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Influence of Diesel Blending Material on Viscosity of Diesel

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ABSTRACT: *Diesel is a most efficient fuel in which we can fulfill energy needs and get smooth operational performance by adjusting its viscosity in particular range. To acquired desired value of viscosity of diesel it is essential to understood relative influence of individual blend on viscosity of diesel. Physical and chemical Properties of the various blending material of diesel are determined by the structural features and boiling range of respective components of diesel. Better understanding of the structure-physical property relationships in blended material is of particular importance when choosing this entire blend for preparation of diesel that will give the desired viscosity of diesel. This paper explores the effect of proportion of individual blend of diesel on its viscosity is studied based on chemical structure, boiling range and physical properties of blend stock to optimize diesel fuel viscosity characteristics*.

KEYWORDS: *diesel blending component; Viscosity*

I. INTRODUCTION

Kerosene, diesel fuel, and aviation turbine fuel (jet fuel) are members of the class of petroleum products known as middle distillates (Gruse and Stevens, 1960; Guthrie, 1967; Kite and Pegg, 1973; Weissermel and Arpe, 1978; Francis and Peters, 1980; Hoffman, 1983;Austin, 1984; Chenier, 1992; Hoffman and McKetta, 1993; Hemighaus, 1998; Speight, 1999; Heinrich and Duée, 2000). As the name implies, these products are higher boiling than gasoline but lower boiling than gas oil. Middle distillates cover the boiling range from approximately 175 to 375°C (350–700°F) and the carbon number range from about C8 to C24.These products have similar properties but different specifications as appropriate for their intended use. The broad definition of fuels for land and marine diesel engines and for nonaviation gas turbines covers many possible combinations of volatility, ignition quality, viscosity, gravity, stability, and other properties.Various specifications are used to characterize these fuels (ASTM D-975,ASTM D-2880). Diesel fuels originally were straight-run products obtained from the distillation of crude oil. Currently, diesel fuel may also contain varying amounts of selected cracked distillates to increase the volume available. The boiling range of diesel fuel is approximately 125–328°C (302–575°F) . Thus, in terms of carbon number and boiling range, diesel fuel occurs predominantly in the kerosene range, and thus many of the test methods applied to kerosene can also be applied to diesel fuel. Diesel fuel depends on the nature of the original crude oil, the refining processes by which the fuel is produced. Furthermore, the specification for diesel fuel can exist in various combinations of characteristics such as, for example, volatility, ignition quality, viscosity, gravity, and stability. The physicochemical properties of the fuels influence the behavior and the performance of the vehicle engine. Density and viscosity are one of the most important characteristics of the liquids used as fuels in diesel engines. These properties influence

The atomization and combustion processes that take place in the diesel engine and the flow properties. One of the most widely used specifications (ASTM D-975) covers three grades of diesel fuel oils, No. l-D, No. 2-D, and No. 4-D. Grades No. l-D and2-D are distillate fuels (ASTM D-975), the types most commonly used in high-speed engines of the mobile type, in medium speed stationary engines, and in railroad engines. Grade 4-D covers the class of more viscous distillates and, at times, blends of these distillates with residual fuel oils. The marine fuel specifications (ASTM D-2069) have four categories of distillate fuels and fifteen categories of fuels containing residual components. Different blending technique may be used to achieve the desired viscosity of fuel and hence performance of fuel. Antismoke and viscosity can be improve by adjusting blending ratio of diesel fuel component in a particular manner which can setup viscosity in a desirable range as a result to reduce or control exhaust smoke, which is of growing concern as more and more attention is paid to atmospheric pollution. Antioxidant and sludge dispersants may also be used, particularly with fuels formulated with cracked components, to prevent the formation of insoluble compounds that could cause line and filter plugging (ASTM D-2068, ASTM D-6371, IP 309). The chemical composition of diesel fuel is extremely complex, with an enormous number of compounds normally present. For this reason, it usually is not practical to analyze diesel fuel for individual compounds but it is often advantageous to define the compounds present as broad classifications of compound types, such as aromatics, paraffins, naphthenes and olefins. One of the most important physical parameters defining diesel fuel, and other middle distillate products, is the boiling range distribution (ASTM D-86, ASTM D-2887, ASTM D-2892).viscosity of diesel fuel is depending on this broad classification. Knowledge for proportion or concentration of this class in distillate stream that used in our diesel for blending will help us to estimate about viscosity trends of blended diesel fuel. To under stood the important of viscosity parameter in diesel fuel it is worth here to discuss application of diesel fuel in diesel engine and basic functioning of diesel engine.

The operating principles of diesel engines are significantly different from those of the spark-ignited engines. In a diesel engine, also known as a *compression-ignited* engine, only air enters the cylinder through the intake system. This air is compressed to a high temperature and pressure and then finely atomized fuel is sprayed into the air at high velocity. When it contacts the high temperature air, the fuel vaporizes quickly, mixes with the air, and undergoes a series of spontaneous chemical reactions that result in a self- ignition or *autoignition*. In this auto ignition combustion spray of diesel fuel is purely dependent on viscosity of diesel in addition to this viscosity of diesel is also played role in power of the engine because the power of the engine is controlled by varying the volume of fuel injected into the cylinder, The timing of the combustion process must be precisely controlled to provide low emissions with optimum fuel efficiency. This timing is determined by the fuel viscosity, fuel injection spray pattern, injection timing plus the short time period between the start of fuel injection and the auto ignition, called the ignition delay.When the auto ignition occurs, the portion of the fuel that had been prepared for combustion burns very rapidly during a period known as *premixed combustion*. When the fuel that had been prepared during the ignition delay is exhausted, the remaining fuel burns at a rate determined by the mixing of the fuel and air. This period is known as mixing-controlled combustion.

The diesel having improper value of viscosity generate fuel-air mixture in the cylinder during the diesel combustion process contributes to the formation of soot particles, one of the most difficult challenges for diesel manufacturer. These particles are formed in high temperature regions of the combustion chamber where the air-fuel ratio is fuel-rich and consists mostly of carbon with small amounts of hydrogen compounds. Although the mechanism is still not understood, biodiesel reduces the amount of soot produced and this appears to be associated with the bound oxygen in the fuel (McCormick, R.L., J.D. Ross, and M.S. Graboski, "Effect of Several Oxygenates on Regulated Emissions from Heavy-Duty Diesel Engines," Environ. Sci. and technol. V. 31, No. 4, 1997, pp. 1144-1150.). The particulate level in the engine exhaust is composed of these soot particles along with high molecular weight hydrocarbons that adsorb to the particles as the gas temperature decreases during the expansion process and in the exhaust pipe. This hydrocarbon material, called the *soluble organic fraction*, diesel with improper viscosity apparently causes a small portion of the fuel to survive the combustion process, probably by coating the cylinder walls, where it is then released during the exhaust process.

Most diesel fuel injection systems compress the fuel for injection using a simple piston and cylinder pump called the plunger and barrel. In order to develop the high pressures needed in modern injection systems, the clearances between the plunger and barrel are approximately one ten-thousandth of an inch. In spite of this small clearance, a substantial fraction of the fuel leaks past the plunger during compression. If fuel viscosity is low, the leakage will correspond to a power loss for the engine. If fuel viscosity is high, the injection pump will be unable to supply sufficient fuel to fill the pumping chamber. Again, the effect will be a loss in power. The viscosity range for typical biodiesel fuels overlaps the diesel fuel range with some biodiesels having viscosities above the limit. (. Tat, M.E. and J.H. Van Gerpen, "The Kinematic Viscosity of Biodiesel and Its Blends with Diesel Fuel," Journal of the American Oil Chemists' Society, V. 76, No. 12, 1999, pp. 1511-1513.)If fuel viscosity is extremely excessive, as is the case with vegetable oils, there will be a degradation of the spray in the cylinder causing poor atomization, contamination of the lubricating oil, and the production of black smoke.

From above discussion it is apparent that how critical role played by viscosity of diesel fuel in its combustion process hence Fuel viscosity is specified in the standard for diesel fuel within a fairly narrow range.

In this paper the relationship between the individual proportion of diesel blending component and its effect on viscosity of diesel were studied

II. EXPERIMENTAL

Diesel fuel is composed of a variety of blending components of different hydrocarbon types. Refiners use blending components to balance the viscosity specifications that produce the optimum diesel fuel for specific applications and operating environments.

Petroleum-derived diesel is composed of about 75% saturated hydrocarbons (primarily paraffins including n, iso, and cycloparaffins), and 25% aromatic hydrocarbons (including naphthalene and alkyl benzenes). The average chemical formula for common diesel fuel is $C_{12}H_{23}$, ranging approximately from $C_{10}H_{20}$ to $C_{15}H_{28}$. Some of the blending components are straight-run streams that come directly from the crude oil in the primary distillation process. Other blending components are hyrdrocracked streams produced from heavy gas oils, thermally cracked distillates typically produced from the delayed coking of refinery residual streams, and light-cycle oils produced from fluid catalytic cracker (FCC) units. Depending on the sulfur content of the crude oil, the straight-run and processed streams may require desulfurization before addition into the final diesel-fuel blend.

refinery stream that contribute for saturated hydrocarbon is LGO,HGO,VD,LK,HK,STRAIGHT RUN HEAVY NAPHTHA, while stream that contribute for aromatic are cracked stream like LCO,HEAVY GASOLINE and AGO. Viscosity of diesel is increases with increasing molecular weight of diesel as well as increasing naphthenic and paraffinic compound in diesel. Among all stream that use for diesel HGO having highest concentration of naphthenic and paraffinic compounds as well higher molecular weight. Considering this basic concept we have prepared diesel sample by using different blending ratio of HGO.

Table No. 01

Volume percentage	**28%**	**15%**	**12%**	**2%**	**21%**	**20%**	**0.8%**	**1.2%**	**TOTL= 100%**
Stream	LGO	HGO	VD	LK CDU	HK CDU	LCO	HEAVY GASOLINE FCCU	AGO VBU	RAW DIESEL
IBP	207	268	254	160	189	166	137	175	156
5%	245	294	281	171	215	191	143	195	171
10%	260	312	287	173	222	199	145	202	179
30%	282	332	311	178	236	227	150	229	207
50%	296	345	329	186.0	244	255	156	259	240
70%	312	350	347	198	251	290	164	291	279
85%	328	377	364	210	257	320	172	314	314
90%	336	389	373	216	260	331	177	323	330
95%	348	393	390	225	265	342	183	336	352
FBP	360	399	397	232	269	346	195	342	361
VISCOSITY@ 40^0C	3.934	9.668	6.798	1.551	2.0235	2.665	NA	2.330	1.946

Table No. 02

Volume percentag e	**28%**	**17%**	**12%**	**2%**	**21%**	**18%**	**0.8%**	**1.2%**	**TOTL= 100%**
Stream	LGO	HGO	VD	LK CDU	HK CDU	LCO	HEAVY GASOLINE FCCU	AGO VBU	RAW DIESEL
IBP	207	268	254	160	189	166	137	175	158
5%	245	294	281	171	215	191	143	195	173
10%	260	312	287	173	222	199	145	202	185
30%	282	332	311	178	236	227	150	229	243
50%	296	345	329	186.0	244	255	156	259	265
70%	312	350	347	198	251	290	164	291	299
85%	328	377	364	210	257	320	172	314	327
90%	336	389	373	216	260	331	177	323	340

95%	348	393	390	225	265	342	183	336	360
FBP	360	399	397	232	269	346	195	342	365
VISCOSITY@ 40^0C	3.934	9.668	6.798	1.551	2.0235	2.665	NA	2.330	2.431

Table No. 03

Volume percentage	**28%**	**19%**	**12%**	**2%**	**21%**	**16%**	**0.8%**	**1.2%**	**TOTL= 100%**
Stream	LGO	HGO	VD	LK CDU	HK CDU	LCO	HEAVY GASOLINE FCCU	AGO VBU	RAW DIESEL
IBP	207	268	254	160	189	166	137	175	178
5%	245	294	281	171	215	191	143	195	221
10%	260	312	287	173	222	199	145	202	233
30%	282	332	311	178	236	227	150	229	266
50%	296	345	329	186.0	244	255	156	259	293
70%	312	350	347	198	251	290	164	291	320
85%	328	377	364	210	257	320	172	314	343
90%	336	389	373	216	260	331	177	323	354
95%	348	393	390	225	265	342	183	336	369
FBP	360	399	397	232	269	346	195	342	374
VISCOSITY@ 40^0C	3.934	9.668	6.798	1.551	2.0235	2.665	NA	2.330	2.931

Table No. 04

Volume percentage	**28%**	**21%**	**12%**	**2%**	**21%**	**14%**	**0.8%**	**1.2%**	**TOTL= 100%**
Stream	LGO	HGO	VD	LK CDU	HK CDU	LCO	HEAVY GASOLINE FCCU	AGO VBU	RAW DIESEL
IBP	207	268	254	160	189	166	137	175	221
5%	245	294	281	171	215	191	143	195	266
10%	260	312	287	173	222	199	145	202	281
30%	282	332	311	178	236	227	150	229	295
50%	296	345	329	186.0	244	255	156	259	325
70%	312	350	347	198	251	290	164	291	335
85%	328	377	364	210	257	320	172	314	350
90%	336	389	373	216	260	331	177	323	360
95%	348	393	390	225	265	342	183	336	372
FBP	360	399	397	232	269	346	195	342	375
VISCOSITY@ 40^0C	3.934	9.668	6.798	1.551	2.0235	2.665	NA	2.330	3.396

III. RESULT & DISCUSSION

Cracked products such as LCO and AGO have a considerably lower cetane value compared to straight run distillates derived from most of the world's crude sources. LCO cetane ranges from 15-25, compared to 40-60 for the straight run distillates HGO,LGO,VD ,LK and HKproduced from the same crude. The aromatics content of LCO from FCC units in a normal gasoline-oriented operation can be as high as 80 wt-%.The components of LCO boil in the diesel range. Over 70% of the aromatic hydrocarbons present in LCO have two rings, while the remainder is typically evenly split between single ring and 3-plus ring aromatics. Two and 3+ ring aromatics combust poorly in the

diesel engine. They have very low cetane values and are the root cause of the low blending
quality of LCO. In spite of this an aromatic streams are added in 15 to 25percentage amounts to diesel fuel to volumetrically increase yields up to the point that their addition maximizes one or more of the diesel-fuel specifications. Aromatics increase the density of the fuel (and thus its heating value) and improve cold flow properties.

The straight run product like HGO having boiling range from 260^0 C to 400^0 C and viscosity value is from 6.3cst to 10.5cst. This stream having highest value of viscosity among all streams that used for blending of diesel. Higher viscosity of HGO is because of its higher concentration of paraffinic and naphthenic compounds. Hydrocarbon compound present in diesel that boil at 260^0C to 360^0C having measure contribution for increasing viscosity of diesel. As we increase the concentration of HGO concentration of hydrocarbon compound between these ranges is increases in diesel as a result net viscosity of diesel is increasing. When we increase the proportion of HGO for purpose of viscosity adjustment it was studied that the higher heating value of a diesel fuel also increases. Because as the carbon number of fuel increases it increase the heating value of fuel molecules and also increases as the ratio of carbon and hydrogen to oxygen and nitrogen increases. (Demirbas 1997). Demirbas (2008) studied the correlation between viscosity and higher heating value (HHV) by performing a linear least square regression analysis and argued that there is high regression between the higher heating value and the viscosity. The HHV of diesel is approximately 46 MJ/kg.

IV. CONCLUSION

Generally diesel having ratio of straight run product and cracked stream product is about 70% and 30% respectively. by changing this ratio to 82% and 18% with help of increasing the proportion of HGO from straight run product and reducing the proportion of LCO from cracked run product over all viscosity of raw diesel is raising from 1.93 cst to 3.40 cst Every 2% increase in HGO and 2% decrease in LCO will give 0.4 to 0.5 cst increment in viscosity of raw diesel. Further desulfurization of this raw diesel will give change in viscosity based on performance of desulfurization process.

As the crude blend of product changing, influence of HGO and LCO on raw diesel viscosity is changing widely. Increasing the blending proportion of HGO from straight run product part of diesel it will shorten the distillation range of diesel fuel. Reducing the blending proportion of LCO will reducing overall aromatic hydrocarbon concentration of diesel fuel.

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