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# THE ANALYSIS OF CHANGES IN TOTAL BASE NUMBER AND THE FLASH POINT IN THE EXPLOITED ENGINE OIL

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***Abstract***

*This paper is a continuation of the analysis of the grade of wear of the engine oil, used in the Caterpillar's marine engine, which is working in the engine's room of the harbour tug. Previous studies were related to the dynamic viscosity, lubricity and the grade of the metallic elements contamination. In these studies, the viscosity of the oil in most samples decreased with time of exploitation. However, in some samples, an increase of the viscosity was observed, what may indicate the fuel entering into the circulation of lubricating oil and its subsequent evaporation.*

*Aim of this study is to determine the size of the Total Base Number changes and the flash point changes.*

*The authors examine the changes in Total Base Number and the flash point of the exploited engine oil, in specified intervals in time between its exchanges. The results are analyzed and compared to the previously obtained results of the viscosity, lubricity and the grade of the metallic elements contamination. The analyses of the Total Base Number were conducted on the RST 822 Radiometer from Radiometer Analytical A/S, according to the polish standard PN-76/C-04163: Petroleum Products. Determination of the Total Base Number by potentiometric titration with perchloric acid. Flash point was determined using the Cleveland, in the open pot, using an ISL FP 92 5G device from Tusnovics Instruments Poland Ltd.*

*The conclusions of this paper lead to better understanding of the processes, which occur in marine engines and its influence on the oil aging. Understanding of this process contributes significantly to a more accurate mathematical modelling of the aging process of engine oil.*

***Keywords:*** *Total Base Number, flash point, oil ageing, dynamic viscosity, oil contamination*

## 1. Introduction

In the Caterpillar CAT3516DITA engine, from which the samples for the research were taken, the oil is changed after approx. 1500 h of the exploitation. The frequency of oil's change is compatible with the recommendations of the engine's producer and oil's supplier and adapted to the harbour tug's work characteristic [1, 10]. After that period, the parameters of oil are worsened to the level in which the further exploitation could cause the damage of the engine [4].

The results of the research on the oil's viscosity are taken from the author's previous work and were made on the Haake Mars III rheometer. The research was made in the plate-cone configuration, with the shear rate up to 200 1/s. Received viscosity characteristic is different from the theoretical characteristic of the viscosity decrease connected with the oil ageing, because it is highly influenced by the processes that are proceeding inside the engine. According to the statement above, the oil was examined further in order to determine the Total Base Number characteristics and the flash point.

High amount of sulphur in the diesel oil causes the acid reaction of the combustion products. The total base number (TBN) is the parameter of the oil that is determining the presence of the alkaline additives that are neutralizing the acid products of combustion and, by that, are stopping the corrosive wearing of the engine [6].

The research on the value of the TBN for the particular samples of oils was made with the use of the radiometer produced by the Radiometer Analytical A/S company.

The flash point is the parameter that determines the burning ability of the mixture of lubricating oil's vapours and the air. The flash point is the lowest temperature in which amount of accumulated vapours of the heated oil together with the supplied air creates the mixture that burns when being close to the flame [6].

The researches on the flash point were made by the Cleveland, in the open pot, using an ISL FP 92 5G device from Tusnovics Instruments Poland Ltd.

## 2. Experimental researches

The results of the research on viscosity [7] are showed on Fig.1. In order to compare the characteristics of the viscosity for the 40ºC and 100ºC, their values were presented dimensionless to show their percentage variation.

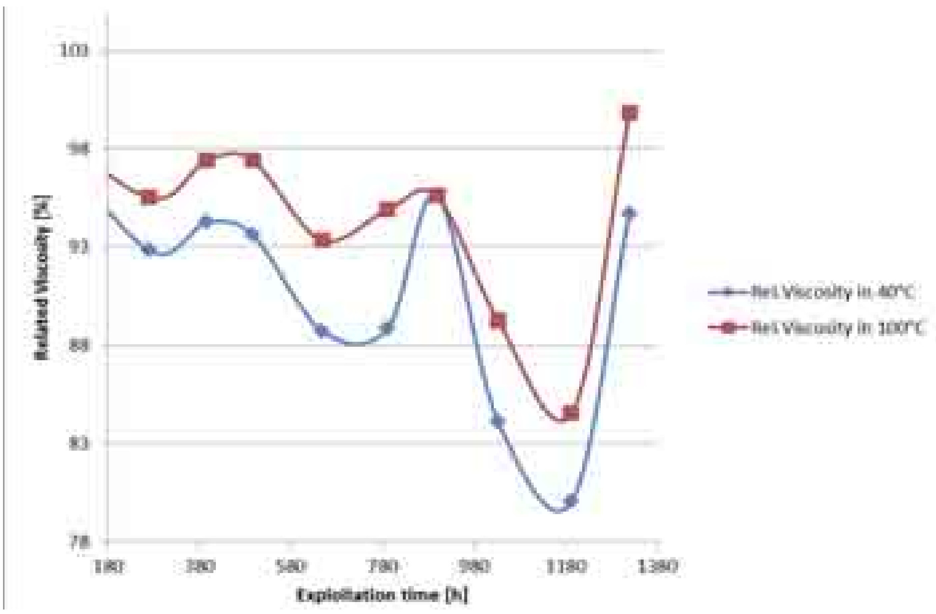


*Fig. 1. Relation between dynamic viscosity for 40ºC and 100ºC in the exploitation time*

The diagram showed on Fig. 1. shows, as predicted, that the shapes of characteristics for 40ºC and 100ºC are similar but are different in their positions to each other. The viscosity of oil at the temperature of 40ºC is relatively lower than the viscosity of oil at the temperature of 100ºC.

The further analysis of the diagram presented on Fig. 1 shows, that after the period of 800h of exploitation the viscosity had at first significantly decreased but later increased. The decrease of the viscosity was probably caused by the presence of fuel in the oil. In order to confirm that assumption, the research on the flash point and on the TBN was made. The increase of the viscosity after 1200h of the oil exploitation time, which is showed on the diagram, was caused by the increase of the pollutions amount that caused the change of oil into a dispersional mixture with the higher viscosity [9]. The increase of the pollutions amount in the oil after 1319 working hours was stated also organoleptic, based on the visible phase separation, after performing the research on the viscosity with the 200 1/s shear rate. Fig. 2 and 3 presents the rheometer's plate with the phase separation of the pollutions.

*Fig. 2. Bottom plate of the rheometer, after 1192h of the oil exploitation time*

*Fig. 3. Bottom plate of the rheometer, after 1319h of the oil exploitation time*

In his earlier works [7], the author of this article had performed the analysis of chemical composition of researched oil samples. The analysis was made with the use of Spectroil Q100 spectrometer and for the presence of chemical elements such like: Al, Cd, Cr, Cu, Fe, Pb, Mg, Mn, Mo, Ni, Ag, Sn, Ti, V, Zn, P, Si, B, Ba, Ca, K and Na. The analysis shows, that Ca is the element that indicates the level of alkaline additives in oil and the TBN [3].

Figure 4 shows the relation between the TBN and the content of Ca.

The analysis of the diagram presented on Fig. 4 shows, that as in the case of viscosity characteristic, after the approx. 800h of exploitation, significant decrease of TBN and relatively low decrease of Ca amount was observed. The diagram also shows the trend of the characteristics for the amount of Ca and TBN that is dependent on the characteristics.

The changes of the flash point in relation to the time of oil's exploitation is showed on the Fig. 5.

The analysis of diagram presented on Fig. 5 on the flash point of the researched samples shows that after approx. 800 hrs of the exploitation the flash point was significantly lower [5, 6]. The difference amount to approx. 20°C, which is about 10% lower than the flash point of new oil.

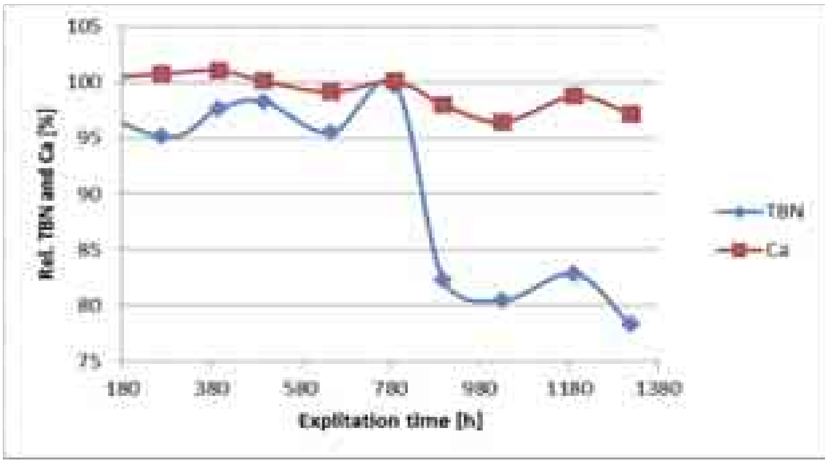


*Fig. 4. Relation between Ca content and TBN of the oil in exploitation time*

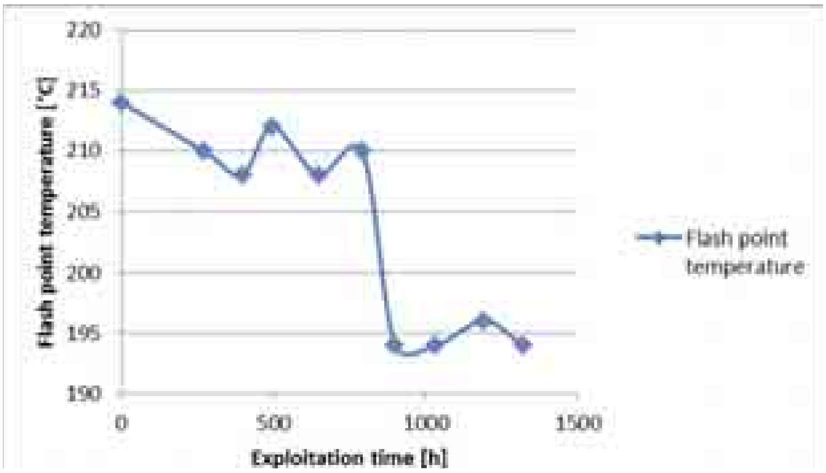


*Fig. 5. Flash point temperature changes in exploitation time*

## 3. Conclusions and observations

The analysis of the diagrams presented in this paper shows, that after approx. 800 hrs of exploitation, the performance of the engine oil was instantly worsened. Because the biggest difference can be observed by the analysis of the, flash point value, it can be stated that the direct cause of oil's parameters worsening was the presence of fuel inside the oil circulation. The worsening of the parameters had caused the loss of the viscosity and anti-corrosive properties of oil and decreased its oxidation resistance [2, 8].

The aim of this work was to determine the physical and chemical parameters of engine oil used in the Caterpillar harbour tug and to explain the ageing processes and the causes of lowering of the oil's properties.

The results of the research, conducted observations and stated relations can be used in mathematical modelling of process and in numerical calculations of capacity forces functioning on the slide bearings inside the engine.

## References

[1] Buckmaster, J., Clavin, P., Linan, A., Matalon, M., Peters, N., Sivashinsky, G., Williams, F. A., *Combustion theory and modeling*, Proceedings of the Combustion Institute, Vol. 30, pp. 1-19, Pittsburgh 2005.

[2] Cerny, J., Strnad, Z., Sebor, G., *Composition and oxidation stability of SAE 15W-40 engine oils*, Tribology International, 34, pp. 127–134, 2001.

[3] Krupowies, J., *Badania pierwiastków śladowych w oleju obiegowym jako element diagnostyki silnika*, Wyższa Szkoła Morska w Szczecinie, Studia nr 34, 2001.

[4] Kaminski, W., *Some problems of exploitation of marine lubricating oils in internal combustion engines*, XXVII Conference SYMSO, conference materials, pp. 167-172, 2006.

[5] Krupowies, J., *Analysis of changes in operating parameters of lubricating oils of marine auxiliary engines*, Scientific Papers of Szczecin Maritime University, No. 1 (73), pp. 411-422, 2004.

[6] Krupowies, J., *Badania zmian właściwości oleju obiegowego okrętowych silników pomocniczych*, Wyższa Szkoła Morska w Szczecinie, Studia Nr 40, 2002.

[7] Sikora, G., Miszczak, A., *The Influence of Oil Ageing on the Change of Viscosity and Lubricity of Engine Oil*, MSM Conference 2012, in press.

[8] Wachal, A., *Limit state oil and its evaluation criteria*, V Kongres Eksploatacyjny, Conference materials, 1983.

[9] Wachal, A., *Fuel and motor oils*, MON, Warszawa 1959.

[10] Wlodarski, J. K., *Piston internal combustion engines*, WKiL, Warszawa 1982.