

1

2,996,455

HIGH VISCOSITY INDEX, LOW VISCOSITY, LOW VOLATILITY MOTOR OIL

Glenn R. Brown, Solon, and Arthur Letcher Jones, Lyndhurst, Ohio, assignors to The Standard Oil Company, Cleveland, Ohio, a corporation of Ohio
No Drawing. Filed Dec. 28, 1956, Ser. No. 631,064
1 Claim. (Cl. 252-59)

This invention relates to oil compositions that are useful primarily as engine lubricating oils and are characterized by a unique and most desirable combination of high viscosity index, low viscosity at low temperatures and low volatility at higher temperatures.

The desirability of providing a lubricating oil having a high viscosity index, i.e., a low viscosity at low temperatures to facilitate cold starting and minimize friction and engine wear while operating at low temperatures and a high viscosity at higher temperatures to insure adequate lubrication and minimize friction and engine wear at engine operating temperatures, has been recognized for some time. The recent trend towards engines of higher horsepower and speed, and toward the use of closer tolerances between moving parts thereof have accentuated the demands for lubricants that will provide effective lubrication under a wide variety of conditions ranging from starting an engine at frigid temperatures to operating it at high speeds for extended periods of time and at average temperatures of several hundred ° F.

The answer of the oil industry to demands for oils to meet these requirements has been to provide the so-called double and triple branded motor oils. These are generally oils or oil blends containing at least about 8% and as much as 15% by volume of one or more high molecular weight polymers, e.g., polybutenes, well known in the industry as viscosity index improvers. It is possible, for example, to blend enough of a viscosity index improver with an oil having a viscosity index of say 100 to increase its viscosity index to 140 or more and thus make it eligible for classification as a triple branded motor oil such as SAE 5W-20.

As so often happens, however, this solution to the problem has brought with it several other problems which are of a magnitude sufficient to have resulted in a considerable decline in the popularity of such multi-branded oils. The new problems created by attempts to produce motor oil blends of high viscosity index through the strategy of blending considerable amounts of viscosity index improver with an oil are basically related to the fact that low viscosity at low temperatures goes hand in hand with high volatility at the temperatures to which a motor oil is subjected during engine operation. Blends of thin oil with high proportions of viscosity index improver to raise the viscosity at 210° F. to an acceptable figure were found to have comparatively short useful life in an engine. Investigations showed this to be due to the relatively high volatility at the operating temperature of the engine. Blends of thicker oil with the same amount of viscosity index improver had reduced volatility at the higher temperature and therefore better consumption characteristics, but were too viscous at low starting temperatures. The use of lesser amounts of viscosity improver with thicker oils can result in acceptable values of viscosity at starting temperatures and volatility at engine operating temperatures, but results in a reduction of viscosity at engine operating temperatures to a point that is inadequate for proper lubrication under the conditions of operation.

Thus it becomes apparent that attempts to blend oils and viscosity index improvers to obtain lubricating oils of optimum characteristics have been frustrated by the

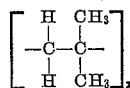
2

inescapable fact that at least one of three basic requirements, i.e., low viscosity at starting temperatures, high viscosity at operating temperatures and low volatility at operating temperatures must be sacrificed, or that, in the alternative, an unsatisfactory compromise must be accepted. In addition to this problem, it also developed that the high molecular weight viscosity index improvers tend to undergo shear breakdown under operating conditions when used in high or moderately high concentration. This breakdown is permanent in that the viscosity lost as a result of the breakdown is not regained after the oil has returned to ambient temperature.

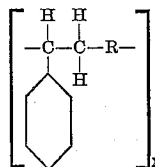
The surprising discovery has now been made that an oil composition having all three desirable attributes of low low-temperature viscosity, high high-temperature viscosity (i.e., high viscosity index) and low volatility can be prepared by blending a maximum of 5% by volume of a high molecular weight viscosity index improver with an oil refined by thermal diffusion to increase the viscosity index thereof from the range of about 90 to 105 to the range of at least 110 and preferably about 115 to 130 or more. It is also within the scope of the invention to blend with the viscosity index improver a blend of two or more oils that have been refined by thermal diffusion to increase their viscosity indexes.

The oil composition of the invention, therefore, essentially comprises a major amount, preferably at least about 80% by volume, of a thermal diffusion refined oil having a viscosity index of at least 110 and preferably between 115 and about 130 and up to about 5% by volume of a high molecular weight viscosity index improver. Compositions within the scope of this definition are characterized by a viscosity index of at least 140, a viscosity of less than 200 SSU at 100° F., a viscosity of at least about 50 SSU at 210° F. and a volatility at atmospheric pressure of less than 5% at about 735° F. and less than 50% at about 800° F.

High molecular weight viscosity index improvers are well known in the lubrication art, as exemplified by the discussion thereof in "Motor Oils and Engine Lubrication," by Carl W. Georgi, Reinhold Publishing Co. (1950), at pages 196 to 207. One is the "Paratone" viscosity index improver, a butene polymer believed to have the general formula



for which the molecular weight is in the range of 10,000 to 15,000. Another is "Acryloid," a polymer of methacrylic acid ester and higher fatty alcohols generally having a molecular weight within the range of 5,000 to 20,000. An example is Acryloid 763 which has a specific gravity of 0.901, a viscosity of 7200 centistokes at 100° F., and a molecular weight, measured in terms of the centistoke viscosity at 100° F. of a 30% solution of the polymer in toluene, of 350 centistokes. A third type is the "Santodex" viscosity index improver prepared by copolymerization of styrene with olefins having eight to twelve carbon atoms and having the general formula



wherein R stands for an alkyl radical having eight to twelve carbon atoms and the molecular weight is of the same order as for the "Paratone" and "Acryloid" types.

Another viscosity index improver, more recently developed (U.S. Patent 2,737,496) is a copolymer containing basic amino nitrogen. An example is the 80/20 (molar) copolymer of lauryl methacrylate and diethyl-aminoethyl methacrylate. It is an oil soluble, highly viscous, tacky material at room temperature and, we are informed, is sold in a 40% solution in a light oil (SAE 20) as PL-164B or LOA-565, the latter in a 7½% solution in a light oil (SAE 20) has a viscosity of 103 centistokes at 100° F.

Thermal diffusion as is now well known in the art, is a method that essentially involves applying a temperature gradient across a thin film of liquid having dissimilar components, thereby separating the liquid into at least two different fractions, and then physically removing the fractions from one another. Inasmuch as this is usually accomplished in apparatus having two closely spaced walls forming a thermal diffusion chamber for confining the liquid while it is subjected to thermal diffusion and one of the walls is relatively heated and the other relatively cooled to impose the temperature gradient across the confined liquid, one of the dissimilar fractions is referred to as the "hot wall" fraction to indicate that it is the fraction that has accumulated adjacent the hot wall and the other fraction is called the "cold wall" fraction for similar reasons. The degree of separation obtainable by means of thermal diffusion is dependent upon a considerable number of variables including the rate of throughput, the relative rates of withdrawal of the hot and cold wall fractions, the magnitude of the temperature gradient imposed, the spacing between the hot and cold wall surfaces, the area of said surfaces, and the like.

In the method of the invention, it has been found that the hot wall fractions of oils subjected to thermal diffusion have remarkably increased viscosity index values and are not affected appreciably in so far as volatility is concerned. While the invention is not to be limited by any theory advanced, it is believed that the thermal diffusion process, when applied to hydrocarbon oils, involves a sorting out by molecular types rather than molecular weights and that the hot wall fractions are characterized by an enriched paraffinic content whereas the cold wall fractions tend to have a higher than initial concentration of aromatic constituents. The term "thermal diffusion refined," as applied to oils and oil blends in this description, is therefore intended to refer to the hot wall fraction obtained by subjecting hydrocarbon oils to thermal diffusion.

The oil compositions of the invention have a considerable number of important advantages. Prominent among these are their low low-temperature viscosities for promoting easy starting, effective lubrication and reducing engine wear at low temperatures, high high-temperature viscosity to promote adequate lubrication, minimize engine wear and reduce friction at operating temperatures, and low volatility to insure adequate "oil mileage." In addition, the oil compositions of the invention are viscosity stable in that they are spared the effects of shear breakdown and consequent permanent reduction in viscosity that is characteristic of the multi-branded oils that have heretofore appeared and have already lost favor in the market.

While the oil compositions of the invention are considered useful primarily as motor lubricating oils, they have many other uses, e.g., as vacuum pump oils, transformer or switch oils, and in many cases where high temperature lubrication is required. The cold wall fractions obtained along with the overhead products in the thermal diffusion process also have a variety of uses. They may be used in hydraulic systems and in applications requiring oils of high specific gravity.

The advantages and utility of the composition and method of the invention will become further apparent from the detailed description in the following example.

EXAMPLE

Part A.—Solvent extracted neutral oils having viscosities of 140 and 300 at 100° F., and therefore identified as 140 SEN and 300 SEN oils, respectively, were refined by thermal diffusion in a six foot vertical, center feed concentric tube column wherein the thermal diffusion separation chamber was formed by the outer wall of the inner tube and the inner wall of the outer tube, the opposed surfaces of the chamber-forming walls being spaced apart a distance of 0.03". The hot wall was maintained at a temperature of 445° F. and the cold wall was maintained at 130° F. The oils were introduced into the thermal diffusion columns at rates of approximately 35 ml./hr. and the rates of withdrawal of the hot wall fraction from the top and the cold wall fraction from the bottom were maintained approximately equal. The initial and final viscosities and viscosity indexes, and the 5 and 50% Engler distillation values, of the thermal diffused oils withdrawn from the top of the column are tabulated in Table I immediately below:

Table I

	300 SEN Oil		140 SEN Oil	
	Initial	T.D. Ref.	Initial	T.D. Ref.
Viscosity: SSU at 100° F.	321.3	196.8	140.9	101.8
Viscosity: SSU at 210° F.	53.5	47.8	42.9	40.1
Viscosity Index	97.0	116.9	94.3	119.2
Engler Volatility:				
5%-----	829	823	734	734
50%-----	875	866	787	771

Part B.—A lubricating oil composition was prepared by blending 61.5% 140 SEN thermal diffusion refined oil (hot wall fraction), and 25.5% 300 SEN thermal diffusion refined oil (hot wall fraction). This blend has a 5% Engler volatility at 739° F. and a 50% Engler volatility at 803° F. To this was added 9% of a heavy oil known as 78 SEB (solvent extracted brightstock) having a viscosity index of 96 and viscosities of 725.8 and 75.0 SSU at 100° F. and 210° F., respectively, and 4% high molecular weight polymeric viscosity index improver (2% Acryloid 763 and 2% of a Du Pont PL-164B or LOA-565 as defined heretofore), the percentages being by volume. The viscosities and viscosity index of this oil composition are given in Table II.

Part C.—The oil composition thus prepared was compared with five commercial triple branded SAE 5W-20 oils identified anonymously herein as oils A, B, C, D and E. Oils A, B, C and D are prepared in accordance with the prevailing practice of blending about 8 to 15% by volume of polymeric viscosity index improver with a relatively thin base oil so as to obtain an oil composition of optimum viscosity characteristics at the expense of high volatility and high consumption. Oil E is an oil prepared by blending a thicker base oil with about 8 to 15% by volume of polymeric viscosity index improver in order to obtain a less volatile oil composition at the expense of high viscosity at low and starting temperatures.

In order to properly compare the five commercial oils with the oil of the example prepared in accordance with the invention, the viscosities at 0° F. and 300° F. were obtained by extrapolation from the measured viscosities at 100 and 210° F. Oil consumption figures were obtained by subjecting all of the oils in rotation to ordinary driving conditions in a fleet of automobiles and these figures were in effect checked by determinations of the temperatures at which 5 and 50% of the compositions were volatilized and also a determination of the percentage of lubricant remaining after subjecting a 0.15 mm. film thereof to a temperature of 300° F. for two hours in a forced draft oven. The higher the residue

5

6

remaining from this film test, the better the oil is with respect to engine wear and rate of oil consumption. The data from these tests is given in Table II.

Table II

	Oil Composition of Parts A and B	Oil A	Oil B	Oil C	Oil D	Oil E
V.I.-----	148.8	150.1	155.4	153.5	152.1	121.1
Measured Viscosity, SSU:						
100° F.-----	194.7	166.8	160.8	167.3	150.8	224.7
210° F.-----	52.56	49.11	49.4	50.11	47.46	50.37
Extrapolated Viscosity, SSU:						
0° F.-----	4,300	3,900	3,200	3,300	3,100	10,800
300° F.-----	38.8	37.3	37.6	38.1	36.9	37.2
Engler Volatility: ° F.						
5%-----	739	675	665	647	680	728
50%-----	803	775	745	762	775	793
Thin Film Evaporation, Percent Lubricant Remaining						
72	56.8	38.2	34.6	62.1	75.3	
Average Oil Consumption, qts./1,000 miles	1.03	1.55	1.49	1.41	1.54	1.05

The data in this table shows that the viscosity, consumption and volatility characteristics of the oil of the invention could not be duplicated in any one of the five competitive oils tested. The volatility of the thermal diffusion refined oils before addition of the viscosity index improver is substantially the same as indicated for the final blend.

Oils A through D are significantly inferior to the oil composition prepared as described in Parts A and B with reference to oil consumption and volatility. The temperatures at which 5 and 50% volatilize are considerably lower than for the oil of the invention. The percentages of thin film remaining are appreciably lower, and the consumption in terms of quarts per 1000 miles are substantially higher, than the corresponding figures for the oil composition of the invention.

Comparison of the oil of the invention with oil E, on the other hand, shows that while the volatility and characteristics of the oils are approximately equal, the viscosity index is considerably lower. The high viscosities of oil E at 100° F., and particularly at 0° F., indicate poor cold weather starting characteristics.

Only the oil prepared in accordance with the invention has the hitherto elusive and desirable combination of high viscosity index, low low-temperature viscosity, low volatility and minimal loss of viscosity resulting from shear breakdown.

It is to be understood that numerous modifications will readily become apparent to those skilled in the art upon reading this description. All such modifications are intended to be included within the scope of the invention as defined in the appended claim.

We claim:

A high viscosity index, low viscosity, low volatility, motor oil composition having a viscosity below about 200 SSU at 100° F. and a viscosity of at least 50 SSU at 210° F.; a viscosity index of at least 140; and a volatility at atmospheric pressure of less than 5% at about 735° F. and less than 50% at 800° F., said composition consisting essentially of (1) at least 80% by volume of a thermally diffused mineral oil obtained by subjecting a solvent extracted mineral oil having a viscosity index of between 95 and 105 to liquid thermal diffusion under conditions including a temperature gradient, an area over which it is imposed, a spacing between the hot and cold walls, and a flow rate to produce a hot wall fraction having a viscosity index of between 115 and 130, and (2) a maximum of 5% by volume of a high molecular weight polymer viscosity index improver.

References Cited in the file of this patent

UNITED STATES PATENTS

2,489,281	Foebr	Nov. 29, 1949
2,492,789	Evans et al.	Dec. 27, 1949
2,541,070	Jones et al.	Feb. 13, 1951
2,541,071	Jones et al.	Feb. 13, 1951
2,694,685	Bartlett	Nov. 16, 1954
2,756,197	Thorpe et al.	July 24, 1956

OTHER REFERENCES

Georgi: Motor Oil and Engine Lubrication, pub. by Reinhold Pub. Corp., N.Y., 1950, pages 150 and 151.
Kalichevsky: Modern Methods of Refining Lubricating Oils, pub. by Reinhold Pub. Corp., N.Y., 1938, p. 20.
Chemical Refining of Petroleum, Kalichevsky et al., Reinhold Pub. Corp., N.Y., 1942, 2nd ed., page 413.