EFFECTS OF HEATING OPERATION ON VALUE OF BITUMEN PENETRATION

Tran T. Thu Thao, Nguyen V. Teron

University of Science and Technology, The University of Danang;
tranthaoxdcd@gmail.com, teronnguyen@dut.udn.vn

Abstract - Penetration is an important factor of bitumen as an indicator of bitumen viscosity. The change in bitumen viscosity will affect mechanical characteristics of the aggregate and bitumen mixture. Based on reviewing existing construction technologies of asphalt pavements combined with the analysis of bitumen heating technologies in tank-trucks and at asphalt mixing plants, we performed a replication of bitumen heating operation in laboratory and testing of penetration factor according to different heating operations. As a result, we proposed suitable extents of heating operation to ensure that the heated bitumen penetration value is acceptable during construction. The study results will help construction units select bitumen heating operation easily, contributing to the increase of pavement lifetime, enhancing road level of services, reducing traffic accidents and boosting economic efficiency.

Key words - heating operation; dense bitumen 60/70; bitumen penetration; level of service; heating technology.

1. Introduction

Dense bitumen is a popular material in pavement construction in Vietnam. Therefore, how to use it efficiently to produce high pavement quality and long duration is the expectation not onlyofinvestors, designersand construction units but also of other road management authorities. Research and practical road exploitation have indicated that asphalt pavement is sensitive to temperature changes; pavement strength and duration are also affected by temperature. The bitumen penetration is characterized by bitumen viscosity. When asphalt content increases and oil content decreases, the viscosity rises. When environment temperature increases, bitumen substances melt and the bitumen viscosity decreases. If the viscosity of bitumen after heating reduces, the bitumen becomes fragile and aged. These problems will lower asphalt pavement expectancy. Therefore, it is necessary to find out how to limit these problems. Exploring a reasonable bitumen heating method to ensure bitumen quality during construction also helps to reduce road damage and increase the duration of asphalt pavement. In our country, a wide range of road damage such as pot-holes and non-restored deformation has influenced the road level of services (LOS) after a short time in operation. These problems partly result from reduced asphalt quality after inadequate heating operation of bitumen. Current researches have only focused on how to improve asphalt pavement quality such as the interaction between aggregate and bitumen or improving the quality of aggregate and bitumen mixture, andthere have been no detailed researches on heating operation of bitumen. Hence, this study is conducted to find out the suitable bitumen heating operation to ensure bitumen quality inpavement construction.

2. Methodology

2.1. Selection of heating operation methods

Experiments with dense bitumen 60/70 have been widely conducted in our country. This study used the dense bitumen 60/70 from ToanTrung asphalt mixing plant. The bitumen physical-mechanical properties were qualified before heating operation.

To select heating method, temperature level, sustained heating duration and the number of heating operation, we followed the existing construction standards and acceptance specification of asphalt pavement [2], [3], [4], and also considered current construction condition such as using fire-wood for bitumen heating on construction site or direct and indirect heating with fuel at asphalt mixing plants.

In the laboratory, we also used two heating methods: heating operation by gas cookers (similar to above fire-wood heating method or direct bitumen heating on tanks) and heating operation by cabinet driers (similar to indirect bitumen heating on tanks). Both methods have the same temperature level, sustained temperature duration and number of heating. Since maintaining the temperature of gas cookers was troublesome, we choose the temperature varying in $\Delta t^0=10^0$C. After heating operation, the bitumen elongation experiments were performed.

2.2. Experiment procedure

Step 1: Preparation of materials, heating instruments and testing equipment.

Step 2: Using the heating instruments for heating operation at different temperature levels, maintaining the temperature in certain duration. The specimens were then cooled down and heated again. This procedure was repeated several times to replicate the practical asphalt pavement usingon construction site, where the redundant bitumen is utilized after previous construction.

Step 3: Conducting bitumen penetration experiments after heated.

Table 1. *The parameters of bitumen in heating operation*

Heating method	Temperature level to be reached (^{0}C)								Sustained temperatureduration (h)					Heating repeat			Specimens
Cabinet drier	145	155	163	170	175	180	190	200	1	2	3.5	5	8	1	2	3	120
Gas cooker	150÷163		163÷170		170÷180		180÷190		1	2	3.5	5	8	1	2	3	60

Figure 1. *Experiment instruments*

3. Result analysis

The penetration value is the average of three experiment results. Any specimen generating a deviation of 04 percent would be eliminated and the experiment would be conducted with another specimen. The experiment results are described in the Table 2.

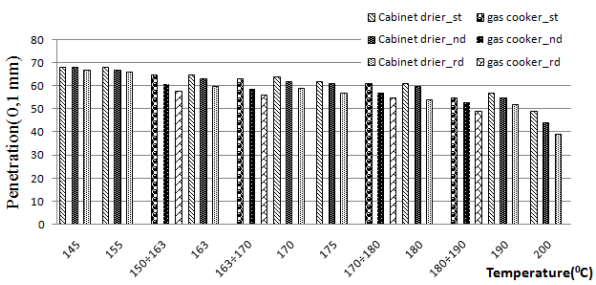

Figure 2. *Bitumen penetration after 1 hour according to repetition of heating at different temperature and heating methods*

The following figures illustrate penetration value after heating operation.

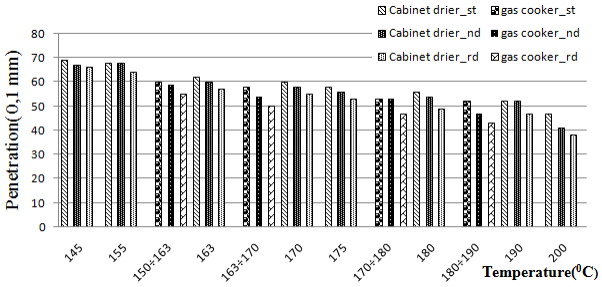

Figure 3. *Bitumen penetration after 2 hours according to repetition of heating at different temperature and heating methods*

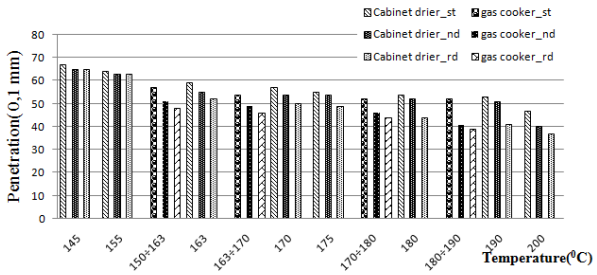

Figure 4. *Bitumen penetration after 3,5 hours according to repetition of heating at different temperature and heating methods*

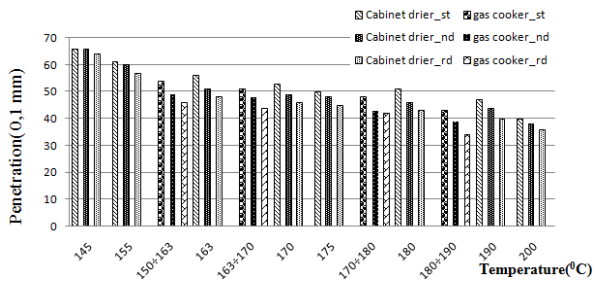

Figure 5. *Bitumen penetration after 5 hours according to repetition of heating at different temperature and heating methods*

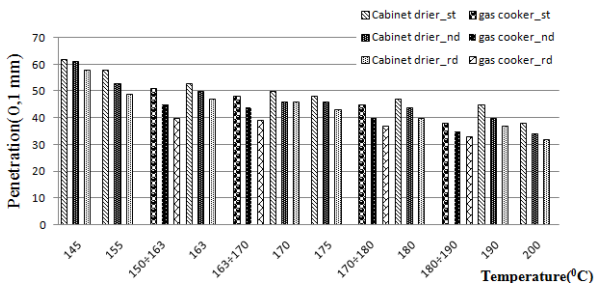

Figure 6. *Bitumen penetration after 8 hours according to repetition of heating at different temperature and heating methods*

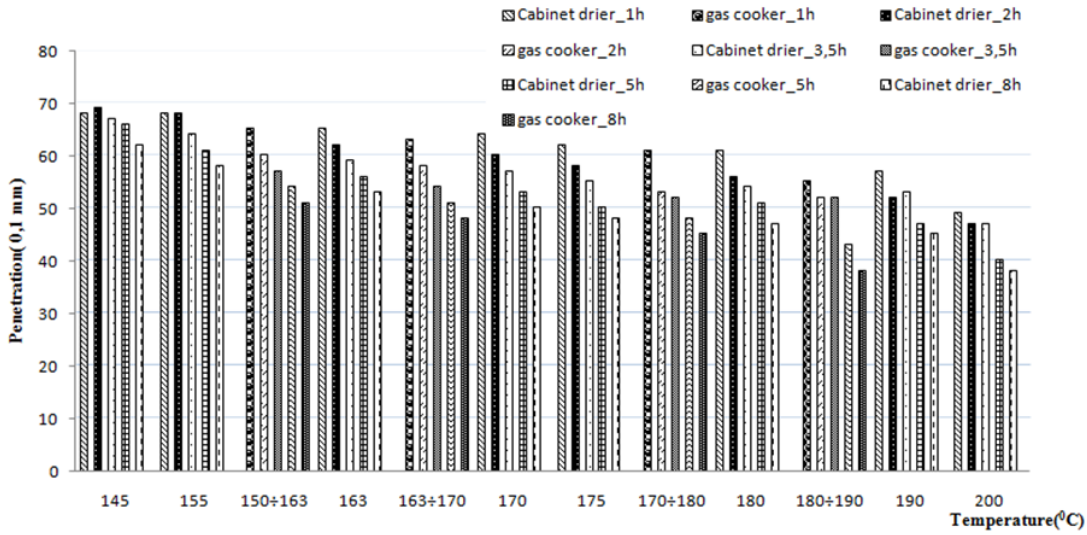

Figure 7. *Bitumen penetration after once heating according to holding time of heating at different temperature and heating methods*

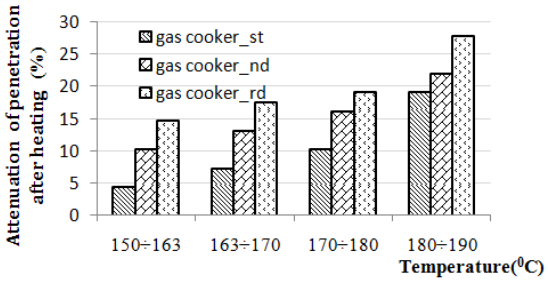

Figure 8. *Attenuation of penetration affter 1 hour according to repetition of heatingat different temperature and heating method by gas cooker*

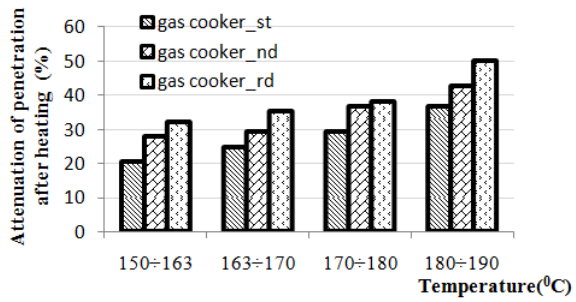

Figure 10. *Attenuation of penetration affter 1 hour according to repetition of heatingat different temperature and heating method by gas cooker*

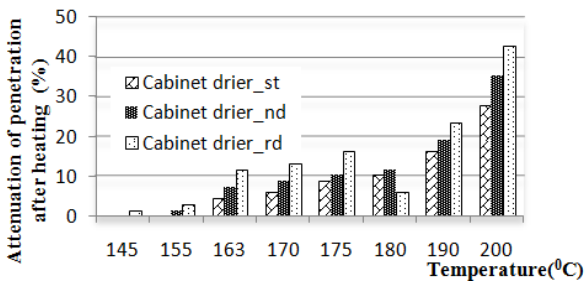

Figure 9. *Attenuation of penetration affter 1 hour according to repetition of heatingat different temperature and heating method by cabinet drier*

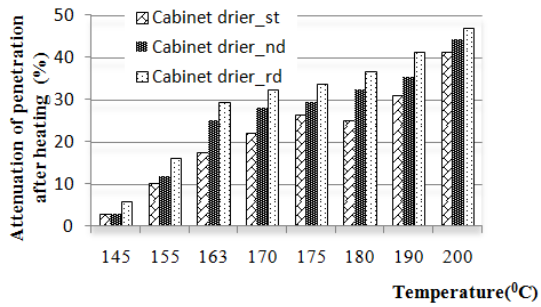

Figure 11. *Attenuation of penetration affter 1 hour according to repetition of heatingat different temperature and heating method by cabinet drier*

4. Discussion

When heating at temperature t≤163^{0}C the penetration decreased slightly Δp<15%; at 163^{0}C< t<180^{0}C, 30%<Δp<40%; at t≥1800^{0}C, Δp≥50% in some cases especially direct heating by gas cooker (Figure 8, 9, 10, 11). At the same time of sustained heating, the higher the temperature got, the lower the penetration was and the more the heating being repeated, the lower the penetration was. This is due to oil substances evaporating at t>163^{0}C, resulted in rapid fragile and aging process of bitumen.

The higher the sustained heating got, the lower the penetration was, especially at high duration of heating the penetration decreased quickly. At sustained heating time greater than 3,5h and temperature t≥180^{0}C, the penetration is almost dissatisfied to the [1] specification if heating by gas cookers as well as with cabinet driers (Figure7).

At the same temperature, same sustained heating and heating repeat, the specimen heated by the cabinet driergave higher 10%-20% elongation than that of the gas cooker, especially at t>163^{0}C (Figure 10, 11). These results haveindicated that heating operation by gas cookers reduced bitumen quality more than the other method and created unequal bitumen quality in the same pot. This is due to the non-uniform heating caused by the former method, which made the bitumen at the pot bottom undergo higher temperature, resulted in oil separation and aging

process. Thereafter, this bitumen became tough, fragile and less flexible.

5. Conclusion

The experiment results have shown that the heating operation has greatly influenced bitumen penetration. The indirect heating methods reduced the bitumen quality slightly, so we suggested that this method be used for bitumen heating operation during construction. The utilization of bitumen from previous construction should be avoided. Furthermore, the dense bitumen 60/70 should not be heated at $t \geq 175^0$C and in the duration of less than 5h. The permission in [4] of bitumen heating operation in 8h>5h is not reasonable.

Table 2. *Penetration results after heating operation*

Holding time of temperature (h)	Repetition of heating (lần)	Heating method	Average value of penetration bitumen after heating (0,1mm)											
			145 (^{0}C)	155 (^{0}C)	150÷ 163 (^{0}C)	163 (^{0}C)	163÷ 170 (^{0}C)	170 (^{0}C)	175 (^{0}C)	170÷ 180 (^{0}C)	180 (^{0}C)	180÷ 190 (^{0}C)	190 (^{0}C)	200 (^{0}C)
1	1	Cabinet drier	68	69		67		64	62		61		57	49
		Gas cooker			65		63			61		55		
	2	Cabinet drier	68	67		67		63	61		60		55	44
		Gas cooker			64		61			57		53		
	3	Cabinet drier	67	66		65		61	60		60		52	39
		Gas cooker			61		58			55		49		
2	1	Cabinet drier	69	68		66		62	61		61		56	47
		Gas cooker			64		62			59		52		
	2	Cabinet drier	67	68		64		58	56		54		52	41
		Gas cooker			64		54			53		47		
	3	Cabinet drier	66	64		63		55	53		49		47	38
		Gas cooker			60		50			47		43		
3,5	1	Cabinet drier	67	64		62		60	59		57		53	47
		Gas cooker			61		58			54		52		
	2	Cabinet drier	65	63		61		54	54		52		51	40
		Gas cooker			59		53			49		41		
	3	Cabinet drier	65	63		58		50	49		44		41	37
		Gas cooker			56		49			48		39		
5	1	Cabinet drier	66	64		61		53	50		51		47	40
		Gas cooker			60		51			48		43		
	2	Cabinet drier	66	62		57		51	49		47		44	38
		Gas cooker			55		48			43		39		
	3	Cabinet drier	64	63		55		46	45		43		40	36
		Gas cooker			53		44			42		34		
8	1	Cabinet drier	65	63		57		50	48		47		45	38
		Gas cooker			56		50			45		38		
	2	Cabinet drier	63	62		54		46	46		44		40	34
		Gas cooker			54		44			40		35		
	3	Cabinet drier	64	59		51		46	43		40		37	32
		Gas cooker			50		39			37		33		

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