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THE RELIABILITY INDICATORS OF THE INDUSTRIAL SYSTEMS

The more the industrial equipment has a higher value and a high technical complexity, the more complex is the analysis of the economical efficiency of its use. In these conditions, it is very important to know which are the expenses that the user has to make to maintain in a functioning state the equipments in order to realize the proposed incomes, and also the expenses that the equipment can make in normal conditions of exploitation.

1. Expenses with the preventive maintenance

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The preventive maintenance represents the totality of the works necessary to prevent the loss of the equipment's working capacity. The operations specific for the preventive maintenance are: oiling works, adjustment, filters cleaning, chains and belts stretching etc. and they are ordered by the designer in the technical book of the product. So, the works' volume in the preventive maintenance is practically dictated by the designer as a result of the technical level of the adopted solutions.

The total expenses made with the preventive maintenance reported to the total volume of work made by the machine represent one of the economical indicators of reliability and they are called specific expenses for the preventive maintenance.

$$_{mp} = \frac{\sum c_{mp}}{T_{kol}} lei / ore$$

where: c_{mp} – the sum of the expenses with the preventive maintenance until the exhausting of the machine's resource (lei); T_{tot} – total resource of the machine (working volume in hours made until the resource exhausting).

2. Expenses with the good functioning (expenses specific for restarting a machine after the accidental failures)

The expenses specific for repairing the exploitation failures or the expenses specific for the good functioning represents the most significant economical indicator of the equipments' reliability.

This indicator s defined as a report between the total expenses made with repairing of the exploitation failures and the total volume of work:

$$c_{mos} = \frac{\sum c_{mos}}{T_{kol}} lei / hour$$
(2),

where: cmce - total expenses made with repairing of the exploitation failures, lei;

 $T_{tot.}$ - total volume of work, hours. $C_{mce} = C_{ps} + C_{ats}$ (3)

where: $C_{p\$}$ - expenses with the sparing parts, lei;

Cats - expenses with technical assistance and service, lei.

3. Expenses with the corrective maintenance

During the life time of a machine more complex repair works can be executed. This is the reason why the expenses with the corrective maintenance are reported to the working volume - hours - executed by the machine from the purchase until the shut-down.

$$c_{gr} = \frac{\sum C_{r}}{T_{ping!}} (lei/hour)$$

where: C_{ri} – total expenses with the repairs on the entire life time of the machine; $T_{tot.ef.}$ – working volume of the machine on the entire machine's life time, hours.

4. Expenses with the fuel;

The expenses with the fuel are determined as a report between the fuel consumption made for realizing a certain work volume:

$$c_{e} = \frac{C_{e} \cdot p_{m}}{T_{m}} (lei/h)$$

where: C_c – the registered fuel consumption, 1; T_{tot} – the work volume, based on which the fuel consumption was made, h; P_m , – fuel unitary price.

5. Expenses with the retribution of the machine operator

They are determined based on the tariffs or wage (negotiated):

$$c_{\tau} = \frac{S}{n_{\tau}} (lei \ l \ hour)$$

where: S - monthly wage of the machine operator, lei/month; ne - medium number of working hour monthly, hours/month.

6. Specific expenses with the conservation and transport maintenance

This indicator, to which no importance is shown regularly, has a considerable importance at some equipment, especially the complex ones.

Specific expenses with the conservation and transport maintenance are determined as a report between the total expenses with stocking, conservation and transportation and the total volume of work:

$$c_{st} = \frac{C_{st}}{T_{st}} (lei / hour)$$

,

(1),

(4)

(5)

(6)

(7)

where: C_{st} - total expenses with stocking, conservation and transportation, lei; T_{tot} - total volume of work, hours.

7. The incomes realized with the equipment

The equipment holders who made final products with their machines will find that the incomes made are influenced in a big way by their reliability.

The specific expenses in the case of using own equipment are determined as following:

$$c_{\mathbf{M}} = \frac{C_{\mathbf{c}} + C_{\mathbf{mce}} + C_{\mathbf{mp}}}{T_{\mathbf{bi}}} + c_{\mathbf{a}} + c_{\mathbf{si}}(\operatorname{lei}/h)$$

where: C_e – total expenses with the fuel, lei;

 C_{mce} – expenses with sparing parts, fees for repairing the accidental failures and for repairs, lei; C_{mp} – expenses with the total technical maintenance, lei; c_a – specific expenses with the expenses in equipment; c_{st} - specific expenses with stocking; T_{TOT} . –total volume of work made by the equipment (h).

8. The influence of the reliability level on the final product's price

Because of the low reliability level of some equipment, the maintaining expenses, the repairing expenses ratio and the amortization represent 50-70% from the fee.

On the other hand, when establishing the fee a profit ratio is consider (maximum 10%), which ensures the supplier the possibility to reinvest. As a result, the value of the fee will be higher.

Example:

Take into consideration 2 types of equipment A and B, A having a low reliability level, and B a high reliability level. After complex reliability trials, in exploitation conditions, the following dates were obtained:

Equipment A: selling price 30,000,000 lei, medium time of good functioning 20 hours, medium time of immobilization for repairing 2.5 hours, medium cost of intervention 120,000 lei, medium productivity per hour 3t/hour, annual volume of works made 150 hours, specific consume of fuel 3.5 l/t, retribution of the operating personnel 2000 lei/hour, technological losses 4.5%, expenses with the preventive maintenance 10,000 lei/hour.

Equipment B: selling price 300,000,000 lei, medium time of good functioning 150 hours, medium cost of intervention 300,000 lei, medium productivity per hour 10t/hour, annual volume of works made 600 hours, specific consume of fuel 1.7 l/t, retribution of the operating personnel 5000 lei/hour, technological losses 1.8%, expenses with the preventive maintenance 80,000 lei/hour.

Incomes made: $V_{TOT} = W_h x T_{TOT} x C_P \cdot T_1$ lei/year, where:

 W_h – equipment's productivity per hour; T_{TOT} – annual working volume, hours; C_p - product's price, lei/tone; T_1 – work's tariff in % from the production.

Considering that a tarrif of 15% from production is requested, we have:

 $V_1 = 3 \ge 150 \ge 200\ 000 \ge 0.15 = 13\ 500\ 000\ 1ei$

 $V_2 = 10 \ge 600 \ge 200\ 000 \ge 0.15 = 180\ 000\ 000\ lei$

Expenses:

- Expenses with the repairs of the failures

$$C_{\bullet} = \frac{T_{\text{ror}}}{t} \cdot C_{\text{mer}} (lei)$$

where:

(8)

 $C_{mce}\xspace$ – specific expenses with the repair, lei/def,

 t_m – medium time of good functioning, hours.

$$C_{\bullet_{a}} = \frac{150}{20} x 120000 = 900000$$
 $C_{\bullet_{a}} = \frac{600}{150} x 300000 = 1200000$

- Fuel expenses:

 $pm = 350 \text{ lei/l}, C_{CA} = 3,5 \text{ x } 150 \text{ x } 3 \text{ x } 350 = 551250 \text{lei}, {}^{C}c_{B} = 1,7x700 \text{ x } 10 \text{ x } 350 \text{ - } 4165000 \text{lei}$

Preventive maintenance expenses:

 $C_{mpA} = 10000 \text{ x } 150 = 1500000 \text{ lei}, C_{mpB} = 8000 \text{ x } 600 = 4800000 \text{ lei}$

- amortization:

 $A_1 = 30000000 : 10 = 3000000$ lei, $A_2 = 300000000 : 10 = 30000$ 00 lei

- Stocking expenses. The stocking expenses are approximately equal and represent the retribution of a maintenance worker for 3 days. Considering the hour tariff of the maintenance worker equal to 2 lei/hour:

 $C_{mps}^{A} = C_{mps}^{B} = 2000 \text{ x } 24 = 48000 \text{ lei}$

- expenses with the retribution of the operating personnel:

 $C_{ret}^{A} = 2000 \text{ x } 150 = 300000 \text{ lei}, C_{ret}^{B} = 5000 \text{ x } 600 = 3000000 \text{ lei}$

Total annual expenses;

 $C_{Ta} = C_e + C_c + A_a + C_{mps} + C_{ret}$ (thousand lei)

 $C_{Ta}^{A} = 900 + 551250 + 1500 + 3000 + 48 + 300 = 6300$ thousand lei

 $C_{Ta}^{B} = 1200 + 4165 + 4800 + 30000 + 48 + 3000 = 43213$ thousand lei

To these expenses are added the expenses with debts to the state budget, insurances, transfer etc., expenses which represent approximately 70% from the C_{Ta} expenses. The real total expenses are:

 $C_A = 1,7 \ge 6300 = 10710$ thousand lei, $C_B = 1,7 \ge 43713 = 74312$ thousand lei

The gross profit made by the two equipment:

 $P_A = 13500000 - 10710000 = 2790000$ lei/year, $P_B = 180000000 - 74312000 = 105688000$ lei/year

It results that while the equipment C_A makes a gross profit of 27,900,000, equipment C_B makes 105,688,000.

To cover the non-performant expenses for the equipment C_A a tariff of 15% of the production was paid. This tariff was adopted by the equipment C_B , although with a tariff of 8-9% it would make a gross profit of 30 million lei annually.

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Поступила в редколлегию 15.05.08