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DIESEL ENGINE FUEL

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This invention relates to a diesel engine fuel and particularly to a diesel engine fuel prepared from relatively low value stocks, which fuel is particularly suitable for use in medium and large bore diesel engines.

Although small bore, high speed diesel engines used in trucks and the like require a fuel of relatively high purity and having a relatively high volatility and high cetane number, as for example a cetane number in the range of 45 to 60, the larger diesel engines such as those used in railroad locomotives, in marine services and in electric generation plants are designed to operate on relatively higher boiling fractions of petroleum having relatively lower cetane numbers. Thus, these larger engines are capable of operating satisfactorily using heavy straight-run gas oil fractions and similar fractions of petroleum having cetane numbers in some instances as low as about 31 to 32. Although such heavy straight-run gas oil fractions are appreciably cheaper than the lighter fractions such as are required for use in the small bore engines, from an economic point of view it is desirable that even less costly fuels be supplied.

As is well understood in the art, a fuel suitable for use in compression ignition engines such as diesel engines, must be one having a sufficiently high cetane number, i. e., one which will not detonate with resulting knocking of the engine. The cetane number of a fuel is determined by comparing the knock induced by the fuel with the knock produced by a standard fuel consisting of a blend of cetane and alphamethyl naphthalene. Thus, a fuel having a cetane number of 35 would produce the same intensity of knock in an engine as a mixture of cetane and alphamethyl naphthalene containing 35% of cetane.

In view of the above, it would be expected that fractions of petroleum containing appreciable proportions of aromatic compounds would not be suitable for use as diesel engine fuel. It has been found, however, that certain blends of two different cycle oils from catalytic cracking operations, each of which cycle oils contains relatively high proportions of aromatic hydrocarbons, are of sufficiently high cetane number to permit their use in the larger diesel engines of the types described.

Thus, it has been found that mixtures of certain cycle oils obtained in catalytic cracking operations carried out on straight-run gas oils, or mixtures of straight-run gas oils with gas oils produced in coking operations, are suitable for use as diesel engine fuel. Such mixtures have cetane values of 31 to 33, greater heat value expressed in B. t. u.'s per gallon than straight-run fuels of similar volatility, and other characteristics making them particularly satisfactory for use as fuels in the mentioned diesel engines. Moreover, it is found that although the

mentioned cycle oils used separately are not entirely satisfactory diesel engine fuels because of undesirable volatility characteristics and/or sludging tendencies, when the two different cycle oils are combined in the proportions disclosed herein, fuels of acceptable quality are obtained. The lack of sludging tendency, which term is used herein in its usual sense and thus refers to the tendency of the composition to precipitate or separate insoluble sludge-like material on standing, is unexpected since the cycle oils employed are each considered to be unstable fractions and it is known that when either of these fractions is combined with small to substantial proportions of straight-run gas oils, they do tend to separate sludge-like materials on standing. Thus, the finding that the particular mixtures of TCC and FCC cycle oils described herein was entirely unexpected.

The cycle oils referred to are relatively cheap as compared with straight-run gas oils and in fact such cycle oils are often used as cutter stocks, i. e., used to reduce the viscosity of residual fuel oils. Moreover, it has been found that the addition of small amounts of certain agents, e. g., amyl nitrate, raises the cetane number of diesel fuels prepared from such cycle oils to values of 35 or higher.

In using straight-run fuels of low volatility under extreme conditions of temperature, particularly in the injection system, there is a tendency to deposit varnish or lacquer-like materials on the moving surfaces, thus causing sticking of the injectors, and, under any condition, more frequent overhauls than would otherwise be required. It is found that with the fuel of this invention these deposits are minimized or completely avoided. The reason for this result is not understood, particularly in view of the fact that the total fuel is derived from cracked materials which would normally be expected to be unstable and therefore have a greater tendency to deposit harmful materials in the injection system of the engine.

It is an object of this invention to provide a fuel suitable for use in the relatively large bore diesel engines, which fuel consists of fractions obtained as by-products in certain catalytic cracking operations. It is another object of this invention to provide a low cost fuel suitable for use in large bore diesel engines, which fuel has a cetane number between about 31 and about 36 and a heat value, expressed in B. t. u.'s per gallon, greater than that of straight-run fuels of similar boiling range, with correspondingly greater power output. Still another object of this invention is to produce a diesel fuel which does not deposit varnish or lacquer-like deposits in the injection system of diesel engines. Other objects of this invention will be apparent as the description thereof proceeds.

In preparing the diesel fuel of this invention two different cycle oils obtained from two different catalytic cracking operations are blended in proportions to give the desired characteristics, particularly the desired volatility, gravity, flash point, etc.

One of the cycle oils used in preparing the final blend is the cycle oil obtained as a by-product in a Thermofor catalytic cracking unit. This unit and conditions under which it is operated are well known in the art. Generally the hydrocarbon fraction used as feed to the unit is a light to medium straight-run gas oil, such as one obtained from a mixed base crude. It will have a boiling range of about 400° F. to about 760° F. In the cracking unit the gas oil is contacted with a silica-alumina pel-

letized or bead type catalyst at a temperature within the range of about 800° F. to about 900° F. and preferably at about 850° F. with a catalyst oil ratio of about 2. The contact time is maintained between about 15 and about 30 seconds and preferably between about 20 and about 25 seconds. Following the catalytic treatment, the products are fractionally distilled to separate gasoline and lighter hydrocarbons, a cycle gas oil fraction and a cracked residual fraction. Part of the cycle gas oil is returned with new feed to the unit. A satisfactory recycle ratio is approximately 0.2. This cycle oil, which will be referred to herein as TCC cycle oil, will have the following characteristics:

Table 1

	TCC cycle oil (typical values)
Distillation, ° F. (ASTM):	
10%	464
50%	522
90%	614
Max.	672
Gravity, ° (API)	28
Viscosity at 100° F. (SSU)	30
Sulfur, percent	0.6
Nitrogen, percent	0.09
Acid solubility, percent	45

As used herein the term "acid solubility" is a measure of the aromatic and olefin content and is expressed in percent by volume. The acid employed per 10 ml. sample is 15 ml. glacial acetic acid and 25 ml. of 15% fuming sulfuric acid.

The second cycle oil employed in preparing the diesel fuel of this invention is a cycle gas oil produced as a by-product in the fluid catalytic cracking of heavy straight-run gas oil, or mixtures of such gas oil with a gas oil fraction recovered from a coking operation. The gas oil feed to this cracking unit is one having an initial boiling point of approximately 425° F. and containing about 28% of material having a boiling point above about 760° F. Fluid catalytic cracking units and methods of effecting such cracking are well known in the art. Briefly, the heavy gas oil feed together with a small amount of cycle gas oil produced in the operation are fed to the cracking unit and contacted with a so-called fluid catalyst which may be in either powder or microspherical form and which is a silica-alumina cracking catalyst, at a temperature between about 900° F. and about 1000° F. and preferably at a temperature of approximately 930° F., the contact time being approximately 5 to 6 seconds. The catalyst-oil ratio is preferably about 16 and the recycle ratio approximately 0.1. Operating under these conditions, the conversion to gasoline and lighter hydrocarbons is approximately 50% by volume. Following catalytic treatment the product is fractionally distilled to separate gasoline and lighter hydrocarbons, a light gas oil stream and a heavy gas oil stream referred to herein as FCC cycle oil, leaving as bottoms a heavy cracked residuum.

Tests on a typical FCC cycle oil are as follows:

Table 2

	FCC cycle oil (typical values)
Distillation, ° F. (ASTM):	
10%	580
50%	670
90%	730
Max.	760
Gravity, ° (API)	20
Viscosity at 100° F. (SSU)	50
Sulfur, percent	0.8
Nitrogen, percent	0.26
Acid solubility, percent	50

The diesel engine fuel of this invention consists of a blend of between about 40% and about 75% by volume of the TCC cycle oil and correspondingly between about 25% and about 60% of the FCC cycle oil. The proportion of each of the cycle oils employed will fall within the above limits and will be such as to produce a finished diesel fuel having the following characteristics:

Table 3

	Limits		Typical Test Values
	Min.	Max.	
Distillation, ° F. (ASTM):			
10%	425		450
50%		575	530
90%		675	650
Max.		760	720
Gravity, ° (API)	25	35	26
Flash Point, ° F. (PMCC)	150		160
Pour Point, ° F.			15
Color (ASTM)			3
Viscosity at 100° F. (SSU)	35	45	36
Cetane Number	31		32–33

A diesel engine fuel prepared by blending 60% by volume of a TCC cycle oil having the characteristics shown in Table 1, with 40% by volume of FCC cycle oil having the characteristics set forth in Table 2, produced a diesel engine fuel having approximately the characteristics set forth as typical test values in Table 3. This fuel, which had a cetane number of 32, was found to operate satisfactorily in a railroad locomotive diesel engine having a normal rating of 1500 H. P. This diesel fuel has a heat value of 143,500 B. t. u. per gallon, as compared with 140,689 B. t. u. per gallon for a straight-run gas oil boiling in substantially the same temperature range. In a comparative test it was observed that using equal feed rates, a locomotive diesel engine which developed 1440 H. P. on the mentioned straight-run gas oil developed 1620 H. P. using the diesel fuel of this invention. The increased value of the diesel fuel of this invention can therefore be realized by operating engines at higher horsepower ratings or if it is desired to maintain the same horsepower as would be obtained using a straight-run gas oil, then smaller amounts of feed may be employed than would be required with the straight-run fuel.

In another test run to determine fuel consumption, locomotive units were operated in heavy freight service over the Sierra Nevada Mountains reaching a maximum elevation of over 7,000 feet with a round trip of 300 miles in 24 hours. In this test one engine was operated on a straight-run gas oil feed and a second engine was operated on the fuel referred to above consisting of 60% TCC cycle oil and 40% FCC cycle oil. In each case the engines were set at comparable horsepower ratings of 1530. While operating in this manner, the fuel consumption rate was determined by the use of compensating fuel meters attached to each unit. The results of this test are presented below:

Fuel Composition	Fuel Meter Readings, Gallons				
	At Start	Half-way	Terminal	Return Half-way	At End of Round Trip
60% TCC Cycle Oil / 40% FCC Cycle Oil	0	368	376	612	638
Straight-Run Gas Oil	0	380	388	630	661

Although the mixture of cycle stocks described hereinabove produces a diesel fuel meeting the requirements

of relatively large bore, low speed diesel engines with respect to all characteristics, including cetane number, in those instances in which higher cetane numbers are desired, i. e., cetane numbers as high as 35 or 36, the addition of small amounts of amyl nitrate or other cetane improvers suitable for use in improving the cetane numbers of refined diesel fuel are found to produce the necessary increase in cetane number. Generally, the fuels of this invention can be converted into 35 cetane fuels by the incorporation of between about 0.1% and about 0.3% by volume of amyl nitrate or equivalent cetane improving agent. Other low molecular weight aliphatic nitrates, organic peroxides, hydroperoxides and the like, may be employed in place of the mentioned amyl nitrate.

The foregoing description and examples are illustrative of the invention. However, as will be understood in the art, the cycle oils useful in preparing the fuel of this invention may vary in their physical and chemical characteristics, depending upon the particular cracking feed stocks employed and upon the conditions under which the two different catalytic cracking operations are carried out. In the preparation of the diesel fuel of this invention it is intended to use the cycle oils produced in the manner described and blend such cycle oils in the proportions indicated herein. Slight variations in the physical and chemical characteristics of the cycle oils and/or the resulting blended fuels do not alter appreciably the desirable characteristics of the final blended fuel.

I claim:

1. A fuel suitable for use in medium and large bore diesel engines, said fuel consisting essentially of a blend of two different distillate cycle oils obtained in catalytic cracking operations, one of said cycle oils having an API gravity of about 28, a Saybolt Universal viscosity at 100° F. of about 30 and an acid solubility of about 45%, and the other cycle oil having an API gravity of about 20, a Saybolt Universal viscosity at 100° F. of about 50 and an acid solubility of about 50%, said fuel having the following characteristics:

	Limits	
	Min.	Max.
Distillation, ° F. (ASTM):		
10%	425	
50%		575
90%		675
Max.		760
Gravity, ° (API)	25	35
Flash Point, ° F. (PMCC)	150	
Viscosity at 100° F. (SSU)	35	45
Cetane Number	31	

2. A diesel engine fuel having an API gravity between about 25 and about 35, a flash point of at least about 150° F., a Saybolt Universal viscosity at 100° F. between about 35 and about 45 and a cetane number of at least about 31, said fuel consisting of between about 40% and 75% by volume of a Thermofor catalytic cracked TCC cycle oil having an API gravity of about 28, a Saybolt Universal viscosity at 100° F. of about 30 and an acid solubility of about 45% and correspondingly between about 25% and about 60% by volume of a fluid catalytic cracked cycle oil having an API gravity of about 20, a Saybolt Universal viscosity at 100° F. of about 50 and an acid solubility of about 50%, said Thermofor catalytic cracked cycle oil and said fluid catalytic cracked cycle oil being distillate fractions.

3. A diesel engine fuel according to claim 2 containing also between about 0.1% and about 0.3% by volume of a cetane improving agent.

4. A diesel engine fuel according to claim 2 containing also between about 0.1% and about 0.3% by volume of amyl nitrate.

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