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MODELLING OF THE OPERATING PERIOD OF A COMPRESSOR UNIT ON A SHIP FROM THE SEISMIC INDUSTRY II PART

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ABSTRACT
A possibility of extending the time between overhauls period of a compressor unit on a ship from the Seismic Industry by using pre-synthesized predictive mathematical models is considered. These mathematical models were created by processing experimental data and refer to cases of before and after overhaul of the Seismic compressor. In the second part, results from the synthesis of predictive mathematical models of the three piston stages of the Seismic compressor are proposed.
KEYWORDS: *Offshore Oil Industry, Seismic Vessel, Seismic Air Compressor, Synthesizing Predictive Mathematical Model, Least Squares Method, Regression Analysis*

1. CHARACTERISTICS AND FEATURES OF THE RESEARCH OBJECT

The first part of the report shows the technological process of creating the high pressure required for the seismic process. The compressed air from the screw compressor has a temperature of 95 °C. Its temperature is then lowered through an air cooler and introduced into the second stage of the Seismic compressor, where it is compressed to 32-36 bar. According to the technological process, air cooling and moisture separation follow after each compression stage until the working pressure for seismic activity is reached. In the third stage of the compressor unit, the air is compressed to 75-85 bar. In the fourth and last stage, the air is compressed to the pressure set by the operator, limited to 175 bar. Only now, after the final cooling and moisture separation, the compressed air enters the seismic air manifold, where it is distributed for the respective seismic purposes [6].

2. INFORMATION PROVISION OF THE MODELLING OF THE PISTON PART OF THE COMPRESSOR UNIT

The necessary data for the mathematical modelling was collected through the Seismic Compressors operation and control software "Phoenix Contact". These were recorded at a fixed mode of operation of the Seismic Compressor with a rotation speed of 1059 min-1 during the operation of the vessel in Seismic mode. Data recording was done every 10 days at the same time of day. 20 data records were collected in the period before and the period after the overhaul of the three stages of the piston side of Seismic Compressor 1.

Overhaul of the piston side of the Seismic compressor is carried out every 8000 operating hours. During this time, all suction and discharge valves on the three stages of the piston compressor are replaced. Pistons are cleaned of deposits and rust, all seal rings and guide rings are replaced. The stuffing boxes of the two piston rods are disassembled and the sealing elements and springs are replaced with new ones [3, 4, 7, 8].

3. PROCESSING DATA FROM THE NEA GROUP SAPS-62E PISTON COMPRESSOR EXPERIMENT

The experimental-statistical study of the dependence between the length of the time of operation of the piston stages of the compressor and the change in their pressures is considered in two cases: when the compressor has undergone an overhaul and before it. The number of data collected during a certain period of time in both cases is the same-20 times and is considered as Factor X = [1 2 3 .....18 19 20].

3.1 Modelling the dependency: operating time of the piston stages of the compressor and pressure in the three stages PK1(2), PK1(3), PK1(4), bar

Results are presented from the scientific search for qualitative, workable models giving the relationship between the operating time of the piston stages of the compressor, considered as the influence of Factor X and the variation of the corresponding pressures during this time. The presentation of the results is for 2nd, 3rd and 4th stage data of the compressor unit after and before overhaul, in the following sequence: data used, obtained mathematical models and satisfying the criteria guaranteeing the quality of the

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models. Only the final results are presented, without showing the multitude of the mathematical modelling structures investigated. [2, 5].

3.1.1 Dependency Modelling: operating time - pressure change after overhaul of stages PK1sr(2), PK1sr(3), PK1sr(4), bar
As a result of the effect of the operating time Factor X, on the pressure in the piston stages of the compressor, the following data were recorded and used for the purpose of modelling after overhaul of the three piston stages:
PK1sr(2)=[34.7 34.4 34.4 34.5 34.5 34.5 33.8 34.2 33.8 33.5 33.3 33.1 32.9 32.6 32.3 32.1 31.8 31.7 31.6 31.5];
PK1sr(3)=[83.5 83.6 83.4 83.5 83.3 83.2 83.0 82.7 82.7 82.5 82.3 82.4 82.0 81.8 81.6 81.4 81.3 81.1 80.9 80.7];
PK1sr(4)=[144.2 143.8 144.1 143.7 143.3 143.6 143.8 143.2 143.0 142.7 142.5 142.2 142.3 141.7 141.4 141.1 140.8 140.5 140.2 139.9];

The structure and coefficients of the mathematical models were determined, giving the relationship between the working time of the piston stages Factor X and the pressure variation of the three stages of Seismic Compressor 1. The results are shown in Table 1. In the first row of the table, the general appearance and structure of the models are given, and in the following, their characteristics and the values of the criteria that should be satisfied for effective use of the Method of Least Squares, respectively Regression Analysis. [1].

Table 1: Results of the research of the effect of the operating time of Seismic Compressor 1, Factor X on the pressure PK1sr(2), PK1sr(3), PK1sr(4), bar, after overhaul

PK1sr(2), PK1sr(3), PK1sr(4)			
Model	PK1sr(2) = 34.8263 -0.0805.x - 0.005. x2	PK1sr(3)= 83.7476 - 0.0876.x - 0.0034. x2	PK1sr(4)=144.1619-0.0596.x-0.0079. x2
Adequacy	Fem= 314.0242 F(0.05;2;17)= 3.59 Conclusion: yes	Fem= 939.2052 F(0.05;2;17)=3.59 Conclusion: yes	Fem= 536.8194 F(0.05;2;17)= 3.59 Conclusion: yes
Standard error SE	SE=0.19324	SE=0.094731	SE=0.18062
Jacques-Berra test for normality	JBem= 1.5846 JBт(0.05;2) = 5.99 Conclusion: normal distribution	JBem= 0.4253 JBт(0.05;2) = 5.99 Conclusion: normal distribution	JBem= 2.1206 JBт(0.05;2) = 5.99 Conclusion: normal distribution
Homoscedasticity according to Glejser test	FFem= 0.0647 Ft(0.05;1;18)=4.41 Conclusion: yes	FFem= 2.9768 Ft(0.05;1;18)=4.41 Conclusion: yes	FFem=3.5182 Ft(0.05;1;18)=.41 Conclusion: yes
Pearson's Ryx	R_lin = 0.98673	R_lin = 0.99551	R_lin =0.99218
Correlation check by the Durbin-Watson test	d = 1.4495 3alfa=5%; dL= 1.201 dU= 1.411 dU<d<4-dU=2.59 Conclusion: no autocorrelation	d = 1.8975 3alfa=5%; dL= 1.201 dU= 1.411 dU<d<4-dU=2.59 Conclusion: no autocorrelation	d = 2.1242 3alfa=5%; dL= 1.201 dU= 1.411 dU<d<4-dU=2.59 Conclusion: no autocorrelation

An analysis of the table shows that the obtained mathematical models describing the relationship between the working time and the change in the respective pressures of the piston stages PK1sr(2), PK1sr(3), PK1sr(4) are adequate and satisfy all the criteria for the effective use of the Regression analysis [1]. According to the models, mathematical prognostics were made in 5 intervals:
prognoza2PK1sr(2) = [30.92 30.6235 30.3169 30.0002 29.6735];
prognoza2PK1sr(3) = [80.4239 80.1916 79.9526 79.7068 79.4542];
prognoza2PK1sr(4) = [139.4188 139.0187 138.6028 138.1711 137.7236];

3.1.2 Dependency Modelling: operating time - pressure change before overhaul of stages PK1sr(2), PK1sr(3), PK1sr(4), bar
As a result of the influence of Factor X, the following data were recorded and used for the modeling, before overhaul of the piston stages of the compressor:

PK1pr(2)=[32.8 32.8 32.8 32.9 32.8 32.5 32.1 31.8 31.6 31.3 31.0 30.6 30.2 29.8 29.5 29.2 28.8 28.3 28.0 27.6];

PK1pr(3)=[82.4 82.3 82.3 82.4 82.4 82.0 81.5 81.1 80.6 80.0 79.6 79.2 78.4 77.5 76.8 76.0 75.3 74.7 74.2 73.7];

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PK1pr(4)=[144.3 143.6 143.5 143.6 141.8 142.8 141.6 140.3 139.7 138.9 138.2 137.3 136.5 135.6 134.2 133.5 132.3 131.8 130.6 129.7];

The results of the study of the influence of Factor X on the pressure variation of the three piston stages of Seismic Compressor 1, before overhaul is given in Table 2.

Table 2: Results of the study of the effect of the operating time of Seismic Compressor 1, Factor X on the pressure PK1pr(2), PK1pr(3), PK1pr(4), bar, before overhaul

PK1sr(2), PK1sr(3), PK1sr(4)			
Model	PK1pr(2) = 33.5307 - 0.1580.x -0.0071. x2	PK1pr(3) = 82.9790 - 0.1111.x - 0.0189 x2	PK1pr(4)=144.9151-0.4056.x-0.0186x2
Adequacy	Fem= 2552.3 F(0.05;2;17)=3.59 Conclusion: yes	Fem=1038.4 F(0.05;2;17)=3.59 Conclusion: yes	Fem=1342.26 F(0.05;2;17)=3.59 Conclusion: yes
Standard error SE	SE=0.11178	SE=0.29313	SE=0.39891
Jacques-Berra test for normality	Jbem= 2.3923 JBт(0.05;2) = 5.99 Conclusion: normal distribution	JBem=1.0807 JBт(0.05;2) = 5.99 Conclusion: normal distribution	JBem= 2.8440 JBт(0.05;2) = 5.99 Conclusion: normal distribution
Homoscedasticity according to Glejser test	Ffem= 0.0647 Ft(0.05;1;18)=4.41 Conclusion: yes	FFem= 0.2014 Ft(0.05;1;18)=4.41 Conclusion: yes	FFem= 1.7647 Ft(0.05;1;18)=4.41 Conclusion: yes
Pearson's Ryx	R_lin = 0.99834	R_lin = 0.99593	R_lin =0.99685
Correlation check by the Durbin-Watson test	d = 2.5697 3alfa=5%; dL= 1.201 dU= 1.411 dU<d<4-dU=2.59 Conclusion: no autocorrelation	d = 1.4309 3alfa=5%; dL= 1.201 dU= 1.411 dU<d<4-dU=2.59 Conclusion: no autocorrelation	d = 2.2663 3alfa=5%; dL= 1.201 dU= 1.411 dU<d<4-dU=2.59 Conclusion: no autocorrelation

The three mathematical models characterizing the pressure in the three piston stages of the compressor unit of the Seismic Ship are adequate and satisfy all the criteria for effective use of the Regression Analysis [1]. Based on them, prognostics were made in 5 intervals of change of the corresponding pressures over the course of the operation time. The same are given below:

prognoza2PK1pr(2) =[27.0728 26.6086 26.1302 25.6376 25.1307];

prognozaPK1pr(3) = [72.2943 71.3688 70.4055 69.4043 68.3652];

prognoza PK1pr(4)= [128.2035 126.9989 125.7572 124.4783 123.1623].

The following plots show, in one coordinate system, the change in pressure in the three stages of the piston compressor: after and before overhaul, in pairs, as well as the values estimated by the models in 5 intervals. A solid line shows the model values, and (*) and (o) show the experimental data. Observations 1 to 20 correspond to the time of data collection, and 21 to 25 are estimated values.

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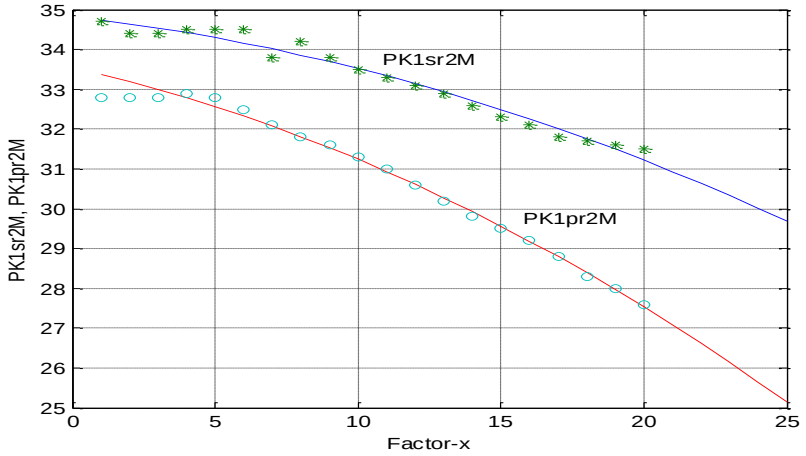


Fig. 1 Second stage pressure change and prognosis

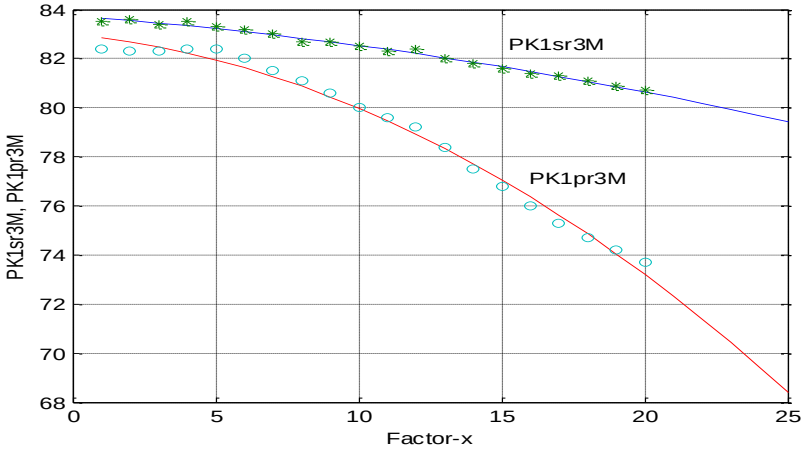


Fig. 2 Third stage pressure change and prognosis

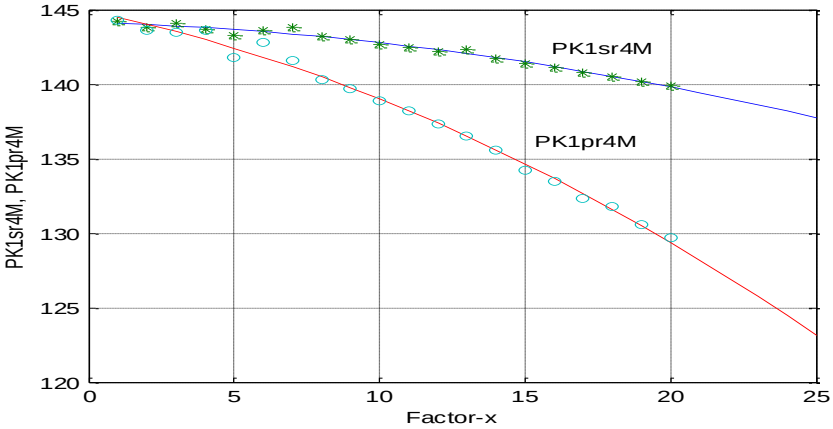


Fig. 3 Fourth stage pressure change and prognosis

4. CONCLUSION

- As a result of the scientific search for appropriate mathematical models approximating the dependence between the operating time of the three piston stages of Seismic Compressor 1, 2nd order models were selected. These models are adequate and meet the requirements for the implementation of the Regression analysis.

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- Based on the models, prognostics were made for the pressure change in the piston stages of Seismic Compressor 1, in 5 intervals.

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