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EXPERIMENTAL DETERMINATION OF ADDING CELLULOSE NITRATE TO THE OCTANIC NUMBER OF FUELS

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Abstract: The paperwork has as purpose improvement of anti-explosive properties of liquid fuels for spark ignition engines through nitrate addition and quantitative determination of the octane number resulting from the CFR ASTM Waukesha engine support.
Key words: nitrate cellulose, fuel, octane number.

1. MATERIALS AND REACTIVE/ REAGENTS USED TO DETERMINE OCTANE NUMBER

The materials and reactive/reagents which are necessary to determine octane number are:
- burette 300 mL with a maximum volumetric tolerance of ±0,2% and standardized (20±5°C);
- standardized barometer;
- dosing cylinders with different standardized capacities (50mL,250mL,500mL and 1000m L);
- 1 L glass vials to prepare primary fuels;
- N-heptane, a minimum purity of 99,75%volume, with max.0,1% volume isooctane and not more than 0,5 mg/L plumb;
- isooctane (2,2,4 trimetil pentane), purity a minimum 99,75% volume, with a maximum of 0,1% heptane normal volume and no more than de 0,5 mg/L lead;
- fuel with cu COR 98 additive;
- bioethanol with purity of minimum 99.97 %;
- methanol with purity of minimum 99.97 %;
- cellulose trinitrate.

2. METHODOLOGY OF DETERMINING OCTANE NUMBER

The testing sample is kept in 1 L laboratory flask, at a temperature of 0 - 6 °C, protected from direct and strong light.

The functioning of ASTM-CFR F1/F2 engine is checked and ensured by controlling and adjusting some parameters before engine start in accordance to the mode and values within the engine operation book:

- level of oil within the crankcase;
- level of cooling liquid within condenser;
- adjusting compression ratio;
- adjusting admission and evacuation valve clearance;
- opening valves on the engine water circuit.

It is recorded the barometric pressure from the location, needed to adjust micrometer for ensuring the corresponding compression pressure, according to Table A4 from ASTM D 2699 [1], [2].

The engine electric supply is switched on from the main button.

The oil crankcase is heated at 57±8°C and the engine cooling circuit is open.

Tank 4 is loaded with warming up fuels and a little compression ratio of approximate 5,5 is ensured.

The electric engine is started, connected to the fly-wheel of the piston, for a constant speed (600 rpm).

The push button to ignite the spark with an advance angle of 13°.

The air is getting warmed up (IAT for RON = Table A.6.4) and the pressure of the oil is checked to be between 172…207 kPa or 25…30 psi;

The warming up of the fuel mixture is started (MIXT) ensuring a temperature of minimum 141°C (285^0 F).

Tank 4 is opened so that the fuel enters the engine and the engine is functioning between 15 and 30 min. with the warming fuel.

Two standards are prepared (mixtures of primary reference fuels: isooctane and regular heptane, a volumetric mixture at burette, with different octane numbers according to ASTM D 2699 and which involves the octane number of the test sample.

The engine is warming up for 15-30 minute, to reach the proper functioning parameters.

The following are loaded:

- tank 1 with inferior COR standard;
- tank 2 with toluene (checkup fuel)
- tank 3 with premium COR/COM standard

The engine containing check-up fuel is tested. If COR is within the parameters from Table 2, then the actual determination follows and if not, the procedure

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„FIT for USE" sets off, adjusting air temperature for IAT.

The following are loaded:

- tank 1 with inferior COR standard;
- tank 2 with toluene (checkup fuel);
- tank 3 with premium COR/COM standard;

Then, it comes the actual attempt:
- The compression degree is adjusted, by correcting the cylinder height according to the air pressure, Tables A.4.9. from ASTM 2699 for the sample [2].
- The liquid level in all 3 tanks of the carburate so that it will be a maximum explosion [2];
- While the engine is in use, on the inferior COR standard and also upon the superior/premium, the adjustment is done so that the explosion parameters should be between 20 and 80 units on knock-meter scale;
- The level of liquids within the tanks is adjusted so that there will be maximum explosions;
- There will be 2 readings of the explosion for both standards and 3 readings for the testing sample,
writing down the corresponding divisions from the knock meter.

The reading order: the order in which the readings are repeated (for the testing sample and respectively the two beginning standards) is the one from Figure 1 from ASTM D 2699.

Testing sample / Standard 1 \ Standard 2 / Testing sample \ Standard 2 / Standard 2 \ Testing sample

Figure 1 The reading order -ASTM D 2699

The difference between the three readings on the Detonometer for the testing sample, as well as the two readings for each standard must not be higher than 0,3 ON units.

If these conditions are not achieved, there will be another readings, restarting the procedure from „ *Order of reading*" in this sequence.

Differences admitted between the COR of the sampling fuel and COR of the standard mixtures used to register the sample, depending on the supposed octane number of the sampling fuel and must be in the limits from Table 5 ASTM D 2699 [2].

On the field

COR 80-90 … … 2 ON units

COR 90-100 … … 1 ON unit.

Across the trial of the respective fuel, the engine is continuously supervised to be aware of any malfunctions like speed of rotations, spark ignition advance, according to some rules from the equipment file of trials /measurements no 56.

In case of lack of water or energy supply, fuel supply is also stopped and as a result the octane number engine.

There will be one single trial (testing sample) but with 3 readings of the explosion intensity for the same sample testing, although there will be triple results for the measured particularity, in conditions of repeatability.

4. CALCULATION AND EXPRESSING RESULTS

The average grade of the readings on the knock meter is calculated separately, on testing sample and respectively for each of the two standard mixtures.

Calculating the octane number of the testing sample is the average calculated for the corresponding readings on the knock meter.

$$ON_S = ON_{LRF} + \frac{KI_{LRF} - KI_S}{KI_{LRF} - KI_S} = ON_{HFR} - ON_{LRF} \qquad (1)$$

ON_{LRF} = octane number of inferior isooctane and n-heptane mixture;
ON_{HRF} = octane number of superior isooctane and n-heptane mixture;
KI_{LRF} = intensity of the explosive mixture of inferior isooctane and n-heptane;
KI_S = intensity of the fuel under research;
KI_{HRF} = intensity of explosive mixture of superior isooctane and n-heptane;

Results are expressed in octane number units, the ratio being calculated according to the octane number and will be rounded to the closest even number.

It was selected from the guide table A6.3 from ASTM D 2699 [2] for CO/R and we found at the intersection of both lines (horizontal and vertical) a value DIAL INDICATOR is 0,504" where we will note that 29,89 inches, the compensation value is 0,000.

In this table it is written the intake air temperature IAT and we found out that we must have an IAT of 51,7.℃(℉). At the value from the guide table, we will compensate this value using Table A6.4 from ASTM D 2699 [2] 0,504" - 0,000 = 0,504. So the value of cylinder height at the pressure in location is 0,504". After the engine reached the optimum functioning parameters, it is the IAT temperature, the compression ratio is decreased at the value of 0,504", the value of the signal amplitude is adjusted but also the SPREAD value, which exists with signal between the standards with the table from Figure A 4.6 from ASTM D 2699 [2] (intensity of the explosion KI spread/octane number), is written in the

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mentioned order at page 46 from this portfolio, after calibrating the level of fuel in every bowl of the carburettor at a maximum explosion rate and we have;
The KI intensity of the fuel to determine is 50 (an average between the three readings), the average of the two readings of KI of inferior level 89 is 54 and the average of the two readings of the superior KI standard is 35. This information is introduced within the calculation algorithm for the standard fuel [3, 4, 5]:

$$CO/R = 89 + \frac{54-50}{54-35}(91-89) = 89 + 0{,}42 = 89{,}42 \quad \text{CO/R} \tag{2}$$

Which mentions that as far as the fuels are concerned, those between CO/R 87,1-91,5 the engine for trial is ready to be used. This way, we can determine the values of octane numbers through RESEARCH method but also through the MOTOR method of all fuels that should be measured.

The properties of the market fuels depend a lot of the characteristics of the oil they originate in, the distillation procedure, different recipe containing specific ingredients and additives dosages.

The anti-explosive features of the fuels depend on their chemical composition. For research, we worked with different types of fuels with different anti explosive features like:
fuel CO/R = 90,1 and CO/M = 80,6; fuel CO/R = 93.0 and CO/M = 83.0; the unleaded gasoline CO/R =95,4 and CO/M = 85,2. Using bio-ethanol and MBTE as additives for increasing anti explosive features of fuels, as an experimental base, there were linear results in increasing octane numbers CO/R as well as CO/M. Increasing anti explosive features was higher for non-additive fuels, not because of higher concentration used for additive but mostly due to their chemical composition. Thus, introducing high quantities of additives, the ratio between CO/R and CO/M increased because of decreasing sensitivity of fuels.
Sensitivity of a fuel refers when anti explosive features properties decrease when the engines' functioning conditions turn more harsh, at higher rotations/revolutions. CO/R represents a milder functioning way of the engines while CO/M represents a more competitive way of functioning in harsher conditions, more exactly the engine CFR ASTM (F1) uses a functioning rotation/revolution of 600 rpm for CO/R, and 900 rpm for CO/M.(F2).

5. DETERMINING THE CONTRIBUTION OF CELLULOSE NITRATE TO THE MODIFICATION OF THE OCTANE NUMBER OF NAPHTA FUEL OF 71 CO/R

To determine the importance of celluloses nitrate for modifying octane number of 71 CO/R naphtha fuel, we used a mixture made up of:

To achieve the previous mixture:
- 215 ml. 71 CO/R naphtha fuel;
- 300ml. methanol with a 99,7 % concentration;
- 50 ml. solution, a mixture made up of methanol with 99,7 % concentration and 4,7 cellulosis nitrate,

To calculate the theoretical octane number of the mixture, it will not be taken into consideration the cellulose nitrate introduced within the mixture.
The theoretical octane number of the mixture will be:

$$CO_a = \frac{V \cdot CO_m + (100-V) \cdot CO_N}{100} = \frac{350 \cdot 114 + 215 \cdot 71}{565} = 97{,}63 \tag{3}$$

where:
CO_a – octane number of the mixture;
V – volume in percentages of the additive hydrocarbon;
CO_N – octane number of the naphtha fuel; CO_h - octane number of the methanol.

Determining the octane number resulting from introducing the 4,7g celluloses nitrate within the fuel, as done in accordance to the methodology to determine octane number depicted previously [6].

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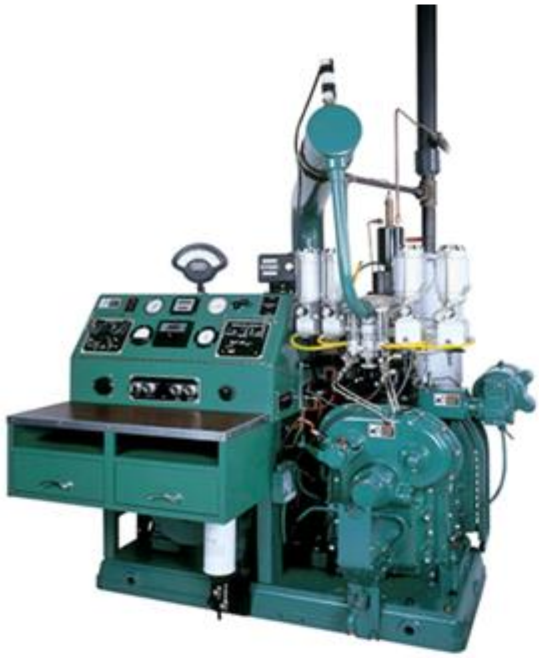

Figure 1 CFR Waukesha F1 / F2 Engine [3]

This determination was done by comparing the mixture of the fuel realized with a standard fuel with an octane number known on a special engine mounting, being composed out of a lab spark ignition engine, single cylinder, four-stroke engine with a ratio of variable compression (Cooperative Research Fuel CFR Waukesha, U.S.A. fig.1.), in normal conditions, settled by American Society for Testing and Materials) ASTM. As a result, it was stated that the mixture has an octane number of 102,5 CO/R

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