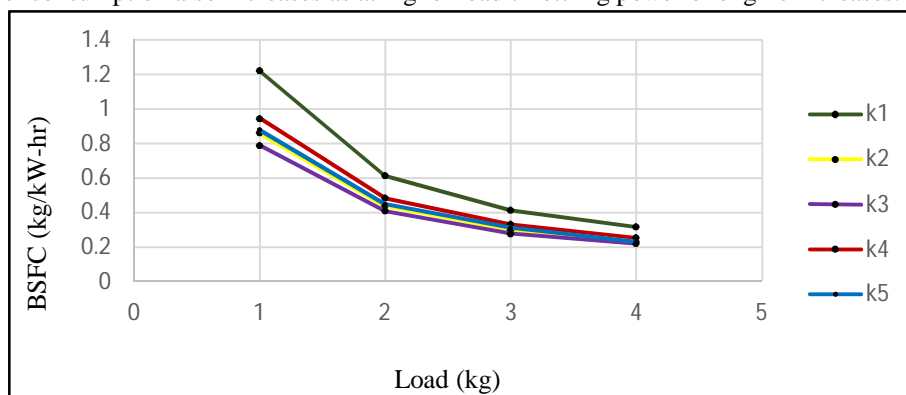


Fig. 4 Variation between Brake specific fuel consumption and load

As throttling of engine increases with respect to load brake specific fuel consumption decreases which can be seen from figure 4.

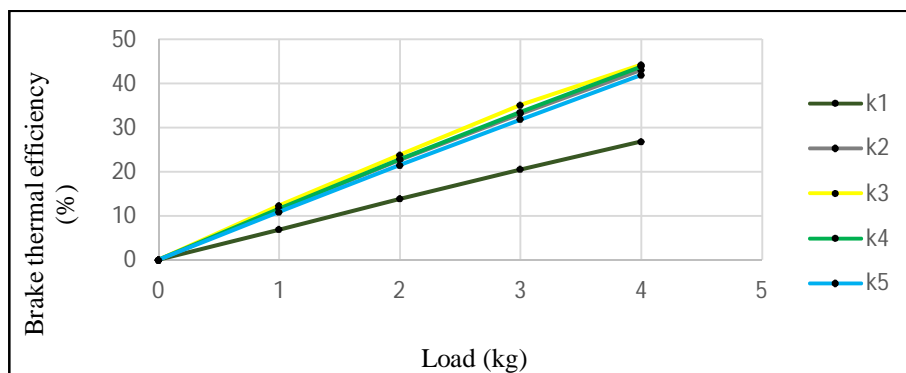


Fig. 5 Variation between Brake thermal efficiency and load

Brake thermal efficiency is more for fuel K3. So better performance will obtain from this fuel. Diesel have very low brake thermal efficiency. It means that 10% water with 2% surfactant will give best performance and as we increase water concentration brake thermal efficiency will fall accordingly.

## V. CONCLUSION

Following conclusions can be drawn from above experiments

- A. Comparing table 8 to table 12 for maximum load condition it can be concluded that minimum heat loss is obtained from fuel K3 (88% diesel with 10% water and 2% surfactant).
- B. Maximum brake thermal efficiency has been obtained for fuel K3.
- C. Minimum fuel consumption has been obtained for fuel K3.

## VI. FUTURE SCOPE

Further possibilities in this research will be use of different type of surfactants with different combination of water. Exhaust gas analysis for different type of pollutants.

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