Robert GRZEBIENIAK, Zbigniew MATUSZAK
Maritime Academy, Szczecin

APPLYING FUEL OIL SEPARATOR WORKING PARAMETERS TO EVALUATING SERVICEABILITY

Key words

Separator, working parameters, fuel oil, serviceability, measurement.

Summary

The various possible stages of the separator's work, including full and partial readiness to work and unserviceability have been considered. Oil separator transition through each of the working stages has been described. Typical oil separator damages have been specified. It has also been pointed out that there are possibilities to diagnose separators during their working time. The significance of separator starting time until the moment of achieving nominal working parameters has been emphasised. For the selected type of separator, nominal parameter values have been defined. The possibilities of measuring the oil separator working parameters and applying them to diagnose its ability to work have been described.

Introduction

Technical machinery diagnosing, including engine room appliances, is a stochastic, usually two-dimensional process. It can be described in the following way [1, 2]:

$$A(t,\ \tau) = [B(t), C(\tau)];\quad t,\ \tau \in R_+ \tag{1}$$

where:

$B(t)$ – is a diagnostic process element realised during the machinery working process, and

$C(\tau)$ – is a diagnostic process element realised during diagnostic measurement and concluding process.

Thus, the diagnostic process specifies a technical condition of a device based on the diagnostic examination, it may also show the duration time of such states.

A separator during its serviceability may be in either the state of readiness or in a working state (Fig. 1). Possible working states of a separator have been presented in Fig. 1.

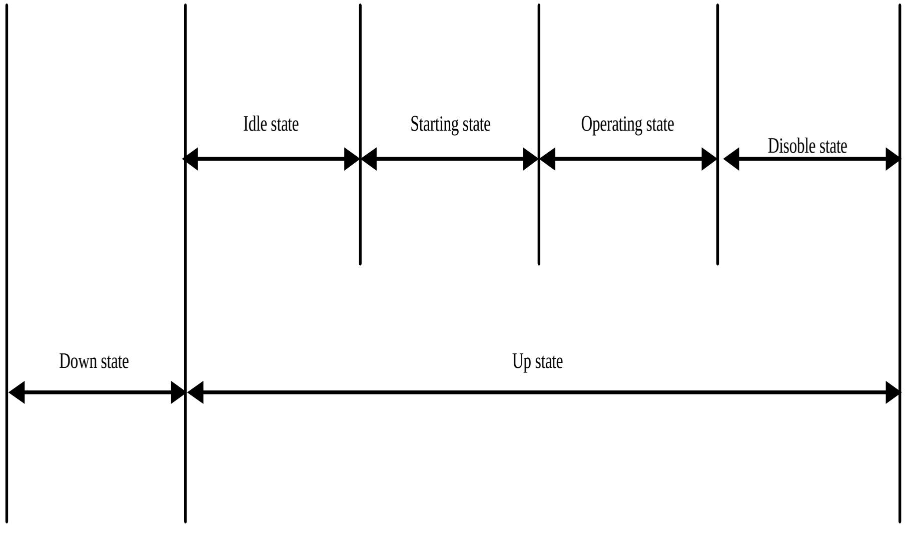

Fig. 1. Possible working states of a separator in details

1. Evaluating of a separator serviceability

Some specific states may be characteristic for a separator and the time of the states is regarded as the time of the states existence. Answering the question concerning the separator's state depends on defining the state of the system and the separator sets. In such case there may appear the following problems:

- specifying the purpose of separator technical state evaluation,
- specifying the form of separator diagnosis,
- showing the separator's technical condition variety during the exploitation,
- describing separator technical condition by means of state features,
- specifying the relation between state features and diagnostic parameters,

- selecting of diagnostic parameters describing the current separator state and its changes during the separator exploitation,
- applying the separator's state diagnosis,
- using diagnostic information in order to make a decision about the range of separator service.

The set of diagnostic parameters is usually created on the basis of initial parameters. The criteria of independence unambiguity and measuring ability have been taken into account. According to [1, 2] selecting the diagnostic parameters during separator's state, evaluating process should contain the following:

- ability of reflecting separator state changes during its exploitation,
- range of information concerning the separator's state,
- adequate diagnostic parameter value's changeability during separator exploitation.

In the possible separator's serviceability evaluation application analysis, the following algorithms have been used:

- minimum diagnostic error,
- information volume,
- correlation with the technical state,
- similarity between diagnostic parameter values.

The above methods make use of the following criterions:

- minimal diagnostic error, that is, parameters whose characteristic is minimal diagnostic error are taken into account,
- maximum information volume, that is parameters of maximum sensitivity to the separator's technical state changes have been selected,
- correlation with the technical state, that is, parameters of the maximum factor value of correlation between diagnostic parameters and the separator's technical states,
- states classification, that is, parameters of maximum the separator's technical states resolution.

Taking into account operating comfort, the authors suggest the use of the *minimum diagnostic error method* based on defining the so called area of covering the density function of conditional parameters $y_j \in Y$ probability specified in [1] by means of the following relationship:

$$D = \mathrm{P}(S_1/y_j)\cdot Q_1 + P(S_2/y_j)\cdot Q_2 \qquad (2)$$

consisting of I type error probability, based on regarding the separator in the serviceability state S_1 as if in a disability state S_2:

$$Q_1 = \int_{y_{gr}}^{+\infty} f(y_j / S_1) dy_j \tag{3}$$

and the II type of probability error, regarding an object in the serviceability state S_1 as if in a disability state S_2:

$$Q_2 = \int_{-\infty}^{y_{gr}} f(y_j / S_2) dy_j \tag{4}$$

Selecting the so called best parameter $y^* \in Y$ is the result of the minimum diagnosis error:

$$y^* = \min_j (D_j) \tag{5}$$

Thus, the problem of choosing diagnostic parameters according to the above methods leads to [3, 4]:

– parameter quality analysis based on the significance of parameter value changes at the separator's technical sets and systems changing and both finding and estimating limiting values y_{gr} according to Bayes least risk criterion with the assumption of errors type I and II,
– quantity analysis based on selecting diagnostic parameters dealing with minimum diagnosis error.

2. Evaluation of the separator's working parameters

In this paper, the analysed diagnostic parameters have been reduced to the ones regarded the working parameters. The reason for this methodological approach was the use of the measuring devices during the diagnostic process, which may be found in the engine room. Thus, the possibility of other diagnostic devices has not been taken into account.

Table 1 contains a list of working parameters for two selected separators.

The table contains rated working parameter values, which when exceeded may lead to shutting off the separator or, in case of safety devices malfunctioning, a faulty fuel oil separating process. Each of the parameters has been given a number, and each parameter measure matches correctly marked places on the separator diagram (Fig. 2) and the diagram of the separated element (Fig. 3).

Table 1. The range of working parameters values for selected *Alfa Laval* separators

Parameter		Oil separator Alfa Laval		Diagnostic availability
No	Name	SU 865	SU 825S	
1	Pressure of the separated element before the booster pump [bar]	0,5÷0,6	0,2–1,0	R
2	Pressure of the separated element behind the booster pump [bar]	4,0	1,8÷3,0	R
3	Temperature of the separated element before the heater [^{o}C]	70÷90	50÷70	R
4	Rotation speed of the separator drum [r.p.m.]	7000	10400	R
5	Temperature of the separated element before the separator drum [^{o}C]	97÷98	87÷90	R
6	Temperature of the separated element behind the heater [^{o}C]	98÷99	88÷91	R
7	Volume stream of the separated element [m^3/h]	5,2÷6,0	1,9÷4,0	R
8	Current intensity of the engine driving the separator [A]	12÷14	7,5÷8,0	R
9	Pressure of the separated element before the separator [bar]	0,4÷0,5	0,2÷1,0	R
10	Pressure of the separated element behind the separator [bar]	1,7÷1,9	1,0÷2,3	R
11	Water pressure of the control circulation [bar]	1,0÷1,4	1,7÷3,4	R
12	Percentage of water before the separating process [%]	-----	-----	RW
13	Percentage of water after the separating process [accepted unit MT]	70÷90	70÷90	RW

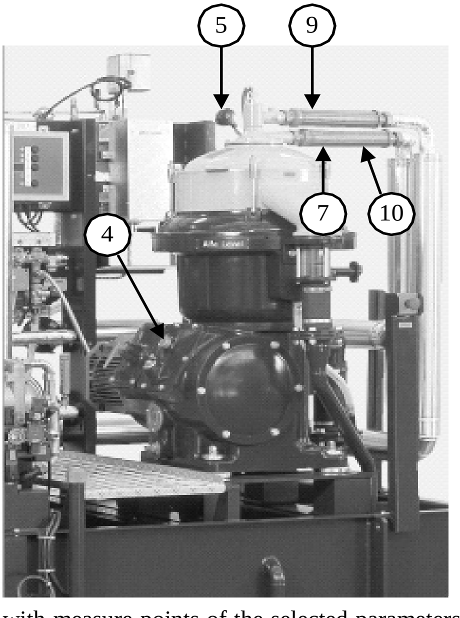

Fig. 2. Fuel oil separator with measure points of the selected parameters marked (4, 5, 7, 9, 10 – see descriptions in Fig. 3)

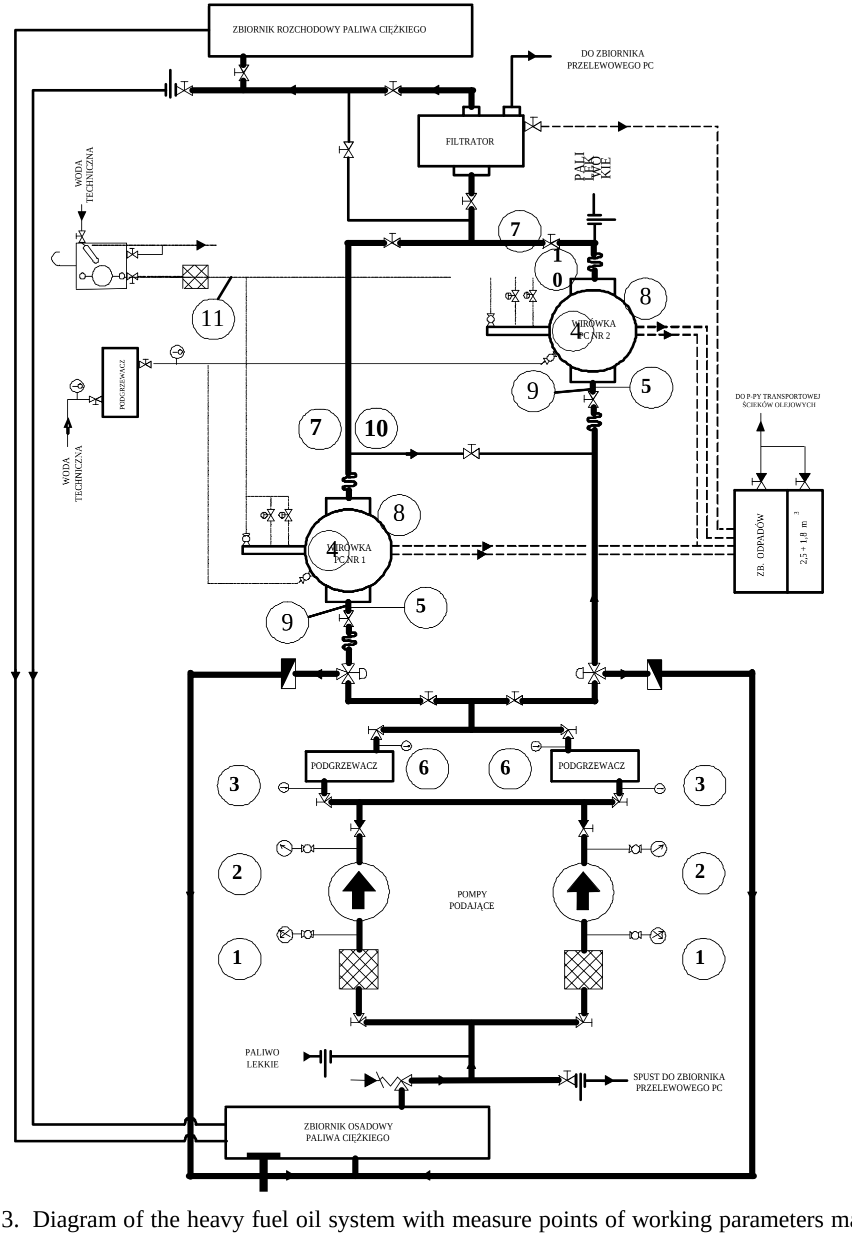

Fig. 3. Diagram of the heavy fuel oil system with measure points of working parameters marked: 1 – pressure of the separated element before the booster pump, 2 – pressure of the separated element behind the booster pump, 3 – temperature of the separated element before the heater, 4 – rotation speed of the separator drum, 5 – temperature of the separated element before the separator drum, 6 – temperature of the separated element behind the heater, 7 – volume stream of the separated element, 8 – current intensity of the engine driving the separator, 9 – pressure of the separated element before the separator, 10 – pressure of the separated element behind the separator, 11 – water pressure of the control circulation

The last column describes diagnostic availability, assumed for analysis, which is regarded for the ease in defining the values of the parameters useful for diagnostic analysis (R – the possibility of keeping observation and reporting parameters while fuel oil or oil separating process; RW – possibility of carrying out observation after the laboratory analysis is over).

The analysis of the separator working parameters shows their high diagnostic availability. This is to be concluded on the basis of the accepted working parameters that may be currently and at any time read from the measuring devices of the separator or inside the separated element.

Conclusions

Separator diagnostics is to assure its failure-free operating. Not so commonly applied diagnostic methods result in some of the separator sub-assemblies getting more vulnerable to damages than others. Due to many years of various separator types observation [4, 5], it may be stated that among the most often damage elements there are the following:

- frictional lining of the centrifugal clutch (in case of damage, the separator drum shall turn too slowly resulting in improper oil separating),
- ring tightening the drum cover (in case of damage, the water closure shall be broken),
- rubber shock absorbing rings (in case of material wear, the separator's operating shall be unequal),
- drum or drum hub tips (in case of damage, the separator's work shall be unequal),
- elements of drive transmission mechanism – bearings, shafts, toothed gear wheels – (in case of damage, the separator's work shall be unequal),
- separator's frictional brake lining (in case of damage, the separator drum shall be rotating too slowly resulting in poor oil separating).

Another very broad issue, which is beyond the scope of the topic presented in the paper, is the problem of the failure of the system devices and elements whose part is the working separator and whose influence on the separator's correct function is very significant [6, 7].

When analysing the separator working parameters, the influence on its technical condition that is the result of the diagnostic process analysis, it is impossible to take into account the influence of the technical condition of the appliance that indirectly affects the separator's working parameters. The pump pressure level depends on its drive quality. Similarly, the separated element temperature shall depend upon the heaters' technical condition (usually a steam heater); thus, indirectly the steam system's technical condition affects the temperatures.

Another problem, which is beyond the scope of the presented material, is working parameter analysis and separator's working diagnosis at the time of actuating the separator, that is, before reaches its full separating ability.

References

1. Niziński S., Michalski R.: Diagnosis of technical obcjects. Wyd. ITTE, Radom, 2002 (in Polish).
2. Żółtowski B.: Fundamentals of machine diagnosis. ATR, Bydgoszcz 1996 (in Polish).
3. Korbicz J., Kościelny J.M., Kowalczuk Z., Cholewa W. (eds.): Diagnosis of processes. WNT, Warszawa 2002 (in Polish).
4. Marine Pollution Prevention Pocket Checklist. Reducing the risk of Port State Control Detentions. Lloyd Register/UK P& I Club 2006.
5. MARPOL: Consolidated edition 2006. International Maritime Organisation, London 2006.
6. Mikołajczak P., Rychlik A.: Diagnostyka, 2003, 28, 79–86 (in Polish).
7. Zachwieja J.: Diagnostyka, 2005, 33, 301–306 (in Polish).

Reviewer:
Andrzej KULCZYCKI

Wybór parametrów pracy wirówek paliwa do oceny ich zdatności

Słowa kluczowe

Wirówka, parametry pracy, paliwo, podatność obsługowa, pomiary.

Streszczenie

Przedstawiono możliwe stany pracy wirówek, uwzględniając stan pełnej zdatności, częściowej zdatności i niezdatności. Wskazano miejsca typowych uszkodzeń występujących w wirówkach oleju. Wskazano na możliwość diagnozowania wirówek w czasie pracy i podkreślono znaczenie czasu rozruchu wirówki do momentu uzyskania parametrów nominalnych pracy. Dla wybranego typu wirówki przedstawiono nominalne wartości parametrów pracy. Opisano możliwość pomiarów parametrów pracy wirówki i wykorzystanie ich do zdiagnozowania jej zdatności.