ASPHALT

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Hardening effect during heating of Indolco asphalts

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Summary

Asphalt requires heating at high temperature for different periods during its processing at the time of application. Both temperature and duration of heating affect the preliminary hardening which is caused by loss of volatiles and oxidation. The heat test can predict the order of hardening expected during particular conditions of application if the actual conditions are simulated well in the test. Three grades of indolco asphalt were heated under different conditions and the effect on their hardness was measured in terms of change in standard penetration and softening point. These results can form a basis of selecting the grade of asphalt as well as the heating conditions for particular application.

Introduction

Asphalt has to be heated to high temperatures for mixing and other operations during application. Ageing asphalt is known to start during processing while most of it occurs during its long term exposure in field service. Though the first stage is short in duration, its effects may be far reaching than during the outdoor exposure where the effects are slow due to lower temperatures. This ageing of asphalt during the first stage is not negligible but substantial as has already been proved earlier (1, 2). Apart from its interactions with other ingredients and aggregates, asphalt in itself undergoes a number of chemical and physical changes when heated to high temperature for application (3-4). This step has to be carried out very cautiously as there have been reports where an ageing equivalent to many years of field exposure (6) had occurred due to excessive heating of asphalt at high temperature.

Actual degree of hardening envisaged during heating of asphalt for application can be predicted by studying the hardening behaviour under desired conditions. Three common grades of Indolco asphalt, viz. 80/100, 60/70 and 30/40, were, therefore, heated at high temperatures for different periods which are common occurrance in their application and the changes were followed by studying the changes in the hardness and softening point.

EXPERIMENTAL PROCEDURE

Three grades of Indolco asphalt (80/100, 60/70 and 30/40) were received from Indian Oil Corporation Ltd. (Madras Refinery). These asphalts were characterised for their chemical and physical properties (7). One kilogram sample of each asphalt was heated at 200 ± 5°C for 7.5 hours. About 250 gram sample was taken out from this bulk at 2.5, 5.0 and 7.5 hours and allowed to cool in air. Similar samples were heated at 225 ± 5°C, 250 ± 5°C, 275 ± 5°C and 300 ± 5°C and the samples were drawn after 2.5, 5.0 and 7.5 hours duration. Since it has been reported earlier (8) that during blowing practically most of the changes in penetration occurred during first eight hours, the period of heating in this study was restricted to 7.5 hours only.

Standard penetration and softening point (ring and ball) of all the control and heated samples were determined according to relevant Indian Standard Specifications (9, 10). Changes in degree of penetration and softening point brought about as a result of heating at high temperatures are depicted in figures 1 and 2 respectively. The maximum percentage decrease in penetration and percentage increase in softening point as a result of heating are given in table 1. Increase in hardness, i.e. ratio of penetration before heating to that of after heating, is computed in Table 2.

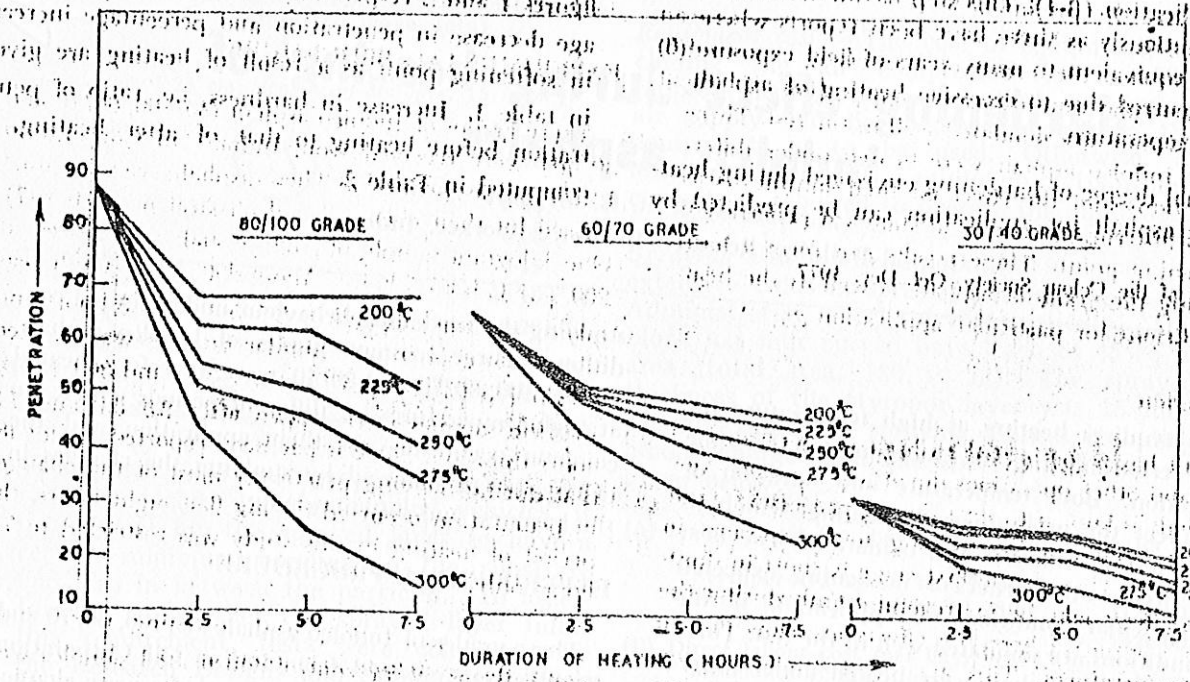

FIG. 1 EFFECT OF HEATING ON PENETRATION OF ASPHALTS

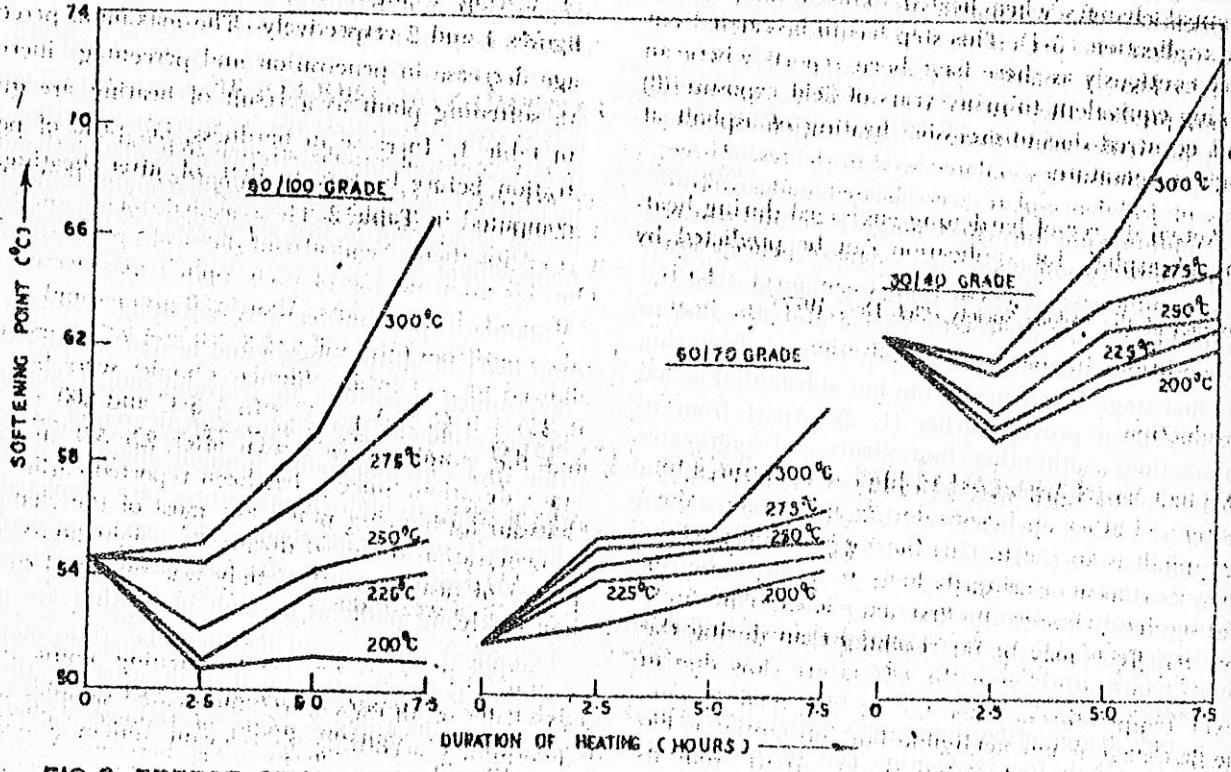

FIG. 2 EFFECT OF HEATING ON SOFTENING POINT OF ASPHALTS

TABLE 1

Effect of Heating on Penetration and Softening Point of Asphalt

Properties	Grade	Temperature of heating (for 7.5 hours) °C				
		200	225	250	275	300
Percent decrease in penetration	80/100	23.8	40.9	53.4	60.2	82.9
	60/70	27.7	30.8	38.5	44.6	63.1
	30/40	34.4	37.5	43.6	50.0	65.6
Percent increase in softening point	80/100	6.6	0.9	1.3	10.6	22.0
	60/70	(–) 5.0	(–) 6.2	7.1	9.3	10.0
	30/40	0.5 (–)	0.5	1.2	3.8	15.0

TABLE 2

Change in Hardness of Asphalt (Po/P)

Tempera- °C	Period hrs.	Hardness* 80/100	60/70	30/40
200	2.5	1.31	1.22	1.18
	5.0	1.31	1.30	1.22
	7.5	1.31	1.38	1.52
225	2.5	1.39	1.21	1.22
	5.0	1.42	1.36	1.28
	7.5	1.69	1.44	1.60
250	2.5	1.57	1.27	1.33
	5.0	1.72	1.44	1.40
	7.5	2.14	1.62	1.77
275	2.5	1.69	1.30	1.45
	5.0	1.91	1.59	1.52
	7.5	2.51	1.80	2.00
300	2.5	2.00	1.48	1.60
	5.0	3.52	2.03	2.00
	7.5	5.87	2.71	2.90

* Hardness — Ratio of penetration before heating to that of after heating.

RESULTS AND DISCUSSION

The three grades of asphalt (i.e. 80/100, 60/70 and 30/40) had initial penetration of 88, 65 and 32 respectively. As expected, there is a general decrease in penetration value after heating (figure 1). The role of temperature and duration of heating in the change in degree of penetration of asphalt is very significant. At lower temperature, (around 200°C) the decrease in penetration does not depend much on duration of heating in the case of softer grade of asphalt (80/100) while in other grades, the decrease is not much affected upto 5 hours after which it becomes faster. As the temperature is raised, the effect of duration of heating becomes much more prominent even in the case of softer grades. In harder grades, however, the trend remains almost constant even at high temperatures.

A comparison of the percentage decrease in penetration of various grades of asphalt after heating at 300°C for 7.5 hours (table 1) shows that the overall decrease in penetration is very high. While it is exceptionally high (i.e. 83 per cent) in the case of 80/100 grade, the decrease in other grades is also around 61 per cent which is quite significant. A noteworthy point here is that there is no marked difference in the decrease in penetration of 60/70 and 30/40 grades. Hardness value is substantially changed when softer grade is heated to high temperature for long duration (table 2). This effect becomes much less prominent at short duration of heating. In harder grades, however, the hardness changes linearly with time and temperature.

Softening point of asphalt, though, undergoes some change as a result of heating, it is not as substantial as is the case with penetration. The temperature and duration of heating have almost no significant effect on the softening point of any grade of asphalt upto 250°C (figure 2). There is a slight decrease in softening point when the asphalts are heated at 275° and 300°C and this effect becomes significant only after 5 hours of heating. The maximum increase in softening point is to the extent of 22 per

cent in the case of 80/100 grade and 16 per cent in the case of other two grades. This trend is similar to that obtained in the case of decrease in penetration i.e. the behaviour of the two harder grades is almost identical as regards the effect of heating on these two properties is concerned.

The hardening during heating is known to be due to loss of volatiles as well as oxidation. Heating accelerates both these processes. Contradictory views have been expressed on the comparative importance of these two factors. While Clark (11) was of the opinion that the loss of more volatile components is the main cause of hardening during heating, Brown (12) maintained that oxidation is mainly responsible for ageing of asphalt during hardening. Removal of more volatile oils leads to increase in percentage of less volatiles and high molecular weight compounds resulting in hardening.

The heat test results can form the basis for selection of asphalt as well as the heating conditions during its processing and application. The changes which might be expected to take place in a given grade of asphalt can also be found out from the results given above. It may, however, be noted that these tests can predict the order of hardening expected during particular conditions of application if the actual conditions are well simulated in the tests. The test temperature should be as close to the optimum temperature of processing as possible. These tests should, however, not be used to predict the amount of hardening of asphalts caused by outdoor exposure because while evaporation may be an important factor in hardening during heating operation, it is a minor factor in hardening during outdoor exposure.

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