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STUDY ON THE EFFICIENCY OF THE LUBRICATION OF AN INDUSTRIAL TURBOCHARGER

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Abstract: *Effective lubrication is important for turbochargers to operate reliably. This can be ensured by regularly monitoring the condition of the used lubricant. In-service lubricant analyses can be used to monitor the functional quality of the oil, provide information on wear affecting lubricated parts, and improve lubrication and increase oil change intervals.*
In this work we made an oil analysis to confirm that the used ISO 32 oil for the lubrication of the turbochargers is a good lubricant and assures a good lubrication, for that we carried out a series of conventional tests such as the viscosity and the point of lightning, in continuation we also carried out a spectrometric analysis of emission and this for the characterizations of the contamination of this oil.

Key words: *Lubrication, turbocharger, oil analysis, emission spectroscopy analysis.*
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1. INTRODUCTION

Lubrication is very important to maintain the performance of a machine [1], it reduces energy losses due to friction, reduce wear of frictional surfaces and noise due to contact. Greasing and lubrication are the basis of maintenance. Neglecting these operations will inevitably lead to more failures, or even the breaking of equipment [2]. Two important parameters condition the correct lubrication of rotating machines are the condition of the lubricant and the condition of the lubricated surfaces [3].

Lubricating oil is considered a fluid structural element of machines and devices. Its main function is to create a layer in the form of a microfilm between the moving parts of the device [4]. Proper lubricant and lubrication methods reduce friction, wear, and contact fatigue and improve the efficiency and durability of a mechanical system [5].

The lubricating oil is a mixture of base oil (>85%) and the rest is additives [6,7], The use of an additive can improve the performance of the lubricant [8].

Oil analysis is one of the techniques of conditional maintenance, it has two objectives; the first is the maintenance of lubricants, and the second is the maintenance of equipment because it allows determining on the one hand the physicochemical characteristics of the lubricant and on the other hand to identify a wear of the mechanical elements.

Different types of analyses can be performed in a variable manner depending on the machine being studied [9]. Viscosity and flash point are the two key parameters in a turbocharger oil analytical program.

Emission spectrometry is an analytical method that allows the quantification of oil contamination by metal particles. This provides very reliable information about the lubricant and the lubricated system [10]. The contamination of the lubricating oil is influenced mainly due to external and internal factors [11,12].

In this work we carried out the analysis of ISO 32 oil to obtain information on the condition of this oil to ensure that it is still performing and fulfilling its lubrication role in an industrial turbocharger during its service.

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2. Materials and Methods

We took in this work as an example of a rotating machine a centrifugal turbocharger which is used at the refining unit RA1k of Skikda, after a well determined duration of operation (two months) of the latter, we took a sample of lubricating oil in order to analyze its properties within the laboratory of the R1AK SONATRACH, and essentially to calculate its viscosity and its flash point.

In addition to the physico-chemical analysis we also performed an emission spectrometric analysis after twenty months of operation (the last sampling) for the characterizations of the contamination of this oil

2.1 Turbocharger

The studied turbocharger is a five-impeller, two-stage centrifugal compressor driven by a steam-powered turbine (steam turbine). It is used to assume the required flow rate and pressure of the 100 reforming unit reactor.

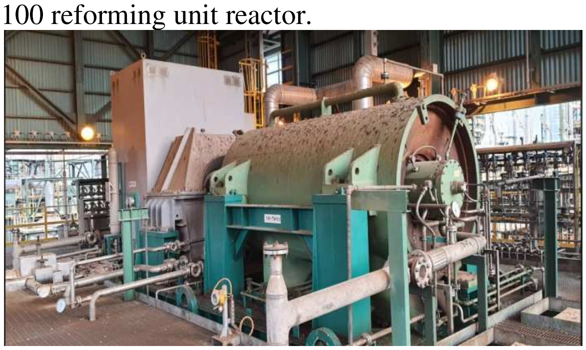

Fig. 1. The studied Turbocharger

2.2 ISO 32 oil

ISO 32 oils are specially designed to meet the lubrication requirements of bearings and many other components related to their technology (gearboxes, certain control circuits, hydraulic circuits, etc.). They are also used for the lubrication of turbo-alternators and turbochargers.

2.3 Flash point measurement

The flash point is the lowest temperature at which the vapors emitted from a product contained in a closed vessel and gradually heated up ignite in the presence of a flame.

The flash point of oil was measured at the laboratory of RA1K Skikda following the ASTM D 93-16a standard using the flash point tester HFP 386 [13].

2.4 Measurement of viscosity ASTM D445

It is defined as the internal resistance for the lubricating oil to flow at a defined temperature [14,15].

The kinematic viscosity of our oil samples was measured at the RA1k laboratory in Skikda according to ASTM D445-17a by a Cannon-Fenske capillary kinematic viscometer [16].

The objective of this method is to measure the gravity flow time of a given volume of liquid in a calibrated capillary viscometer under a reproducible liquid load and at a precisely controlled temperature. The kinematic viscosity is the product of the measured flow time by the calibration constant of the viscometer [17,18].

2.5 Spectrometry analysis

Spectrometry is the study of the interaction of photos with molecules accompanied by a variation of energy. The quantification of the energy gives the possible values of the energy levels. Depending on the case, it can be absorption, emission or inelastic diffusion [19,20].Emission spectrometry analysis allows to quickly determine the concentrations, expressed in ppm (particles per million) by mass, of the various elements present in oils in the form of additives (calcium, magnesium...), metallic wear particles (iron, nickel, chromium, tin, copper, aluminium...), or various solid contaminants (atmospheric dusts, silicone...).

Emission spectrometry analysis was performed on the used oils, as well as on another new oil that serves as a reference after twenty months of operation (the last sampling) using a RotrOil spectrometer.

Then RotrOil spectrometer is a compact, transportable, and easy-to-use optical emission spectrometer that complies with the requirements of the ASTM D6595-00 standard test method for the determination of metal and contaminant wear in used lubricating oils or used hydraulic fluids by rotating disk electrode atomic emission spectrometry [21].

The spectrometric analysis was performed in the central laboratory (EL HADJAR in Annaba) .

3. Analysis and discussion of the results:

Table 1

The obtained values of viscosity and flash point

Time (Months)	Viscosity (Sct)	Flash point
2	32.69	202
4	33.79	199
6	32.38	198
8	33.35	202
10	33.88	202
12	33.82	204
14	33.92	202
16	34.2	200
18	33.46	202
20	34.07	202

These values are shown in the following figures:

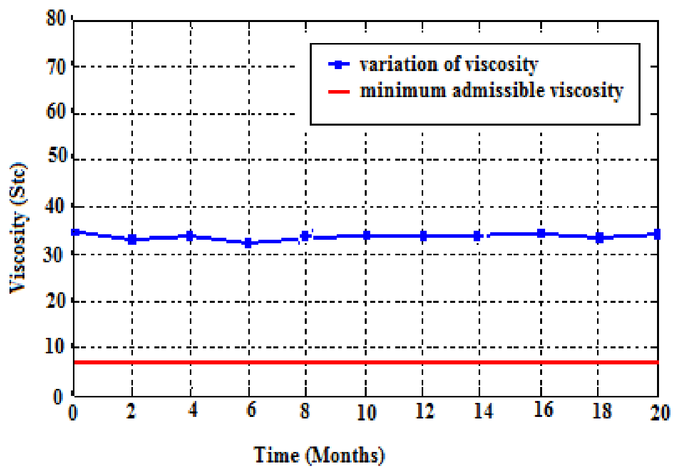

Fig.2. The variation of the viscosity as a function of service time.

The viscosity is the most important parameter that characterizes lubricating oil; it is interpreted in relation to new oil. The viscosity of the studied fresh oil (new) is about 34.62 Sct, according to the standards the minimum admissible viscosity to assume a good lubrication is 20% lower than the viscosity of the new oil [22,23], here the minimum admissible viscosity of the studied oil is about 6.92 cSt.

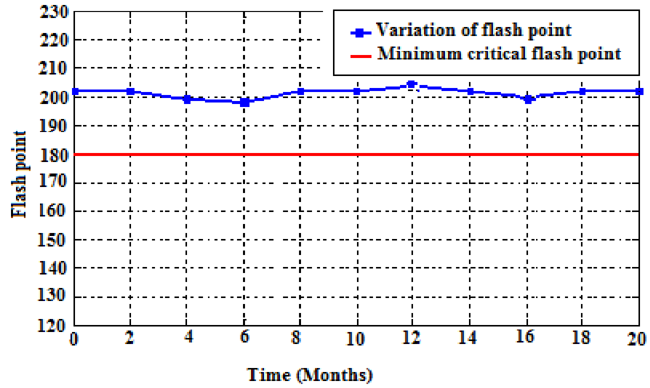

Fig.3. Variation of the flash point as a function of service time

The minimum critical flash point value for a turbocharger oil is below 180°C (<180°C) [24]. The flash point of the studied fresh oil is about 202°C.

From the two figures (2 and 3) it can be seen that the viscosity of the studied oil is higher than the minimum permissible viscosity and its flash point does not reach the critical value which shows that this oil is still performing well and that it ensures a good lubrication.

able.2

The concentrations of the elements of the used oil and the new oil

Wear metal program	New oil (ppm)	Used oil (ppm)
AG	0	0
AL	3	3
B	0	0
BA	1	1
CA	0	1
CD	0	0
CR	0	0
CU	0	1
FE	0	0
MN	0	0
NI	0	0
PB	0	1
SI	3	25
SN	0	0
TI	0	0
V	1	1
Program additive	New oil (ppm)	Used oil (ppm)
NMG*1	1	18
MO*1	7	0
ZN*1	0	0

These values are shown in the following figure:

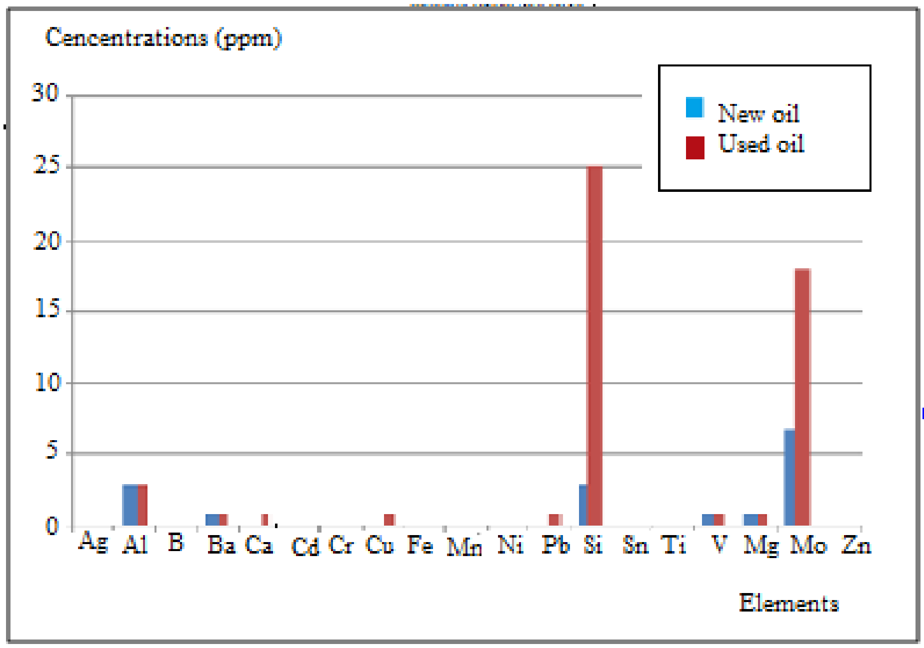

Fig.4. Concentrations of the different elements present in the studied oil.

From figure 4, we can see that there is not a big difference between the concentrations of the elements present in the new oil and the used oil (after twenty months of operation) but there is a remarkable element which is the silicon and its origin is the atmospheric dust.

The concentrations of metallic wear particles (iron, nickel, chromium, tin, copper, aluminium...) are normal but we can mention some elements and their possible origins [23]:

- Aluminium: bearings, pumps, thrust washers.
- Nickel: bearings, turbine blades, valve train.
- Titanium: bearing hub, compressor blades.

4. CONCLUSION

The lubrication in general is an important operation for the preservation of the state of the parts in movement especially the rotating machines which are machines whose lubrication of the various parts must be controlled daily.

The analysis of a sample of oil taken can then be enough to reveal the abnormal wear of one of the components, the bad state of a filter, or the degradation of the lubricant (following an oxidation, pollution, a temperature of use too high, etc).

From the results obtained, the following conclusions can be drawn:

- Viscosity and light point are the two key parameters in a turbocharger oil analysis program, they play an important role in extending its life and improving its performance, therefore, they must be monitored regularly.
- The viscosity and the flash point of the studied oil no longer reach the critical limits, which indicate that our oil is a good lubricant and that it provides good lubrication.
- The viscosity and the flash point of the oils studied no longer reach the critical limits, which tells us that our oil is a good lubricant and that it provides good lubrication
- According to the results of the spectroscopic analysis, the wear due to normal turbocharger operation is considered acceptable while the remarkable element of this analysis (silicon), is related to the operating conditions of the turbocharger (dust).

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Studiu privind eficiența lubrifierii unui turbocompresor industrial

Rezumat: O lubrifiere eficientă este importantă pentru ca turbocompresoarele să funcționeze în mod fiabil. Acest lucru poate fi asigurat prin monitorizarea regulată a stării lubrifiantului utilizat. Analizele lubrifiantului în exploatare pot fi utilizate pentru a monitoriza calitatea funcțională a uleiului, pentru a furniza informații despre uzura care afectează piesele lubrifiate și pentru a îmbunătăți lubrifierea și a mări intervalele de schimb de ulei.

În această lucrare am realizat o analiză a uleiului pentru a confirma că uleiul ISO 32 utilizat pentru lubrifierea turbocompresoarelor este un lubrifiant bun și asigură o bună lubrifiere, pentru aceasta am efectuat o serie de teste convenționale cum ar fi vâscozitatea și punctul de fulgere, în continuare am efectuat și o analiză spectrometrică de emisie și aceasta pentru caracterizarea contaminării acestui ulei

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