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Influence of the Water Quality on the Reliability of Centrifuge Pumps for Natural Gas Adsorption Plants

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Abstract

This work analyses the influence of the water quality on the reliability of the rotary pumps in the gas drying-treatment plants. The study was done considering two water qualities depending on foreign bodies which increase the abrasion on the rotary pump components.

Key words: *gas adsorption plants, water quality, centrifuge pump, reliability.*

General Data on Centrifuge Pumps Operated in Natural Gas Adsorption Drying-Treatment Plants

The first types of natural gas adsorption drying-treatment equipment had water as element that helps recovery of the heat partially consumed in the process of gas heating due to regeneration of adsorption environment. Thus, the water cycle has as aim the recovery of heat given by regeneration gases at the exit from adsorption vessel, recovery made in water-gas double-tube heat exchangers (water-gas coolers), followed by reheating in water chamber. The purpose of reheating is to rise the water temperature so that the gas regenerating preheating (in pre heaters) is as good as possible. Before recirculation on the same line water has to be first cooled - process taking place in the cooling towers. Here is the place where the most part of the water is waste due the evaporation or wind.

Due to the fact the circuit has major water waste as well as the fact that supplied water is not softened the pipes and equipment on this line get clogged. These facts lowered the efficiency of thermal transfer and made parts of equipment useless (the pre heaters for instance).

Practice has proved that using water as carrier generated a lot of defects and high energy consumption. Theoretical calculation and practice showed that not using water chambers reduces the consumption by 45-50 %. Once the water chambers failed and the chance of replacing them was impossible, the functional role of the pumps ceased too. Switching to gas heating without front plate cooling of the water chamber (pseudo-direct heating) resulted in decreasing of thermal energy consumption and no energy consumption thus the energy independence of installations was accomplished.

Reliability Analysis

Centrifuge pumps life depends mostly of water quality they pump and it is usually 3 to 6 years. On establishing this period it is taken into account the fact that all parts are replaced at least once - pump body has the longest period of life.

Hypothetically, the life of pumps depends on the nature of the liquid they pump through and on the quality of maintenance works; hypotheses valid if considered that the pump producers supply good quality parts.

Theoretically, the nature of pumped liquids will affect the hydraulic part of the centrifuge pumps and the quality of maintenance works that of the mechanical one. In practice uneven wear of the rotor results in vibrations transmitted to the ball bearings followed by premature defects of the latter.

In this paper we shall demonstrate that between the two causes of the defects there is a close connection and for this purpose we will consider the case of the centrifuge pumps from Glavanesti Drying Gas Station. The case is self-evident by the large quantity of foreign body in suspension in the water.

Improvement of water quality implies two situations caused by using two water sources of different qualities:

- poor quality until the autumn of 2006;
- better quality after 2007.

This analysis considers the evolution of reliability during the period 2003-2006.

The duration of pump repairing do not exceeds 8 hrs period in which the back-up pump is used, that is why a situation when repairing means days this time is not imported; out of this we consider studying of maintenance period unimportant.

But we have to mention that there are no records of the moments of the day when the defects occur, because in case of first pump failure the back-up pump starts.

The defects have mainly consisted (in descending order of coming out frequency) of failure of ball bearings, driving shaft, rotor, gland and casing in the end.

The moments were after 78, 112, 243, 321, 457, 513, 653, 820, 973, 1106, 1246 days.

The moments of defects coming out had the following meanings:

Table 1. Meanings of moments of defects coming out

Time of defect	Meaning of defect
78, 112, 243	Ball bearings failure
321	Ball bearings and gland failure
457, 513	Ball bearings failure
653	Ball bearings, shaft and coupling key failure
820	Gland and ball bearings failure
973, 1106	Ball bearings failure
1246	Rotor, shaft, ball bearings, casing ball bearing

Using the following program written in Matlab language:

```
t=[78 112 243 321 457 513 653 820 973 1106 1246]';
disp('Weibull parameters and confidence intervals);
[parmhat,parmci]=wblfit(t);
wblplot(t);
```

```
disp('Weibull test Kolmogorov-Smirnov');
a=parmhat(1);b=parmhat(2);
[h,p,kv]=kstest(t, [t  wblcdf(t, a,b)]);
y=wblcdf(parmhat(1),parmhat(2));
xx=0:1:max(t);yy=1-exp(-(xx./a).^b);
plot(xx,yy,'g-');
grid on;
title('failure data verification to Weibull law');
hold off; *
```

data are checked and written into Weibull distribution law. The law is used for the coefficients: a=655.92 and b=1.52.

Weibull law has the distribution function form:

$$F(t) = 1 - e^{-\left(\frac{t}{a}\right)^b} \tag{1}$$

Reliability function is:

$$R(t) = 1 - F(t) \tag{2}$$

Frequecy (probability density) function is:

$$f(x) = ba^{-b}x^{b-1}e^{-\left(\frac{x}{a}\right)^b} I_{(0,\infty)}(x) \tag{3}$$

In fig. 1 is demonstrated the conformity with the Weibull distribution law and in fig. 2 there are presented the curves of reliability and non reliability.

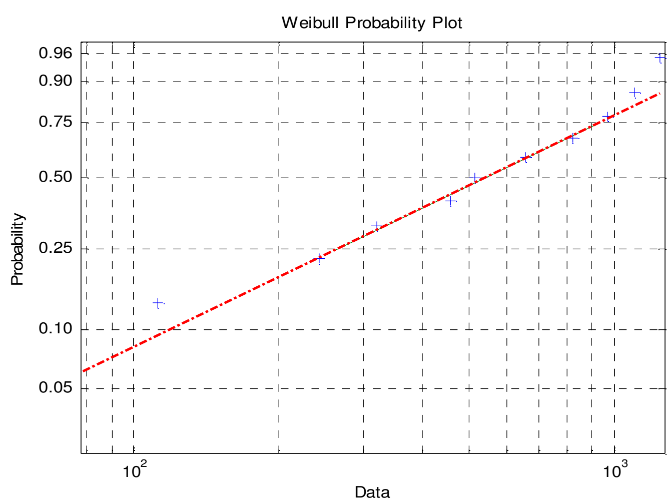

Fig. 1. Checking the failures of centrifuge pump with the Weibull Distribution Law

In fig. 2, the curve of failure probability is fitted with the Kaplan-Maier empiric distribution law. The confidence interval has the value of: 0.05 and is represented empirically.

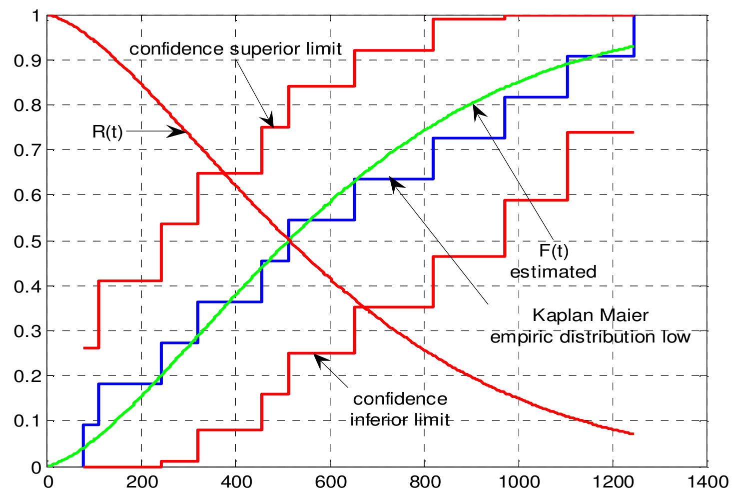

Fig. 2. Distribution law and reliability curve of the centrifuge pump from SUG Glavanesti

Using the following program written in Matlab language:

```
t=[78 112 243 321 457 513 653 820 973 1106 1246]
y=wblpdf(t,655.92,1.52);plot(t,y,'b');hold on;grid on;
Xlabel('time[days]');
Ylabel('f(t)');
title('Weibull distribution law, probability density (frequency) function');
```

we can see the probability density function (fig. 3)

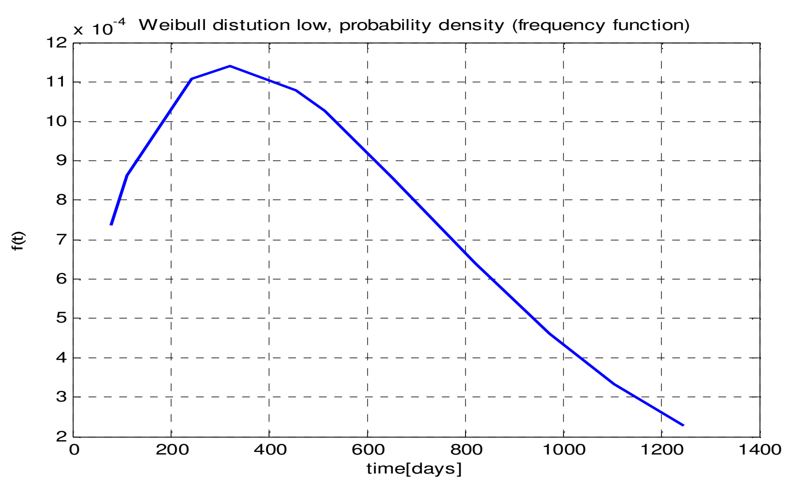

Fig. 3. Probability density of failures

In fig. 2, one can see the curve of failure frequency for the parameters *a* and *b* calculated before.

As it can be seen, in the first period of life the failure frequency increases. It means that this period corresponds to the lapping period.

Since the quality of water changed (autumn of 2006) we can say that the function of the centrifuge pump changed too. The better quality of water made the wear of the rotor be less intense. This fact has as result no lost of rotor balance and improvement of shaft and ball bearings functioning.

In figs. 3 and 5, are presented the rotor and centrifuge pump shaft after service. One can see the edge of the rotor is damaged due to abrasion and lack of material unevenness. It was measured 0.48 mm coaxial deviation to an initial one of 0.01 mm.

After the new pump installation (begining of Febrary 2007) just two failures of the ball bearing occured, the rest of the parts being in good state fact that increases the value of reliability to 0.956 for the first year compared to 0.9123 for the first period inthe first case. Abrasion has a strong effect on the sealing/waterproofing system that results in premature failure of ball bearings.

Fig. 3. Centrifuge pump rotor

Fig. 4. Centrifuge pump shaft

The study was done on condition that all the maintenance actions were kept the same for the two periods.

Finally we can say that the liquid abrasion is the decisive factor for the centrifuge pump reliability when the maintenance actions are kept.

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Influența calității apei asupra fiabilității pompelor centrifuge din instalațiile de uscare-tratare gaze naturale

Rezumat

Articolul analizează infuența calității lichidului vehiculat asupra fiabilității pompelor centrifuge. Pentru această analiză au fost alese două perioade de timp, perioade în care caltatea apei a fost diferită. În prima perioadă s-a folosit o sursă de apă de suprafață cu o cantitate mare de impurități mecanice iar în a douaperioadă o sursă freatică de apă.