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RESEARCH OF CHANGES IN PROPERTIES OF BITUMEN DURING THERMO-OXIDATIVE AGING

Long-term work of road pavements is provided by saving in stability of their basic physical-technical characteristics under various operating loads and weather-climatic conditions. One of the main reasons for such stability is the stability of bitumen to resist aging.

The process of aging of bitumen - a combination of irreversible changes in the structure and physical- technical characteristics of bitumen that occur under the influence of external factors in their preparation, processing technology and work in the pavement. The most fast aging of bitumen occurs in thin films in the preparation of asphalt mixtures. The main factors of aging air are oxygen and high temperatures, which cause intensive oxidative and thermooxidative processes.

The purpose of this work was to study resisting purpose of oxidized bitumen to thermooxidative aging.

As the objects of study were taken bitumen types BND 40/60, BND 60/90, BND 90/130 Mozyr refineries, BND 60/90 and 90/130 BND PJSC "Ukrtatnafta". The test results are shown in Table 1. The values of physical-technical properties of bitumen were taken in accordance with the requirements DSTU 4044.

Heating bitumen to GOST 18180 and to RTFOT methods leads to changes in their properties. Penetration bitumen after heating is decreasing (Figure 1).

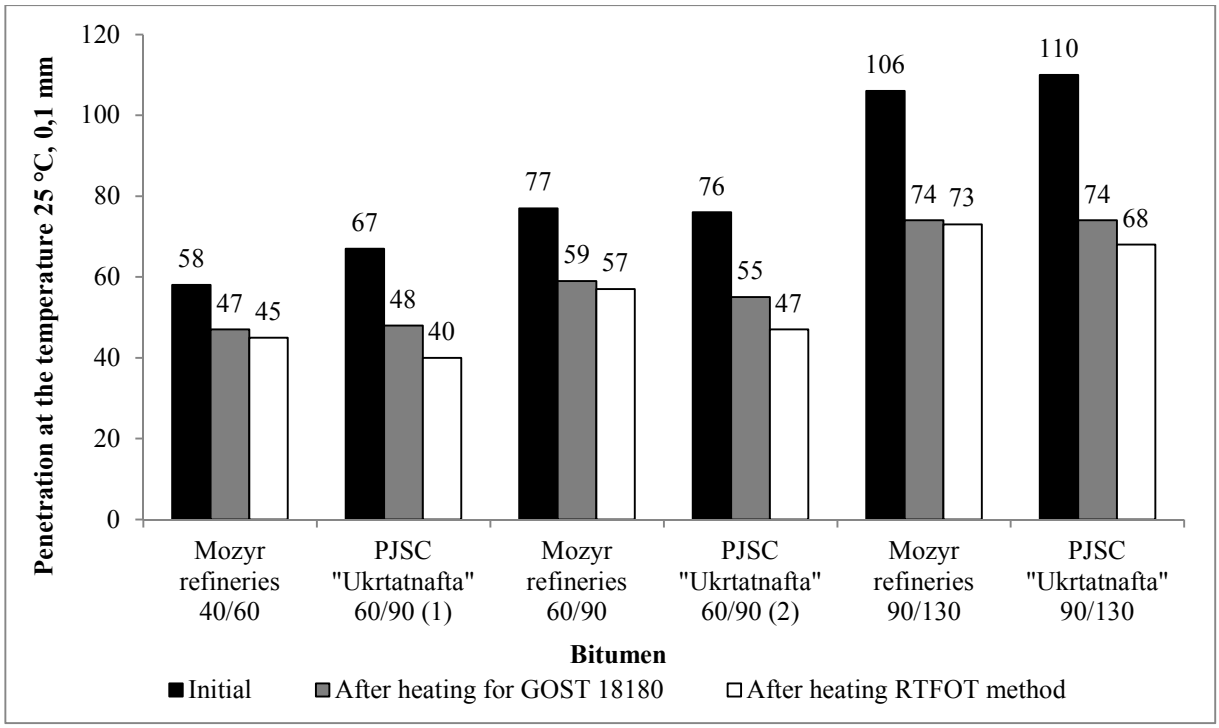

Figure 1: Change penetration bitumen after heating

Table 1. Results of the determination of physical-technical properties of bitumen before and after aging

Name of indicators	The test results of bitumen					
	Mozyr refineries 40/60	PJSC "Ukrtatnafta" 60/90 (1)	Mozyr refineries 60/90	PJSC "Ukrtatnafta" 60/90 (2)	Mozyr refineries 90/130	PJSC "Ukrtatnafta" 90/130
1 Penetration at the temperature 25 °C, 0,1 mm						
Initial	58	67	77	76	106	110
After heating for GOST 18180	47	48	59	55	74	74
After heating RTFOT method	45	40	57	47	73	68
2 Softening temperature, °C						
Initial	52,0	49,7	48,5	48,6	46,0	45,1
After heating for GOST 18180	55,6	53,2	52,8	52,4	49,7	49,2
After heating RTFOT method	57,0	54,7	54,0	53,4	50,4	50,2
3 Temperature brittleness, °C						
Initial	-22	-23,5	-25	-24	-27	-25
After heating for GOST 18180	-17	-21	-24	-22	-26	-23
After heating RTFOT method	-17	-21	-24	-21	-30	-22
4 Dynamic viscosity at the temperature 60 ºC, Pa · s						
Initial	775	390	390	326	155	198
After heating for GOST 18180	1800	868	955	710	385	420
After heating RTFOT method	2300	1218	1060	988	430	524
5 Change in weight, %						
After heating for GOST 18180	0,31	0,35	0,42	0,39	0,62	0,46
After heating RTFOT method	0,37	0,03	0,48	0,00	0,70	0,14
6 Index aging						
After heating for GOST 18180	2,32	2,23	2,45	2,18	2,48	2,12
After heating RTFOT method	2,97	3,12	2,72	3,03	2,77	2,65
7 The residual penetration, %						
After heating for GOST 18180	81	72	77	72	70	67
After heating RTFOT method	78	60	74	62	69	62

Thus, the greater the initial penetration bitumen the less its residual penetration (Figure 2). An interesting fact is that the residual penetration bitumen Mozyrs refineries is almost the same as after heating to GOST 18180, and after heating by method RTFOT. However bitumen PJSC "Ukrtatnafta" aging more after heating method RTFOT. In this case there is a law of decrease in the difference between the residual penetration after heating of GOST 18180 and residual penetration after heating method RTFOT. Thus, the difference of values residual penetration for bitumen PJSC "Ukrtatnafta" with penetration 67 • 0,1 mm is 12%, and with value of increasing initial penetration bitumen to 76 • 0,1 mm and 110 • 0,1 mm difference in residual penetration is 10% and 5%, respectively. The specified trend is probably explained by the fact that when heating GOST 18180 exposed oxidation first of all surface investigated specimen and the oxidation of the total volume of the specimen depends on its viscosity.

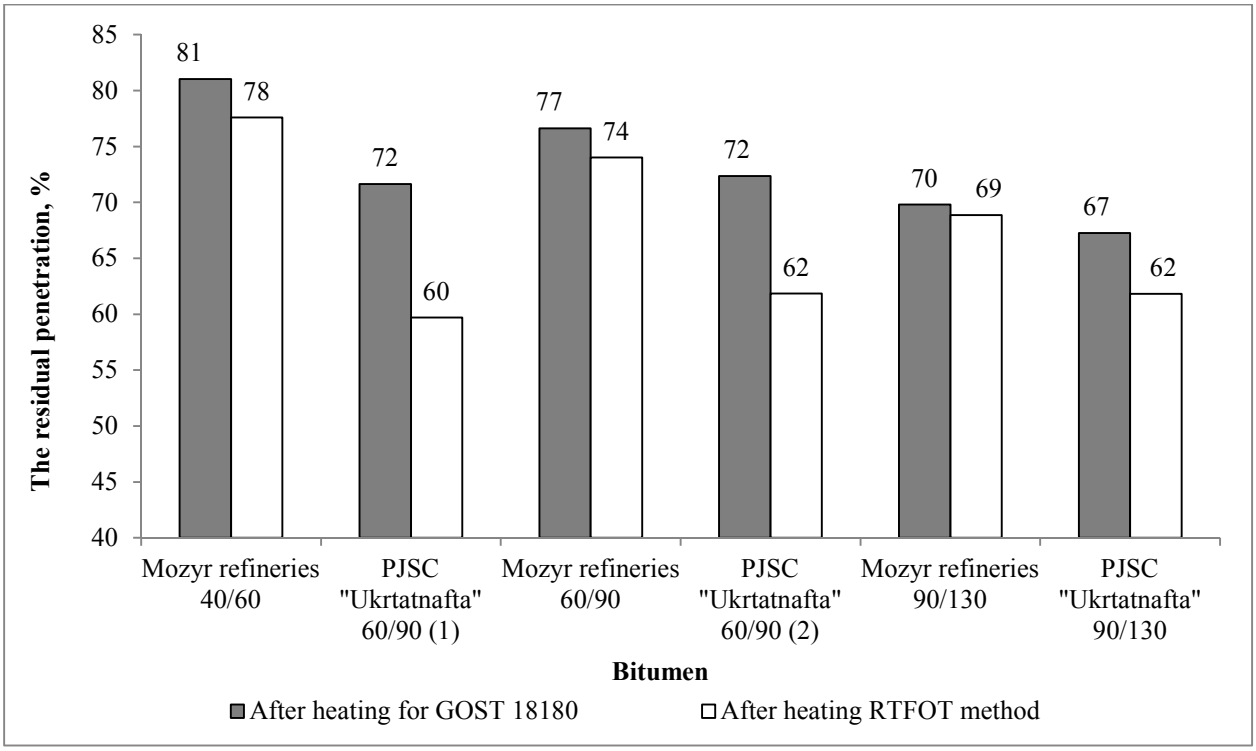

Figure 2: The residual penetration bitumen after heating

The softening temperature and the brittleness of bitumen increases with heating (Figure 3 and Figure 4).

In contrast to the close values of residual penetration bitumen Mozyrs refineries at their heating by both methods, changes in temperature of softening is more significant. Heating RTFOT method leads to larger changes in temperature softening. The greater the viscosity of bitumen the greater the difference between the temperatures of softening determined after heating in two ways. For bitumen PJSC "Ukrtatnafta" observed a similar trend in the changes of temperature softening.

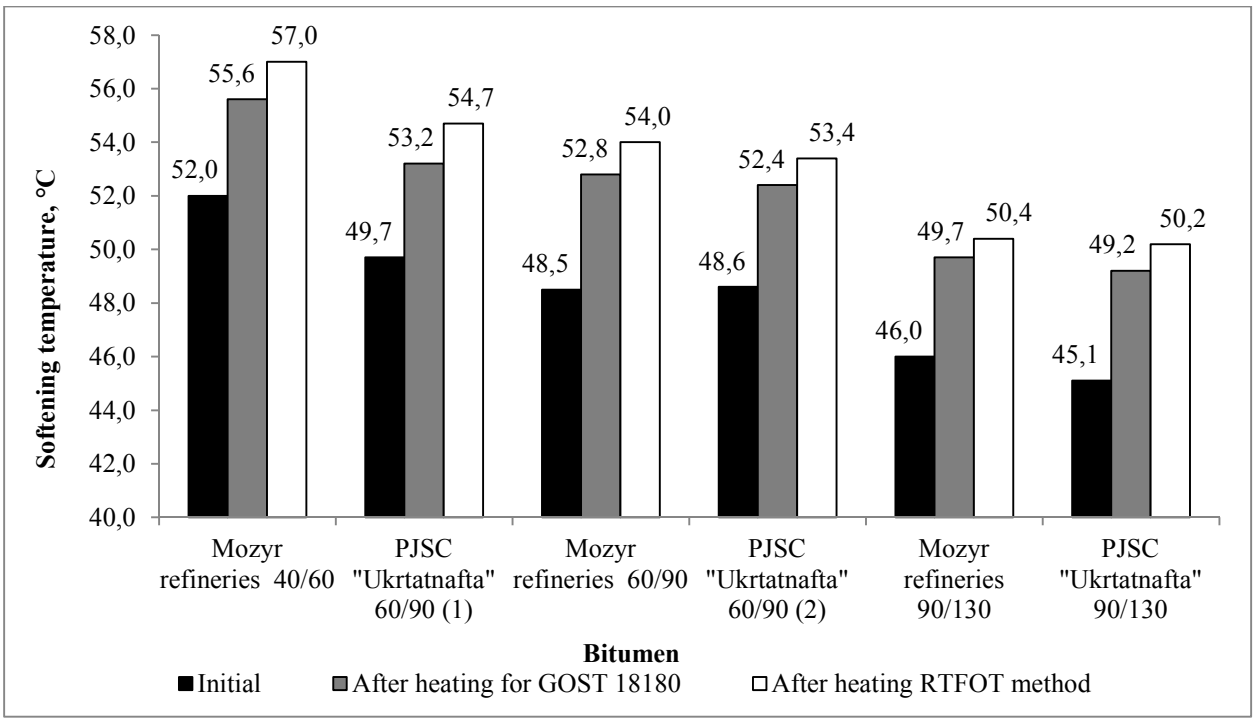

Figure 3: Change of temperature softening of bitumen at heating

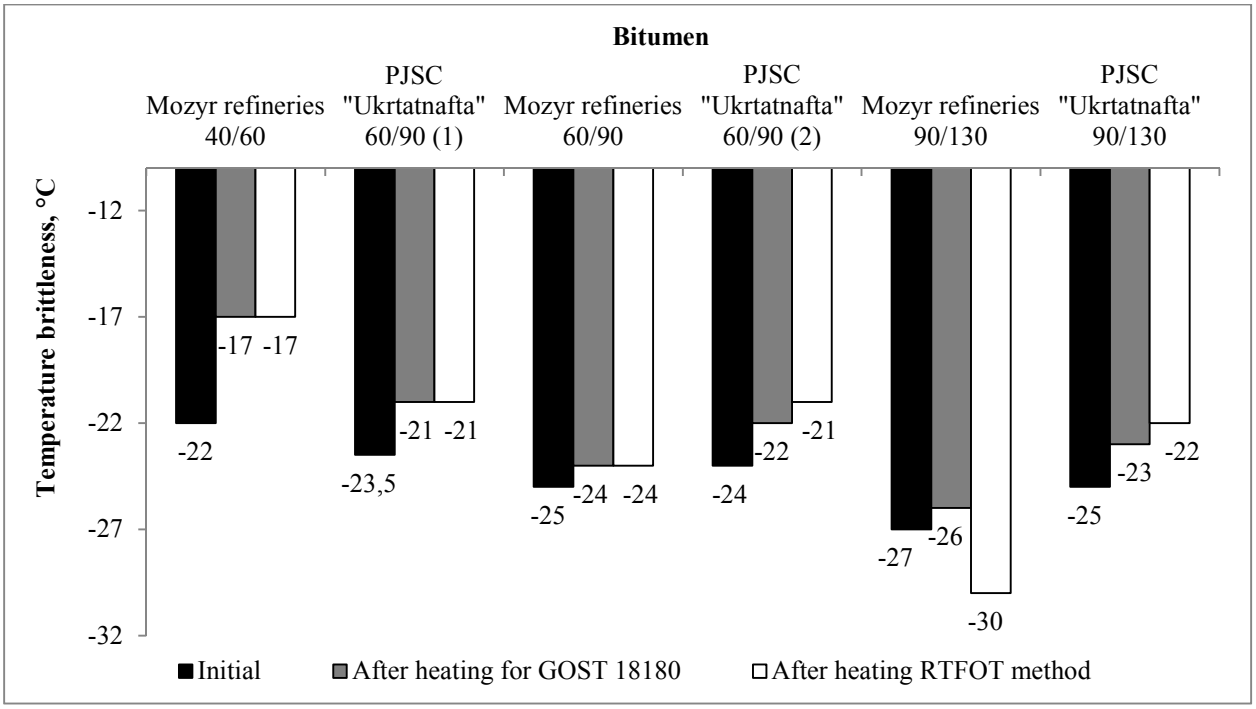

Figure 4: Change of temperature brittleness of bitumen at heating

Temperature brittleness of bitumen at heating increases less rapidly. The heating RTFOT method leads to the slightly larger changes in temperature brittleness than heating GOST 18180. The highest growth temperature brittleness observed in heating bitumen brand BND 40/60 Mozyrs refineries. Less growth temperature brittleness while more intensive growth softening temperature leads to increased interval plasticity tested bitumen toward higher temperatures.

When bitumen is heating for both methods, dynamic viscosity is growing (Figure 5). As in previous cases heating RTFOT method leads to the larger changes than heating GOST 18180.

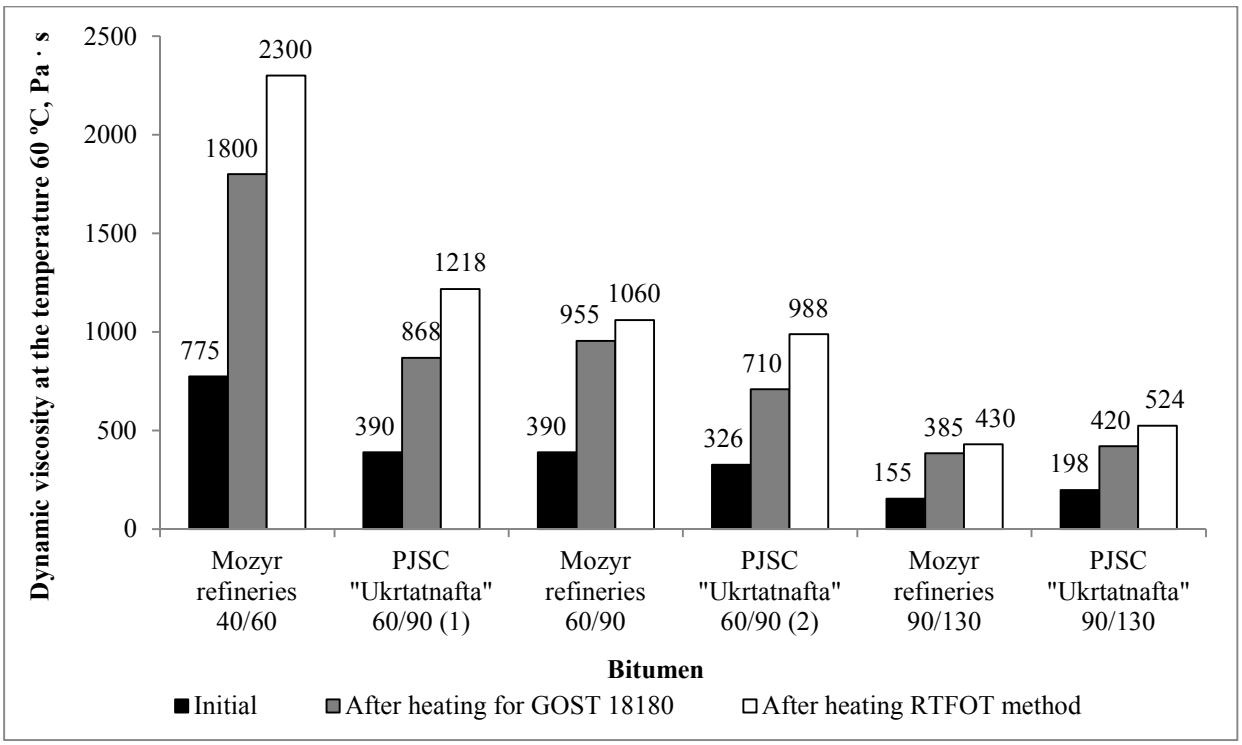

Figure 5: Changing the dynamic viscosity of bitumen at heating

However unlike residual penetration at 25 ° C, where the increase in viscosity of bitumen occurs during its growth as a heating GOST 18180 so and, by RTFOT, bitumen aging index Mozyr refineries (defined as the ratio of the dynamic viscosity of bitumen after heating to the dynamic viscosity of bitumen initial) while heating GOST 18180 reduced, while heating method RTFOT - increases (Figure 6). For bitumen PJSC "Ukrtatnafta" growth index of aging with increasing viscosity of bitumen occurs when heating by both methods. It should be noted that more resistant to aging is bitumen with a lower index of aging.

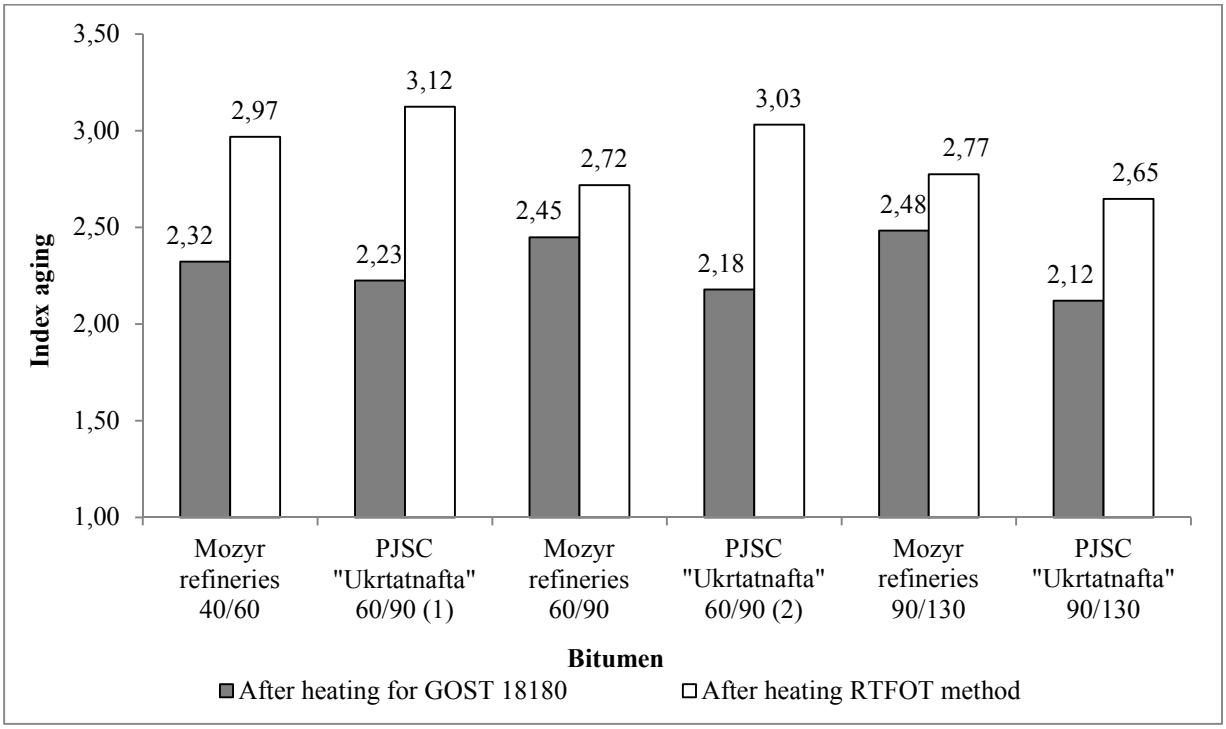

Figure 6: The index of aging of bitumen after heating

To increase the stability of oxidized bitumen to high temperatures technological and operational factors can be achieved by compounding them with distillation bitumens. In this accordance with studies were conducted compounded bitumens obtained by the combination of oxidized bitumen BND 60/90 marks of distillation bitumen conforming to EN 12509. The number distillation bitumen ranged from 10% to 50% by weight of bitumen compounded. The test results are shown in Table 2.

Table 2. Results of the determination of physical-technical properties of bitumen, obtained by compounding bitumen different types before and after aging

Name of indicators	The test results			
	PJSC "Ukrtatnafta" 60/90 (1)	compounded bitumen from oxidized bitumen PJSC "Ukrtatnafta" 60/90 (1) containing bitumen distillation mark 100/150, %		
		10 %	30 %	50 %
1	2	3	4	5
1 Penetration at the temperature 25 °C, 0,1 mm				
Initial	67	66	75	86
After heating for GOST 18180	48	51	58	64
After heating RTFOT method	40	48	53	58
2 Softening temperature, °C				
Initial	49,7	48,7	46,2	44,4
After heating for GOST 18180	53,2	52,1	49,3	48
After heating RTFOT method	54,7	53,3	51,6	49,4
3 Temperature brittleness, °C				
Initial	-23,5	-23	-22	-20
After heating for GOST 18180	-21	-21	-21	-19
After heating RTFOT method	-21	-25	-25	-22
4 Розтяжність, см				
4.1 за температури 25 °С:				
- вихідного	68	> 100	> 100	> 100
- після прогріття за ГОСТ 18180	-	> 100	> 100	> 100
- після прогріття за методом RTFOT	-	> 100	> 100	> 100
4.2 за температури 0 °С:				
- вихідного	3,0	2,4	4,0	5,1
- після прогріття за ГОСТ 18180	2,3	1,7	3,7	3,8
- після прогріття за методом RTFOT	2,2	1,4	3,3	3,2
5 Dynamic viscosity at the temperature 60 ºC, Pa · s				
Initial	390	405	275	230
After heating for GOST 18180	870	689	492	387
After heating RTFOT method	1217	973	698	552
6 Change in weight, %				
After heating for GOST 18180	-0,35	-0,3	-0,31	-0,5
After heating RTFOT method	-0,03	+0,1	+0,11	+0,1
7 Index aging				
After heating for GOST 18180	2,23	1,7	1,79	1,68
After heating RTFOT method	3,12	2,4	2,54	2,4
8 The residual penetration, %				
After heating for GOST 18180	72	78	77	74
After heating RTFOT method	60	73	71	67

The test results show that compounded bitumen is more resistant to aging than oxidized bitumen.

Thus, the residual penetration oxidized bitumen at heating the method of GOST 18180 is 72%, while heating method RTFOT - 60%. Add to oxidized bitumen 10% distillation bitumen 100/150 marks leads to an increase in residual penetration to 78% and 73%, respectively (Figure 7).

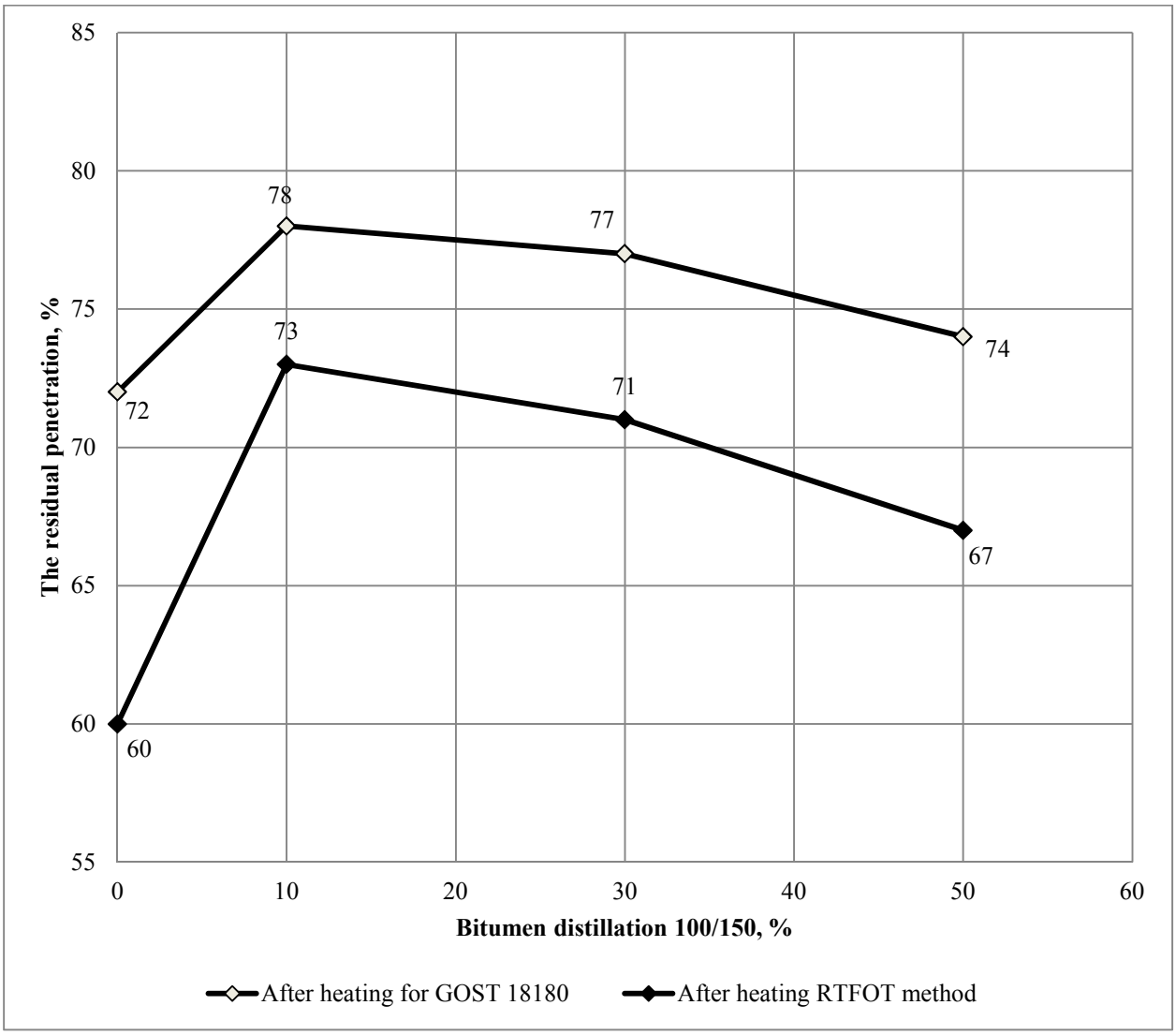

Figure 7: Residual penetration compounded bitumen depending on the content of distillation bitumen

Increasing residual penetration at heating by both methods indicates that compounded bitumen compared with oxidized less changes its consistency, and thus are more resistant to aging.

The increase of distillation bitumen to 30% and 50% leads to a decrease of the residual penetration. However, residual penetration compounded bitumen still is greater than oxidized bitumen. In this case, reduce of residual penetration probably associated with an increase in penetration compounded bitumen, as is widely accepted that less viscous bitumen aging intense than more viscous.

The index of aging also show a greater resistance to aging compounded bitumen compared with oxidized. Even when administered 10% distillation bitumen 100/150 mark is a

significant decrease in the index of aging. Thus, when heating according to GOST 18180 from 2.23 to 1.7, while heating to EN 12607 - from 3.12 to 2.4 (Figure 8). By increasing the distillation bitumen content by 30% and 50% the aging index virtually unchanged, indicating increased stability compounded bitumen to the aging even with increasing their penetration (ie less viscous bitumen compounded change their properties during thermal aging a little more than a viscous binders).

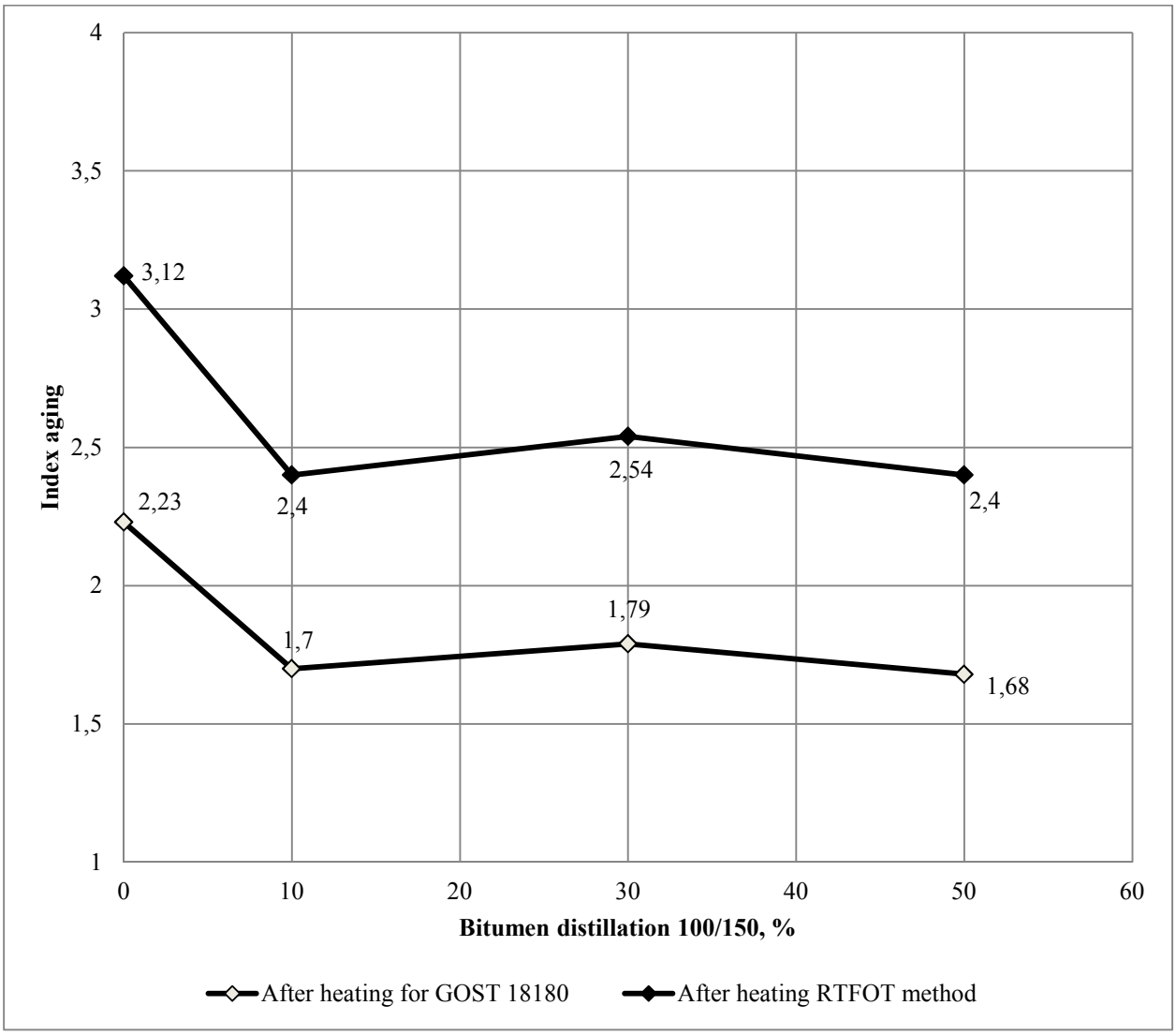

Figure 8: Index aging of bitumen depending on the content of distillation bitumen

It also should be noted that the difference between aging indexes obtained by heating bitumen by two methods for compounded bitumen is less than oxidized (0.7 to 0.89), which may indicate a lower rate of formation of oxidative protective film on the surface of the samples during heating of GOST 18180, which prevents air to specimen volume and thus leads to the distortion of the results research relatively influence of technological temperature on aging of bitumen.

Changing the softening temperature of bitumen as during heating the method of GOST 18180 and EN 12607 method is almost the same for all investigated bitumen. The value of the test results are within the error of the experiment. Temperature brittleness of bitumen at their heating under both methods varies in different ways. Thus, when heating bitumen method GOST 18180 temperature brittleness compounded bitumen increases, while heating to EN 12607

there is a decrease in temperature brittleness. This may indicate a different character the aging process bitumen during heating by this method.

As a result of aging is a gradual transition bitumen from the structure type "sol" to type "sol-gel", and further to the type of "gel". Thus, lowering the temperature brittleness during heating to EN 12 607 is quite logical, because due to aging of compounded bitumen is upgraded structure of "sol" to the structure of the "sol-gel".

SUMMARY

1. Heating the bitumen method according to GOST 18180 and by RTFOT method, leads to changes in their properties. There is a decrease penetration, growth temperature softening and temperature brittleness, increased values of dynamic viscosity. The properties of oxidized bitumen PJSC "Ukrtatnafta" change over properties of oxidized bitumen Mozyr refineries. This is probably due to the fact that the production of these bitumens used are different materials.

2. Character of change properties of bitumen in the thermooxidative aging depending on the evaluation method of aging is different. Thus, estimating the residual penetration aging (change in penetration after heating), we can assume that more resistant to aging are bitumens with lower depth permeability needle (ie more viscous). In assessing the aging index aging obtain results which show greater resistance to aging of bitumen with lower viscosity.

3. Introduction of the oxidized bitumen distillation bitumen leads to an increase in its residual penetration and reduce aging index as at heating according to GOST 18180 and in heating accordance with EN 12607. Changes in temperature softening and temperature brittleness compounded bitumen is almost the same as oxidized bitumen. Extensibility at 25 °C and 0 °C with heating according to GOST 18180 and EN 12607 declining, but despite this, in some cases it is more than extensibility oxidized bitumen, which is not subjected to aging. All the foregoing indicates greater resistance to aging compounded bitumen compared to oxidized.