Analysis of the Hydraulic Pump Flow Efficiency

Zdenko Tkáč, Plamen Kangalov, Ján Kosiba, Ľubomír Hujo, Juraj Tulík

Abstract: This present paper deals with analysis of the hydraulic pump type UD 25 flow efficiency by application of ecological hydraulic fluid MOL Farm UTTO Synt in the gear-hydraulic circuit of tractor Zetor Forterra 114 41. Analysis was performed with calculation of standard deviation and calculation of the hydraulic pump flow efficiency. The flow efficiency of the hydraulic pump after the statistical analysis for all measurements is higher.

Key words: statistical analysis, hydraulic device, standard deviation

INTRODUCTION

The hydraulic devices have wide application in powerful mechanisms of an agricultural and forest machines as well as in many other areas. The development of modern hydraulic components is aimed at increasing transferred power, decreasing energy severity, minimizing environmental pollution and increasing technical durability and machine reliability (Tkáč et al., 2008, Cvíčela et al., 2008).

Due to advantages in renewability and environmental acceptability, bio-sourced and biodegradable hydraulic fluids are increasingly used in fluid power applications (Shick, 2008). In this time, the difference between of conventionally produced fluid and ecological fluid two or three times of the price. Therefore is necessary to look for new solutions how to extend the technical life, which could have the effect on their increase use (Tkáč et al., 2010).

Most current lubricants contain petroleum base stocks, which are toxic to environment and difficult to dispose of after use (Kučera et al., 2011). Over 60 % of the lubricants used in the world are lost to the environment. Vegetable oils have a capability to contribute towards the goal of energy independence and security since they are a renewable resource (Campanella et al., 2010).

At the present time, hydrostatic systems are widely dispersed in the industry. They provide various types of motions. The power transmission is performed by means of hydraulic fluid. Hydraulic fluid needs service and observation of operating parameters (Majdan et al., 2008). From the viewpoint of hydraulic fluid utilization in a machine, it is important to know the operating characteristics of a fluid, i. e. to know the effect of fluid on the technical condition of hydraulic system components (Tkáč, 2008 et al., Jablonický, 2007 et al.).

MATERIALS AND METHODS

The test is performed by comparing of the technical condition of the hydraulic pump before and after the test. For the evaluation of the technical condition of the hydraulic pump used the method of technical diagnostics. For the hydraulic pump is most accurate method the measurement of the flow characteristics.

From the measurement of the flow characteristics are determined of the hydraulic pump flow efficiency by the following equation (Tkáč et al., 2010):

$$\eta_{pr} = \frac{Q}{V_G \cdot n} \cdot 100 \qquad (1)$$

Q – output flow rate (dm^3*rpm)
V_G – geometrical volume of hydraulic pump (dm^3)
n – nominal rotation speed of hydraulic pump (rpm)

The flow efficiencies were monitored on a new hydraulic pump, after completing 450 engine hours of the tractor and after completing 900 engine hours of the tractor. The flow efficiencies were followed on the laboratory device at the speed of hydraulic pump n = 1,500 rpm (nominal speed of hydraulic pump) and the pressure of p = 20 MPa.

Statistical analysis

The standard deviation σ is defined as the positive square root of the scatter. Calculate the standard deviation, if we have a complete set of possible states of the process (system). Standard deviation or root of mean square is in probability theory and statistics, the statistical measure of the dispersion. Simply said refers to how widely distributed are the values in a set (Hill et al., 2006).

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{2}$$

n – range of the basic statistical set

x_i – individual values of the basic statistical set

$\bar{x}$ – arithmetic average of the statistical set

We say that a continuous random quantity *x* has a normal (Gaussian) distribution with parameters $\bar{x}$, σ^2 if density is:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}}.e^{-\frac{(\bar{x}-\alpha)^2}{2\sigma^2}} \quad \text{for} \quad x \in R_1, \alpha \in (-\infty,\infty), \sigma > 0 \tag{3}$$

e – base of the natural logarithm

σ – standard deviation

$\bar{x}$ – arithmetic average of the statistical set

If a variable *x* has a normal distribution with parameters $\bar{x}$, σ^2, then after transformation:

$$Z_i = \frac{x_i - \bar{x}}{\sigma} \tag{4}$$

σ – standard deviation

x_i – individual values of basic statistical set

$\bar{x}$ – arithmetic average of statistical set

z_i – variable with normal distribution

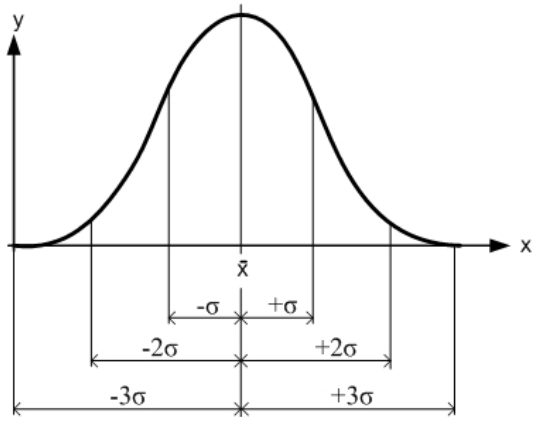

Fig 1. Normal distribution

When selecting of a value from the range –1σ, +1σ the probability of a standard normal distribution is 68.27%.

When selecting of a value from the range –2σ, +2σ the probability of a standard normal distribution is 95.46%.

When selecting of a value from the range –3 σ, +3σ the probability of a standard normal distribution is 99.73% (Figure 1).

When using a larger range is less likely that the process will by done wrong including case when the measured value are outside of control limits and they are affect by random

variations. The use of a wide range makes it difficult to identify the changes in the process, which is non-random and must be ascertained (Figure 1).

We chose to evaluate will be the data of -1σ and +1 σ so that we obtain a values closest to the nominal pressure of the hydraulic pump (p = 20 MPa). When choosing of -1σ and +1 σ is credibility of the results 68.27%. From this statistical sample set of the values, were calculated the flow efficiency of the hydraulic pump. Figure 3 shows the flow efficiencies of the hydraulic pump after the statistical processing.

RESULTS AND DISCUSSION

Figure 2 shows the measurement flow efficiency of hydraulic pump and flow efficiency after statistical analysis.

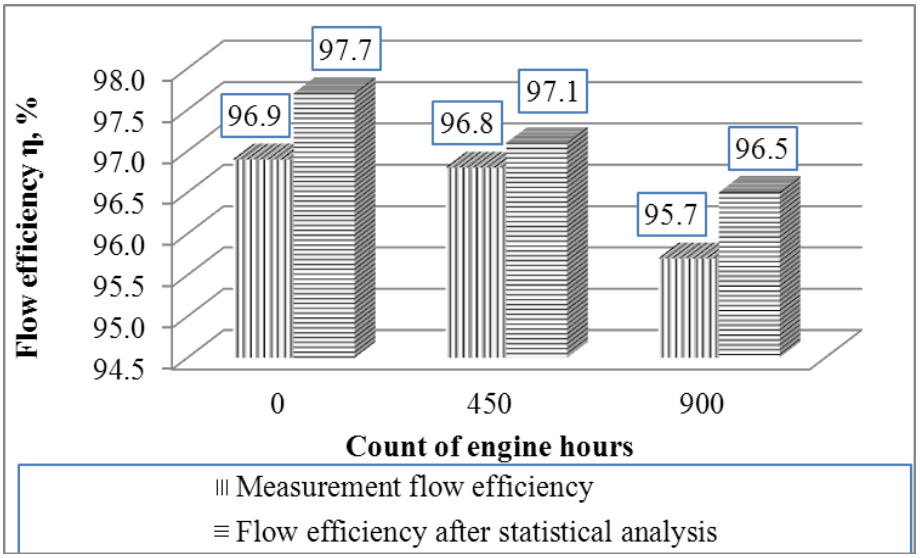

Fig. 2 Measurement flow efficiency and flow efficiency after statistical analysis of hydraulic pump

From comparison of the measured results and the results after the statistical analysis follow that the trend of the changes of the flow efficiency not occur. The flow efficiency of the hydraulic pump after the statistical analysis for all measurements is higher. This difference is caused by the fact that the results are selected of 68.27 % of the measured values from the statistical file.

CONCLUSION

In this paper, there are presented the results of testing the synthetic oil MOL Farm UTTO Synt operating in the gear-hydraulic circuit of Zetor Forterra 114 41, one of the best sold and most used tractors in Slovakia. Measurement of flow characteristics of the hydraulic pump was performed on the experimental laboratory hydraulic device designed at the Department of Transport and Handling, SUA in Nitra. Flow characteristics of hydraulic pump have minimal downward trend. The test was carried out in cooperation between the Department of Transport and Handling, SUA in Nitra and Slovnaft, a.s..

ACKNOWLEDGEMENTS

Supported by the Ministry of Education of the Slovak Republic, project VEGA 1/0857/12 “Reduction of unfavorable impacts of agricultural and transport machinery on environment”.

The research leading to these results has received funding from the European Community under project no 26220220180:

Building Research Centre “AgroBioTech”.

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