(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 July 2011 (28.07.2011)

PCT

(10) International Publication Number
WO 2011/089259 A1

(51) **International Patent Classification**:
C10M 145/14 (2006.01)

(21) **International Application Number**:
PCT/EP2011/050943

(22) **International Filing Date**:
25 January 2011 (25.01.2011)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
2010-013474 25 January 2010 (25.01.2010) JP
2011-010286 20 January 2011 (20.01.2011) JP

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

WO 2011/089259 A1

(54) **Title**: LUBRICATING OIL COMPOSITION

(57) **Abstract**: Lubricating oil composition comprising a base oil having a kinematic viscosity at 1000C in the range of from 3 to 6 mm^2/s and not less than 18% by mass of flowability improver in which the peak-top temperature measured by DSC is not less than 13°C lower than the crystallisation onset temperature measured by DSC of the aforementioned base oil, wherein the lubricating oil composition has a kinematic viscosity at 1000C in the range of from 9.3 to 12.5 mm^2/s, a viscosity index of not less than 200, a pour point of -40°C or lower, and a flash point of not less than 200°C. The lubricating oil composition of the present invention satisfies practical performance requirements for all of viscosity index, low-temperature flowability and flash point.

Lubricating Oil Composition

Technical Field of the Invention

The present invention relates to a lubricating oil composition having a high viscosity index, excellent low-temperature flowability, and a high flash point, and which can be satisfactorily used as a hydraulic oil, turbine oil, compressor oil, machine-tool lubricating oil, gear oil and so on.

Background of the Invention

In lubricating oils such as hydraulic oils used in automobiles and machine tools, the viscosity is generally lower the higher the temperature, but it is desirable in practice that as far as possible there should be no variation in viscosity over a wide range from low temperatures to high temperatures. The method of improving the temperature dependence of the viscosity by adding high molecular compounds known as viscosity index improvers to lubricating oils is therefore widely carried out. The viscosity index (VI) is an indicator of the resistance to change in viscosity due to temperature change, and the higher its value the smaller the change in viscosity due to temperature change. From the standpoint of energy conservation, a desirable VI is regarded as being not less than 180, but more preferably not less than 200. For example, Japanese laid-open Patent 2009-96995, which is based on the Inventors' work discloses a hydraulic oil for use in construction machinery with a viscosity index of 200 to 220.

In devising a way to improve the VI, merely increasing the amount of viscosity index improver added will mean some loss in low-temperature flowability, and

there is also the problem that the domain of temperature use will be limited. But ways of combating the problem with low-temperature flowability have been considered, by using additives and low-viscosity base oils. There have been various types of research on additives with a view to improving low-temperature flowability. For example, Japanese Laid-open Patent 2004-352946 has disclosed a pour-point depressant for hydrocarbon oils which has better pour-point depressing capability than products of the prior art through satisfying specified conditions for its composition.

However, there are many and various kinds of additives intended to improve low-temperature flowability (referred to hereafter as flowability improvers). On the one hand, because the base oils of lubricating oil compositions to which flowability improvers are added are manufactured under various manufacturing conditions depending on the raw materials and plant apparatus, there are naturally many and various kinds of these. However, as to whether they do offer the characteristics expected of a lubricating oil composition to which a flowability improver has been added, given that it depends on a suitable combination of flowability improver and base oil and there are no specific ways to determine the optimal flowability improver for the base oil, the present situation is that various tests are carried out on various combinations of base oil and flowability improver, and the flowability improver is selected by reference to the results thereof. There have therefore been problems in that the selection of which flowability improver is best used with a desired base oil requires time and money and is considerably influenced by the experience of the person making the selection.

On the other hand, methods of using low-viscosity oils to improve low-temperature flowability have also been under consideration. However, in this case, although no problems arise with the selection of a flowability improver, there have been problems in that the flash point decreases, and as a result there have been increased complications as regards storage due to fire safety regulations, and problems as regards safety when handling. Also, given that the base oil has a low viscosity, there have been problems in that the requisite amount of viscosity index improver increases, which increases costs, and the polymers which make up the viscosity index improver also end up shearing.

In other words, in the blending methods used hitherto, when costs and so on are taken into account, it has been difficult to reconcile in a suitable way all the factors of viscosity index, low-temperature flowability and flash point, so that there have been no lubricating oil compositions which satisfy the practical requirements for all of these factors, viscosity index, low-temperature flowability and flash point. In the case of hydraulic oils in particular, it has been difficult to satisfy the provisions for low-temperature use of JCMAS HK P041.2004, which is the standard for hydraulic oils used in construction, and there has been nothing which satisfies the performance requirements thereof.

The aim of this invention is therefore to offer a lubricating oil composition which will satisfy the practical performance requirements as regards all of viscosity index, low-temperature flowability and flash point.

Summary of the Invention

According to the present invention there is provided

a lubricating oil composition comprising a base oil having a kinematic viscosity at 100°C in the range of from 3 to 6 mm^2/s and not less than 18% by mass of flowability improver having a peak-top temperature measured by DSC of not less than 13°C lower than the crystallisation onset temperature measured by DSC of the base oil, wherein the lubricating oil composition has a kinematic viscosity at 100°C in the range of from 9.3 to 12.5 mm^2/s, a viscosity index of not less than 200, a pour point of -40°C or lower, and a flash point of not less than 200°C.

Detailed Description of the Invention

Lubricating oils, including hydraulic oils, are mostly classified into Class III Petroleum and Class IV Petroleum of Hazardous Materials Category IV in fire-safety laws. In the case of a Class III Petroleum of Category IV, the classification criterion is a flash point of not less than 70°C but less than 200°C, and in the case of a Class IV Petroleum of Category IV a flash point of not less than 200°C. The lubricating oil composition of this invention also requires the flash point to be not less than 200°C. Also, taking into account the broad range of various applications, the kinematic viscosity at 100°C must be within the scope of SAE30 of the SAE viscosity classification, or more specifically from 9.3 to 12.5 mm^2/s.

The term “DSC” as used herein means differential scanning calorimetry. The measurements may be taken by methods known in the art. There is no special limitation, and it is possible, for example, to use the following conditions.

Apparatus used: DSC6200 (commercial name, made by SII Ltd)

Atmosphere: no gas purge

Sample amount: 8 mg to 10 mg

Temperature conditions (heat history removal): After holding for 2 minutes at 50°C, holding for 2 minutes at -60°C, then holding for 5 minutes again at 50°C

Temperature conditions (evaluation): dropping from 50°C to -60°C at 20°C/minute

Sample pans: Sealed aluminium pans

Reference sample: α-aluminium oxide

Temperature correction samples: Sn, In, n-tridecan.

The term “Crystallisation onset temperature” as used herein means the temperature, in the transitions due to change of heat flow relative to the temperature measured by DSC, when it begins a transition which is different from the previous one, and it is obtained by the method described in JIS K 7121 9.2 “Methods of Obtaining Temperature of Crystallisation, Extrapolated Crystallisation Onset Temperature”. It may, for example, also be taken as the temperature when the measured heat flow becomes greater than 0, but if the changes over time of the amount of heat put out are small, in other words if the period the heat is put out is long and a broad peak appears, or if the changes over time for the amount of heat put out are large, in other words if the temperature period the heat is put out is short and a sharp peak appears, there is a risk that the influence on flowability improvement will vary. Therefore, the crystallization onset temperature is preferably taken as the intersection of the tangent of the point of inflection in the transition due to change of heat flow relative to temperature measured by DSC and the axis line which shows the measured temperature.

The term “peak-top temperature” as used herein means

the temperature where the heat flow is largest in the transition due to change in heat flow relative to the temperature measured by the aforementioned DSC.

According to this invention, it is possible to satisfy the practical requirements regarding lubricating oil compositions by selecting a suitable flowability improver for a desired base oil through the crystallisation onset temperature and the peak-top temperature as measured by DSC of the base oil and flowability improver. More specifically, it is possible to achieve a viscosity index of not less than 200, a pour point of -40°C or lower, and a flash point of not less than 200°C.

Furthermore, in the blending methods of the prior art, depending on the performance of the base oil, there have been cases of not satisfying the requirements even with high-performance flowability improvers, but according to this invention it is possible easily to select a suitable combination by measuring the crystallisation onset temperature of the base oil measured by DSC and the peak-top temperature of the flowability improver.

However, if the pour point is being reduced, it is only natural that it is preferable to use a base oil and a flowability improver where both have a low pour point, but it has already been said that there is a problem in that this invites a reduction of the flash point in low-viscosity base oils with a low pour point. Also, using a base oil and a flowability improver with low pour points involves an increase in cost. However, excessive low-temperature flowability is not necessary, and if it gives performance to a degree that matches the consumer's requirements, specifically, say, a pour point of about -

40°C, it can withstand use well enough. The lubricating oil composition of this invention can be blended by taking this sort of problem into account. Specifically, it is possible first to determine a base oil in order to clear the target pour point, for example -40°C, and, taking the crystallisation onset temperature thereof as the criterion, to pare down candidates for the flowability improver to be used, so that it is possible to select an ideal flowability improver which benefits cost and necessary performance.

Furthermore, once the crystallisation onset temperature and peak-top temperature of the flowability improver have been measured by DSC, it is possible to use them for selection work thereafter, so that if it is decided to reflect this in selection work thereafter, tests for selection itself are not needed, and it is not necessary to make the selection of the test object on the basis of experience. Consequently, this brings the advantage that selection of the desired base oil and ideal flowability improver can be made easily and accurately without being influenced by the experience of the selector.

Furthermore, as regards a base oil mixture mixed in any proportions, there is the advantage that it is possible to obtain the crystallisation onset temperature thereof by calculation, using the crystallisation onset temperatures of the individual base oils. Normally, base oils are marketed with viscosities such as SAE10, SAE20, SAE30 and SAE40, but when incorporating additives the need arises to regulate the viscosities by blending a plurality of base oils with different viscosities as appropriate to the viscosities of the additives, so that there have been many base oil mixtures. Therefore, in the

past, as regards the finally blended product, there has been the need to confirm the flowability again. In contrast, in this invention if the crystallisation onset temperatures of the base oils to be used have been measured in advance, it is possible, by exploiting their additivity, to calculate the crystallisation onset temperature of the base oil mixture mixed in whatever proportions, by using the crystallisation onset temperatures of the individual base oils. With regard to the calculated crystallisation temperature, by selecting flowability improvers where the peak-top temperature is not less than 13°C lower, it is possible to assume flowability at -40°C.

It is necessary that the kinematic viscosity @ 100°C for the base oil is in the range of from 3 to 6 mm^2/s. If it is less than 3 mm^2/s, a fire-prevention problem will arise owing to a reduction in the flash point and a problem will arise with a reduction in shear stability. If it is greater than 6 mm^2/s, the pour point will increase and there will be a problem in that low-temperature flowability will be degraded.

For the base oil in the lubricating oil composition of the present invention it is possible to use the mineral oils, synthetic oils or mixtures thereof used in normal lubricating oils, and it possible to use, singly or as mixtures, base oils which belong to Group I, Group II, Group III, Group IV and Group V of the API (American Petroleum Institute) base oil categories.

Group I base oils include, for example, paraffinic mineral oils obtained by a suitable combination of refining processes such as solvent refining, hydrorefining, and dewaxing in respect of lubricating oil fractions obtained by atmospheric distillation of crude

oil. The viscosity index should be in the range of from 80 to less than 120 and preferably in the range of from 95 to 110. The kinematic viscosity at 40°C should preferably be in the range of from 2 to 680 mm^2/s and even more preferably in the range of from 8 to 220 mm^2/s. Also, the total sulphur content should be less than 1.5% by mass and preferably less than 1.0% by mass. The total nitrogen content should be less than 50 ppm and preferably less than 25 ppm. In addition, oils with an aniline point in the range of from 80 to 150°C and preferably in the range of from 90 to 120°C should be used.

Group II base oils include, for example, paraffinic mineral oils obtained by a suitable combination of refining processes such as hydrocracking and dewaxing in respect of lubricating oil fractions obtained by atmospheric distillation of crude oil. Group II base oils refined by hydrorefining methods such as the Gulf Company method have a total sulphur content of less than 10 ppm and an aromatic content of not more than 5% and so can be used for this invention. The viscosity of these base oils is not specially limited, but the viscosity index should be in the range of from 80 to less than 120 and preferably in the range of from 100 to 120. The kinematic viscosity at 40°C should preferably be in the range of from 2 to 680 mm^2/s and more preferably in the range of from 8 to 220 mm^2/s. Also, the total sulphur content should be less than 300 ppm, preferably less than 50 ppm and more preferably less than 10 ppm. The total nitrogen content should also be less than 10 ppm and preferably less than 1 ppm. In addition, oils with an aniline point in the range of from 80 to 150°C and preferably in the range of from 100 to 135°C should be used.

Group III base oils include, for example, paraffinic mineral oils manufactured by a high degree of hydrorefining in respect of lubricating oil fractions obtained by atmospheric distillation of crude oil, base oils refined by Isodewaxing which dewaxes and substitutes with isoparaffins GTL (gas-to-liquid) waxes synthesised by the Fischer-Tropsch process in the technology of making liquid fuels from natural gas, and waxes produced by dewaxing processes, and base oils refined by the Mobil wax isomerisation process. These are also suitable for use in this invention. The viscosity of these base oils is not specially limited, but the viscosity index should be not less than 120, and preferably in the range of from 120 to 140. The kinematic viscosity at 40°C should preferably be in the range of from 2 to 680 mm^2/s and more preferably in the range of from 8 to 220 mm^2/s. Also, the total sulphur content should be less than 100 ppm and preferably less than 10 ppm. The total nitrogen content should also be less than 10 ppm and preferably less than 1 ppm. In addition, oils with an aniline point in the range of from 80 to 150°C and preferably in the range of from 110 to 135°C should be used.

As examples of Group IV base oils mention may be made of the polyolefins. Said polyolefins include polymers of various olefins and hydrides thereof. Any olefin may be used, and as examples mention may be made of ethylene, propylene, butene and α-olefins with 5 or more carbon atoms. In the manufacture of polyolefins it is possible to use one kind or combinations of two or more kinds of the aforementioned olefins. In particular the polyolefins known as poly-α-olefins (PAO) are suitable. The viscosities of these synthetic base oils is not specially limited, but the kinematic viscosity at

40°C should preferably be in the range of from 2 to 680 mm^2/s and more preferably in the range of from 8 to 220 mm^2/s.

Group V base oils are esters and other base oils that do not belong to Groups I to IV.

It is possible to use any of the aforementioned base oils of Groups I to V, but those of Group I, Group II and Group III are especially preferred.

Table 1 shows typical examples of the properties of the various base oils in the API classification.

Table 1

Class	Sulphur component, mass%		Saturated component. mass %	Viscosity index
Group I	> 0.03	and/or	< 90	80 ~ 120
Group II	≤ 0.03	and	≥ 90	80 ~ 120
Group III	≤ 0.03	and	≥ 90	≥ 120
Group IV	Poly-α-olefins (PAO)			
Group V	Those not belonging to Groups I ~ IV (esters)			

Source: Base Oil Interchangeability Guidelines API Publication 1509, API 13th Ed., Washington D.C. (1995)

Also, it is possible to ensure a pour point of -40°C or lower, a viscosity index of not less than 200 and a flash point of not less than 200°C for the lubricating oil by regulating the kinematic viscosity at 100°C in the range of from 3 to 6 mm^2/s and by adding a flowability improver in which the difference in its peak-top temperature as measured by DSC relative to the crystallisation onset temperature of the base oil as measured by DSC is not less than 13°C. With such a lubricating oil, it becomes possible to offer a hydraulic oil for use in construction which, in particular, has

excellent energy conservation, low-temperature flowability and fire safety.

For the flowability improver it is possible to use polymethacrylates known in the art. However, there are appropriate combinations relative to the base oil, and there are cases where, if there is a mistake in the combination, the desired effect will not be achieved. Table 2 shows, by varying the amount of flowability improver added, the pour points obtained when adding different flowability improvers to a base oil mixture of Base Oil 1 and Base Oil 2 of Table 3 given later (the flowability improvers, both Flowability Improver A and Flowability Improver B in Table 2, were the same as Polymer 2 and Polymer 3 mentioned later). As can be confirmed in Table 2, whereas the pour point in the case where Flowability Improver B has been added is virtually the same independent of the amount added, the behaviour of the pour point in the case where Flowability Improver A has been added is that it rises as the amount added increases. It can thus be seen that, depending on the base oil combined with the flowability improver, a synergistic effect or, in reverse, a detrimental effect, may be manifested. In consequence, it is necessary to select a flowability improver that is suitable for the base oil. Specifically, it is necessary that the peak-top temperature as measured by DSC should be not less than 13°C lower than the crystallisation onset temperature of the base oil as measured by DSC.

Also, the crystallization onset temperature of the fluidity improver used in the present invention is not more than -23°C, preferably not more than -25°C, more preferably not more than -27°C.

In addition, the peak top temperature of the flowability improver is not more than -35°C, preferably not more than -40°C, more preferably not more than -45°C.

The mass-average molecular weight of the fluidity improver is not more than 55,000, preferably less than 54,000, more preferably less than 53,000.

Table 2

Amount of additive wt%	0	1	5	10	15
Flowability Improver A (Polymer 2)					
Kinematic viscosity @ 40°C mm^2/s	17.68	18.81	23.71	31.99	43.65
Kinematic viscosity @ 100°C mm^2/s	3.818	4.092	5.257	7.115	9.517
Pour point °C	-22.5	-45.0	-40.0	-32.5	-32.5
Flowability Improver B (Polymer 3)					
Kinematic viscosity @ 40°C mm^2/s	17.68	18.75	23.41	31.34	42.44
Kinematic viscosity @ 100°C mm^2/s	3.818	4.076	5.174	6.927	9.171
Pour point °C	-22.5	-42.5	-47.5	-47.5	-47.5

Measurement of the properties shown in Table 2 was by the methods given below.

Kinematic viscosity @ 40°C, and kinematic viscosity @ 100°C were obtained in accordance with JIS K 2283 “Crude oil and petroleum products - Determination of kinematic viscosity and calculation of viscosity index”.

Pour point was obtained in accordance with JIS K 2269 “Crude oil and petroleum products - Determination of pour point and cloud point”.

Examples

Lubricating oil compositions were prepared using the base oils shown in Table 3 and the flowability improvers (hereinafter “polymers”) shown in Table 4 below.

Table 3

Values for Base Oil Characteristics

	Base oil 1	Base oil 2	Base oil 3	Base oil 4
Category	Group I	Group II	Group III	Group III
Kinematic viscosity @ 40°C mm^2/s	24.32	12.42	19.64	45.62
Kinematic viscosity @ 100°C mm^2/s	4.59	3.08	4.25	7.6
Viscosity index	102	106	123	133
Pour point °C	-17.5	-25.0	-25.0	-12.5
Crystallisation onset temperature °C	-20.5	-39	-17.6	-18.5
Peak-top temperature °C	-24.1	-52.6	-53.4	-57.6
Flash point °C	216	204	230	260

Table 4

Values for Flowability Improver Characteristics

	Polymer 1	Polymer 2	Polymer 3
Compound type	PMA	PMA	PMA
Molecular weight Mw(mass average molecular weight)	44,000	57,000	52,000
Crystallisation onset temperature °C	-27.9	-20.7	-34.7
Peak-top temperature °C	-49.7	-30.6	-49.9

In Table 4, Polymer 1 was AC812 commercially available from Sanyo Chemical Industries, Ltd., Polymer 2 was Viscoplex 8-200 commercially available from Evonik Degussa Japan Co., Ltd. and Polymer 3 was Viscoplex 8-219 commercially available from Evonik Degussa Japan Co., Ltd.

Measurement of the kinematic viscosities (@ 40°C and @ 100°C) was by the method given below. Measurement of the crystallisation onset temperature, the peak-top temperature and the molecular weight was by the methods given below.

Crystallisation Onset Temperature

The crystallisation onset temperature was obtained in accordance with JIS K 7121 9.2 “Methods of Obtaining Temperature of Crystallisation, (2) Extrapolated Crystallisation Onset Temperature”. The DSC conditions were as follows:

Apparatus used: DSC6200 (commercial name, made by SII Ltd)

Atmosphere: no gas purge

Sample amount: 8 mg to 10 mg

Temperature conditions (heat history removal): After holding for 2 minutes at 50°C,

holding for 2 minutes at -60°C, then holding for 5 minutes again at 50°C

Temperature conditions (evaluation): dropping from 50°C to -60°C at 20°C/minute

Sample pans: Sealed aluminium pans

Reference sample: α-aluminium oxide

Temperature correction samples: Sn, In, n-tridecan.

Peak-Top Temperature

The temperature where the heat flow is largest in the transition due to change of heat flow relative to the temperature as measured by DSC when performing measurement of the crystallisation onset temperature.

Mass Average Molecular Weight

The mass average molecular weight was calculated based on “JIS K7252-1 Plastics Determination of average molecular mass and molecular mass distribution of polymers using size-exclusion chromatography Part 1 General principles”

Apparatus: Shodex GPC-101

Detector: Refractive Index (RI) Detector

Column: KF-G (Shodex) *1, KF-805L (Shodex) *2

Ambient Temperature: 40°C

Carrier Solvent: THF

Carrier Flow rate: 0.8ml/min (Ref. 0.3ml/min)

Standard sample: Shodex Standard (Polystyrene)

Mp = $2.0*10^3$

Mp = $5.0*10^3$

Mp = $1.01*10^4$

Mp = $2.95*10^4$

Mp = $9.60*10^4$

Mp = $2.05*10^5$

Standard curve: cubic equation

Sample concentration: about 2 mass%

Amount of sample injection: 50 µl

The pour point, viscosity and flash point of the prepared lubricating compositions were measured. In addition, calculations were made of the crystallisation onset temperatures and peak temperatures of the base oil mixtures according to the proportions in the base oil mixture, on the basis of the crystallisation onset temperatures and peak temperatures of the individual base oils shown in Table 3. The measured values and the calculated values are shown in Table 5.

Table 5

		Ex. 1 mass%	Ex. 2 mass%	Comp. Ex. 1 mass%	Comp. Ex. 2 mass%	Comp. Ex. 3 mass%	Comp. Ex. 4 mass%	Comp. Ex. 5 mass%
Base oil	Base Oil 1	34.00	46.00	45.75	0	51.00	81.00	82.50
	Base Oil 2	42.50	32.50	33.50	0	21.50	0	0
	Base Oil 3	0	0	0	43.32	0	0	0
	Base Oil 4	0	0	0	33.18	0	0	0
Polymers	Polymer 1	22	0	0	0	0	17.5	0
	Polymer 2	0	0	19.25	22	26	0	0
	Polymer 3	0	20	0	0	0	0	16
Additive	Hydraulic oil package	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Base oil mixture characteristics	Kinematic viscosity @ 100°C mm^2/s	3.65	3.71	3.84	5.43	4.05	4.59	4.59
	Kinematic viscosity @ 40°C mm^2/s	16.46	16.95	17.99	28.01	19.61	24.32	24.32
	Viscosity index	105	104	103	132	104	102	102
Viscosity characteristics	Kinematic viscosity @ 100°C mm^2/s	12.01	12.07	12.13	16.68	17.91	12.02	11.26

	Kinematic viscosity @ 40°C mm^2/s	57.56	59.2	58.82	87.82	95.42	66.16	59.67
Values for DSC	Base oil crystallisation onset temperature °C (check unit)	-30.8	-28.2	-28.3	-17.9	-26.0	-20.5	-20.5
	Polymer crystallisation onset temperature °C (check unit)	-27.9	-34.7	-20.7	-20.7	-20.7	-27.9	-34.7
	Base oil mixture peak-top temperature °C (check unit)	-40.0	-36.0	-36.2	-55.2	-32.7	-24.1	-24.1
	Polymer peak-top Temperature °C (check unit)	-49.7	-49.9	-30.6	-30.6	-30.6	-49.7	-49.9
	BS-Pt	18.9	21.7	2.3	12.7	4.6	29.2	29.4
Values for properties	Pour point °C	-40	-45	-27.5	-27.5	-27.5	-40	-40
	Viscosity index	211	205	211	206	207	181	185
	Flash point °C	210	208	209	230	202	208	216

The crystallisation onset temperatures of the base oil mixtures were values calculated by totalling the crystallisation onset temperatures of each of the base oils by reference to their proportions in the base oil mixture. For example, taking the crystallisation onset temperature of Base Oil A as Ta, the crystallisation onset temperature of Base Oil B as Tb, the proportion of Base Oil A in the mixture as Ra and the proportion of Base Oil B in the mixture as Rb, then Ra + Rb = 1 and the crystallisation onset temperature of the mixture is Ra x Ta + Rb x Tb. A calculation similar to that for the crystallisation onset temperature of the mixture was also done for the peak-top temperature of the base oil mixture.

The same amount of a widely marketed hydraulic oil additives package was added to each example and comparative example. The hydraulic oil package included, as the additives, a metallic detergent, an anti-wear agent, an amine-based anti-oxidant, a phenolic anti-oxidant, a corrosion inhibitor, a defoaming agent and a metal deactivator.

Measurement of the kinematic viscosities (@ 40°C and @ 100°C) and of the pour points shown in Table 5 was by the aforementioned methods. Measurement of the viscosity index was by the method given below.

Viscosity index

Determined in accordance with JIS K 2283 “Crude oil and petroleum products - Determination of kinematic viscosity and calculation of viscosity index”.

Flash point

Determined by the Cleveland open cup method in JIS K 2265 “Crude oil and petroleum products - Determination of flash point”.

As shown in Table 5, Example 1 was a base oil mixture of Base Oil A and Base Oil B blended in the respective proportions of 34.00% by mass and 42.50% by mass. Recalculating on the basis of the mixing proportions by using the individual crystallisation onset temperatures of each (shown in Table 3), the result was -30.8°C. However, the peak-top temperature of the flowability improver (Polymer 1) being used in Example 1 was -49.7°C. The value whereby peak-top temperature of the polymer was subtracted from the crystallisation onset temperature of the base oil (Bs - Pt) was 18.9. Similarly, in Example 2 it was 21.7°C, in Comparative Example 1 it was 2.3°C, in Comparative Example 2 it was 12.7°C, in Comparative Example 3 it was 4.6°C, in Comparative Example 4 it was 29.2°C, and in Comparative Example 5 it was 29.4°C. On the basis of these results it was possible to achieve a pour point of -40°C by adding at least not less than 18% by mass of a flowability improver with a Bs - Pt of not less than 13°C to a base oil having a kinematic viscosity at 100°C in the range of from 3 to 6 mm^2/s.

In other words, in the case of Comparative Examples 1 to 3 where a flowability improver with a Bs - Pt of less than 13°C was added, even though the amount was large the pour point was clearly higher than -40°C. In the case of Comparative Examples 4 and 5, where the amount of flowability improver of Bs - Pt of not less than 13°C added was less than 18% by mass, the viscosity index in both cases was less than 200, and they were clearly not suitable as high-efficiency hydraulic oils. Furthermore, given that the flash point in all of the aforementioned examples and comparative examples was not less than 200°C, they clearly satisfy the flash point

requirements for hydraulic oils used in construction, in addition to the aforementioned requirements for pour point and viscosity index in the case of base oils having a kinematic viscosity at 100° in the range of from 3 to 6 mm^2/s.

C L A I M S

1. Lubricating oil composition comprising a base oil having a kinematic viscosity at 100°C in the range of from 3 to 6 mm^2/s and not less than 18% by mass of flowability improver in which the peak-top temperature measured by DSC is not less than 13°C lower than the crystallisation onset temperature measured by DSC of the aforementioned base oil, wherein the lubricating oil composition has a kinematic viscosity at 100°C in the range of from 9.3 to 12.5 mm^2/s, a viscosity index of not less than 200, a pour point of -40°C or lower, and a flash point of not less than 200°C.

2. Lubricating oil composition according to Claim 1 wherein the crystallization onset temperature of the fluidity improver is not more than -23°C.

3. Lubricating oil composition according to Claim 1 or 2 wherein the peak-top temperature of the fluididty improver is not more than -35°C.

4. Lubricating oil composition according to any of Claims 1 to 3 wherein the mass average molecular weight of the aforementioned fluidity improver is not more than 55,000.

5. Lubricating oil composition according to any of Claims 1 to 4 wherein the base oil is selected from base oils belonging to Group I, Group II, Group III, Group IV and Group V of the API (American Petroleum Institute) base oil categories, and mixtures thereof.

6. Lubricating oil composition according to any of Claims 1 to 5 wherein the base oil is selected from base oils belonging to Group I, Group II and Group III of the

API (American Petroleum Institute) base oil categories, and mixtures thereof.

7. Lubricating oil composition according to any of Claims 1 to 6 wherein the flowability improver is a polymethacrylate.

8. Use of a lubricating oil composition according to any of Claims 1 to 7 as a hydraulic oil, a turbine oil, a compressor oil, a machine-tool lubricating oil or a gear oil.

9. Use of a lubricating oil composition according to any of Claims 1 to 7 for providing improved energy conservation.

10. Use of a lubricating oil composition according to any of Claims 1 to 7 for providing improved low temperature flowability.

11. Use of a lubricating oil composition according to any of Claims 1 to 7 for providing improved fire safety.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/050943

A. CLASSIFICATION OF SUBJECT MATTER
INV. C10M145/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C10M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/197410 A1 (PLACEK DOUGLAS G [US] ET AL) 23 August 2007 (2007-08-23) paragraphs [0114], [0139] - paragraph [0141]; claims 1,2,5-8,10,11-13,16,18-20; table 1	1-11
A	WO 2009/024610 A1 (SHELL INT RESEARCH [NL]; DIXON RICHARD THOMAS [GB]; LUEBBERS MARTIN [D) 26 February 2009 (2009-02-26) page 8; example 1; tables 1,2,3	1-11
A	WO 2006/111211 A1 (ROHMAX ADDITIVES GMBH [DE]) 26 October 2006 (2006-10-26) page 20, line 2 - line 14; example 7; table 3 page 18, line 3 - line 10	1-11

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 March 2011	17/03/2011

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1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/050943

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