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Examples of Viscosity Measurement With Sine-Wave Vibro Viscometer SV-10 Concerning Typical Lubricants (Viscosities at 40°C and 100°C in Particular)

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Introduction

The results of viscosity measurement with the sine-wave vibro viscometer SV-10 concerning four types of lubricants provided from a customer as sample will be described hereinafter.

Sample and Instrument

1. Sample

Viscosities of four typical lubricants, described below, provided by a customer for determining viscosity were measured.

1: Hydraulic oil, standard type
2: Diesel engine oil, standard type
3: Automatic transmission fluid, luxurious type
4: Gasoline engine oil

2. Instrument

The sine-wave vibro viscometer SV-10 (made by A&D Co., Ltd.), which measures viscosity by vibrating its sensor plates immersed in a sample at relatively low frequency (approx. 30Hz) of sine-wave, was used as the measuring instrument of viscosity. Since the instrument produces low frequency and very small amplitude (approx. 0.4mmpp), it does not impair the composition of the sample unlike a rotational viscometer. The instrument can measure viscosity of a sample according to the temperature of the entire sample due to the small thermal capacity of the sensor plate, and it is also possible to perform real-time measurement of the correlation between the viscosity and temperature of the sample. The instrument can measure viscosities ranging from 0.3mPa·s to 10000mPa·s (10Pa·s) with no need to change the sensor plates during the measurement, thus continuous measurement of viscosity is possible from low to high viscosities.

Method

This viscosity measurement, as shown in Fig.1, was performed while observing the behavior displayed in real-time on the screen of a personal computer connected to the viscometer SV-10 via RS232C interface.

The procedure of the viscosity measurement was as follows; after completely washing and drying a 200ml glass beaker, an unopened tank of the sample was rolled over several times slowly enough to agitate the content before approx. 150ml of the sample was poured into the beaker, and then viscosity measurements were performed on a hot stirrer.

1. The height of the sensor unit (head) of SV-10 was adjusted to fix the sensor plates in the prescribed position.
2. The hot stirrer was rotated to stir the sample slowly, preventing it from making viewable ruffles on the liquid surface.
3. The viscosity measurement was started at room temperature and the viscosity was measured for approx. five minutes.
4. The heater of the hot stirrer was turned on and measurement was continued while heating the sample until the temperature of the sample reached approx. 110°C.
5. The hot stirrer was turned off when the temperature of the sample reached approx. 110°C, and the sample was left at room temperature to naturally cool to approx. 30°C while the viscosity continued to be measured.

In brief, for each sample of the four lubricants, a continual viscosity measurement was performed following the above procedure 1 to 5 while stirring slowly and continually changing the temperature of the sample from approx.

25°C (room temperature) to 110°C and to approx. 30°C (around room temperature) in order to burden the sample with a temperature load on heating, followed by cooling.
At the same time, the relative dial setting position of the hot stirrer's revolving speed was not changed during the measurement. The data about the viscosity and temperature of the sample during the measurement was transmitted in real-time to the computer via RS232C, and sampling was made at intervals of five seconds.

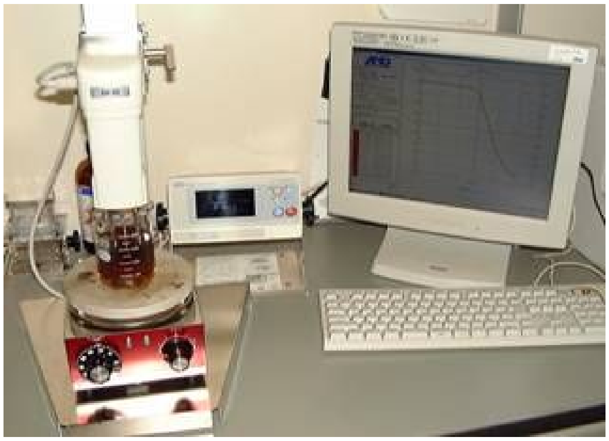

Fig. 1 View of Viscosity Measurement

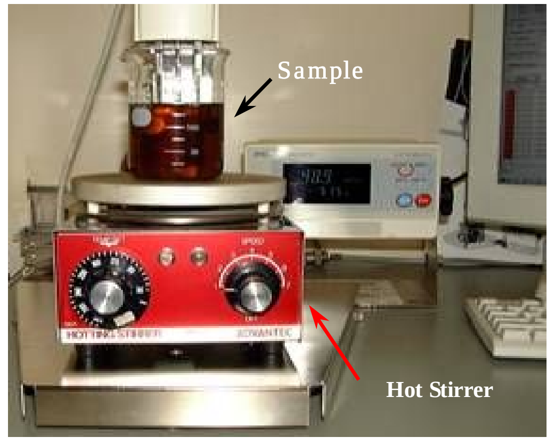

Fig. 2 Viscosity Measuring Unit

Result and Review

Table 1 shows the viscosities (readings of SV-10) of the four lubricants measured at 40°C and 100°C on heating and cooling.
The sine-wave vibro viscometer SV-10, under its measuring principles, produces a relative indication of the measured viscosity (instrument reading) as a product of the specific gravity and the viscosity. Therefore, an absolute viscosity can be obtained by dividing the viscosity shown in Table 1 by the specific gravity of the sample.
Additionally, a kinetic viscosity can be obtained by dividing the absolute viscosity, which is calculated as above, by the density (here, the same as the specific gravity) of the sample.

Table 1. Viscosities (readings of SV-10) of the four lubricants measured at 40°C and 100°C on heating and cooling

SV-10 Viscosity Measurement Values (mPa·s)	40°C			100°C		
	Heating	Cooling	Average	Heating	Cooling	Average
1: Hydraulic oil, standard type	39.2	38.5	**38.9**	5.56	5.80	**5.68**
2: Diesel engine oil, standard type	85.1	83.2	**84.2**	9.32	9.37	**9.35**
3: Automatic transmission fluid, luxurious type	21.3	21.3	**21.3**	5.11	5.34	**5.23**
4: Gasoline engine oil	49.5	48.8	**49.2**	8.11	8.17	**8.14**

For each sample, Figures 4 to 7 show the graphs, which were created with the graph function of the communication software WinCT-Viscosity, equipped as standard with SV-10, of the continual behavior of the viscosity and temperature during the measurement.
Figs.4a&b show the graphs of the viscosity and temperature of Hydraulic oil, standard type while being stirred slowly as well as heating from 25°C room temperature to 110°C, followed by cooling naturally to 30°C again (around room temperature). Fig.4a, the graph on the left, shows the elapsed time plotted along the horizontal axis and the viscosity (in red) and the temperature (in blue) plotted along the vertical axes on the left and right respectively. The blue curve on the graph shows the process of change in temperature; the process of heating followed by cooling appears in the shape of a mountain. On the other hand, the viscosity (in red) appears in a U-shaped curve, which is in inverse proportion to the temperature curve. Fig.4b, the graph on the right, shows the temperature plotted along the horizontal axis and the viscosity plotted along the vertical axis in order to define the correlation between the viscosity and temperature. As shown in the graph, a nonlinear inverse correlation between

the viscosity and temperature can be observed. In addition, since the curves on both heating and cooling processes are almost superposed, it is considered an excellent repeatability of viscosity measurement with the sample and SV-10's measuring system.

In the same way, Figs.5a and 5b show the results of Diesel engine oil, standard type, Figs.6a and 6b show those of Automatic transmission fluid, luxurious type), and Figs. 7a and 7b show those of Gasoline engine oil.

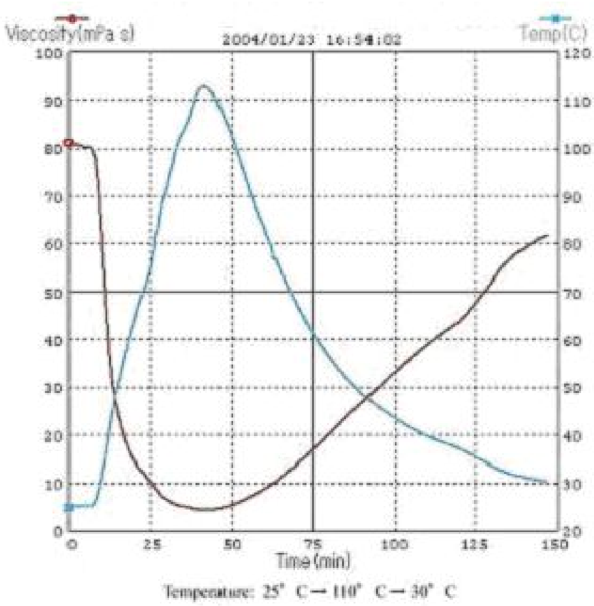

Fig.4a Viscosity Change (in red) in Relation to Temperature Change (in blue) of Hydraulic oil, standard type (Changes With Time)

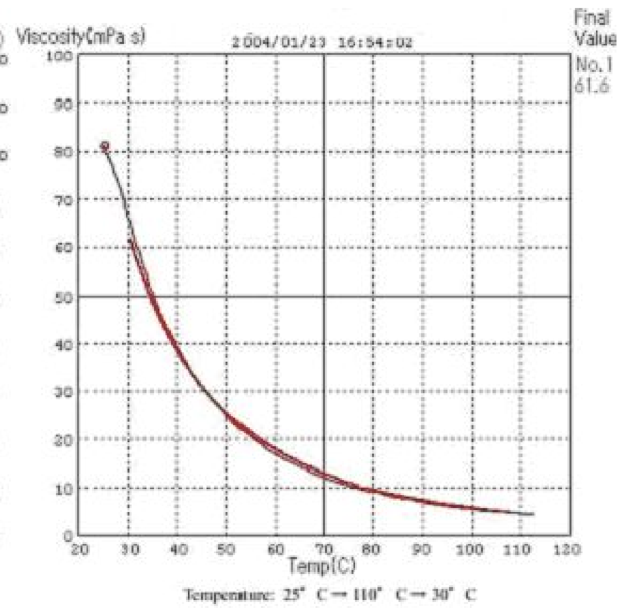

Fig.4b Correlation Between the Temperature and Viscosity of Hydraulic oil, standard type

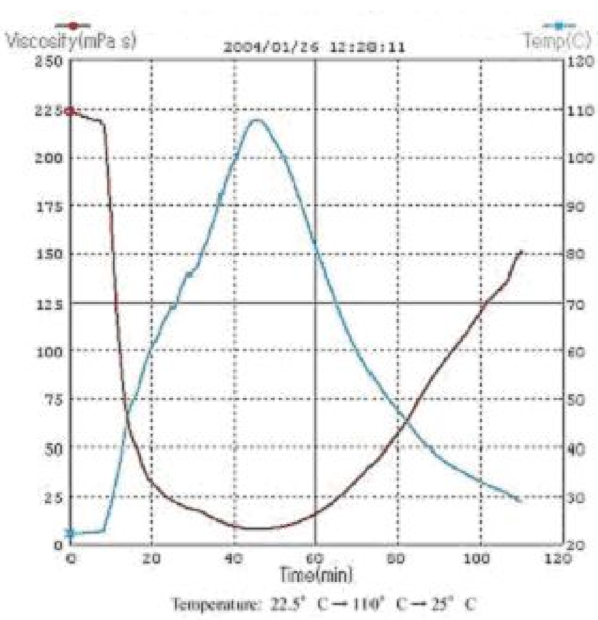

Fig.5a Viscosity Change (in red) in Relation to Temperature Change (in blue) of Diesel engine oil, standard type (Changes With Time)

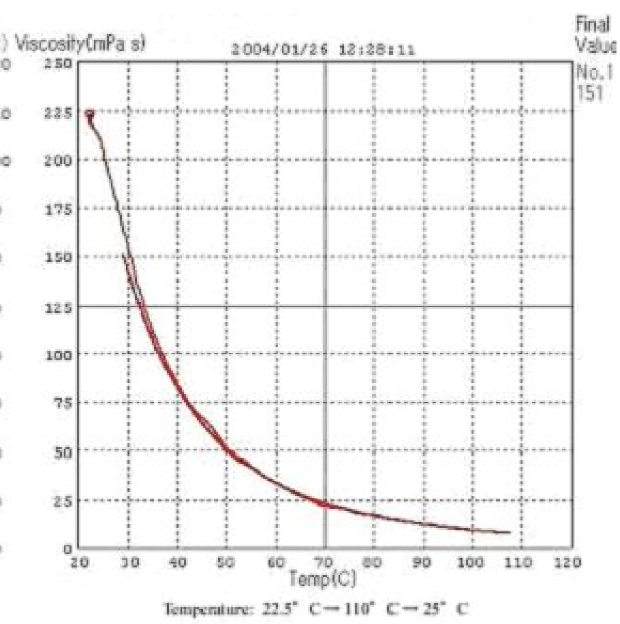

Fig. 5b Correlation Between the Temperature and Viscosity of Diesel engine oil, standard type

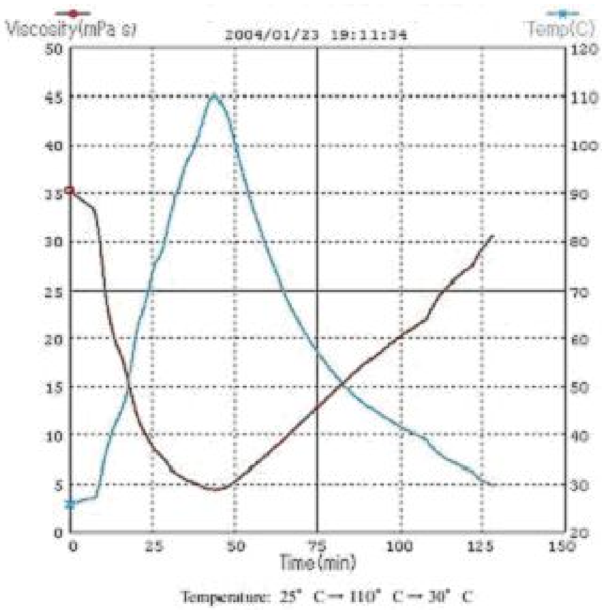

Fig.6a Viscosity Change (in red) in Relation to Temperature Change (in blue) of Automatic Transmission Fluid, Luxurious Type (Changes With Time)

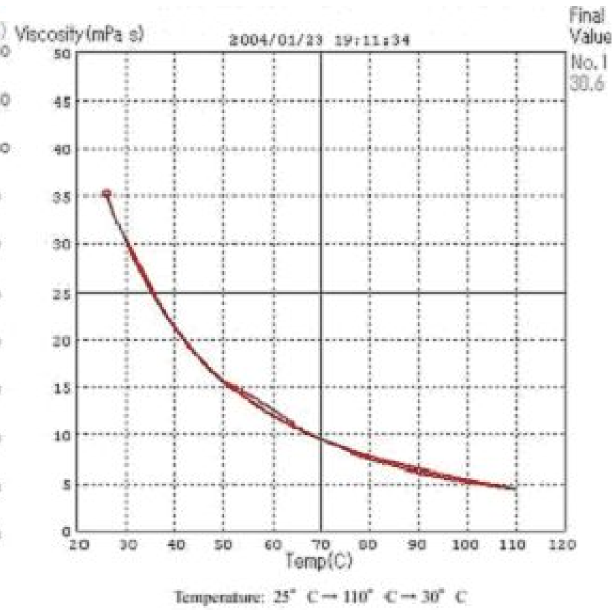

Fig.6b Correlation Between the Temperature and Viscosity of Automatic Transmission Fluid, Luxurious Type

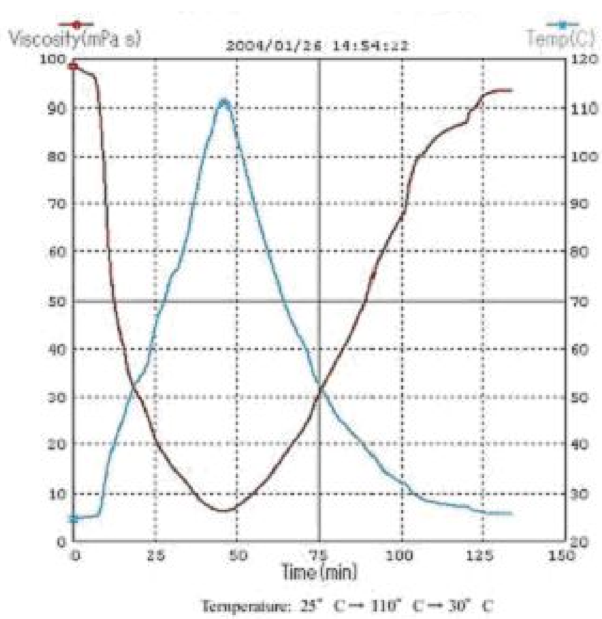

Fig.7a Viscosity Change (in red) in Relation to Temperature Change (in blue) of Gasoline Engine Oil (Changes With Time)

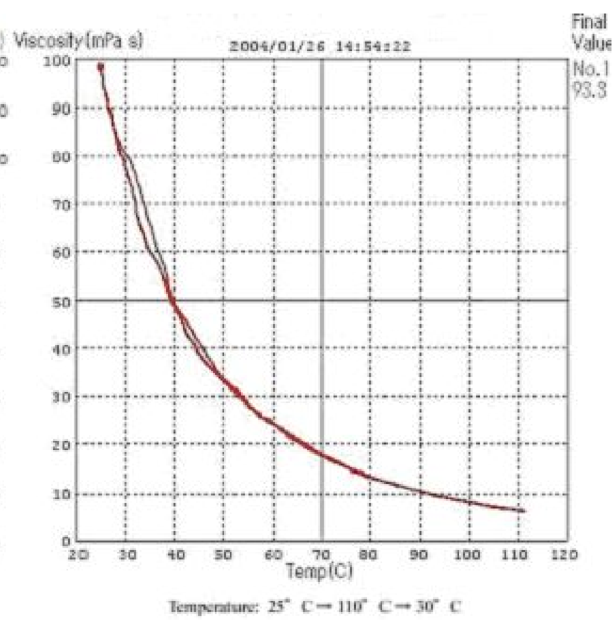

Fig.7b Correlation Between the Temperature and Viscosity of Gasoline Engine Oil

Conclusion

1. Viscosities of four typical types of lubricants were measured with the viscometer SV-10.

2. The facts that the correlation between the viscosity and temperature of each sample is in a nonlinear inverse correlation on both the heating and cooling processes and that during the processes viscosity at the same temperature shows almost the same value, which is considered an excellent repeatability, were confirmed.

3. Since excellent measurement repeatability is observed as described in 2 above, the viscosities of each sample at representative temperatures 40°C and 100°C are shown in Table 1 as a summary of the results. It is considered that the significant individual differences between the samples can be distinguished by measuring the viscosity of the four lubricants at the above mentioned two points of temperature using the sine-wave vibro viscometer SV-10, although significant difference tests should be repeated a greater number of times with more samples before making such determination.