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ECONOMIC EVALUATION OF THE EFFICIENCY OF UPGRADING THE STAND FOR ENGINE RUNNING-IN

Abstract

Introduction. Existing stands for running-in of repaired engines require modernization, which will reduce its duration and save fuel and energy resources. The issue of determining the amount of profit from the implementation of this scientific development requires a detailed feasibility study due to the fact that the run-in is only one of the many operations for engine repair, and as a service is not provided separately.

The purpose of this work is to calculate interrelated technical and economic indicators and determine the feasibility of

investing in the modernization of the control device of the rolling stand.

Methods. As research methods, general logical methods of cognition (analysis, synthesis), a calculation-constructive method are used. The information base of the study was the experimental data of the enterprise with an annual repair program for 737 tractor engines.

The aim of the research is to calculate the interrelated technical and economic indicators (physical indicators, initial cost indicators, criteria for evaluating the effectiveness of investment in a project) and determine the feasibility of investments in upgrading the running-bench control device.

Results. The obtained values of the criteria indicators of capital investment efficiency during the modernization of the control device for the rolling stand indicate the feasibility of implementing the project.

Discussion. The proposed method can be used by repair companies when justifying decisions on upgrading stands for engine running-in.

Since the factories are equipped with obsolete break-in stands that do not correspond to farm equipment, they require replacement. The absence of modern break-in-brake stands at repair facilities may cause a refusal to issue them a production license and product certification.

In further studies, it is important to establish the dependence of changes in the costs of maintenance and repair during operation in production conditions of engines run-in on a modernized stand and on a non-modernized one.

Keywords: economic assessment, modernization, bench running, engine, technical condition.

Introduction.

The maximum effect when upgrading the existing run-in stand of an enterprise that repairs automotive engines can be achieved by replacing the control device, which provides operation in manual mode or according to a strict program, with a more advanced one, which allows running-in engines depending on their technical condition [1; 2].

However, the cost of new equipment is usually higher, which may cast doubt on the feasibility of such a replacement.

Due to the fact that running-in is only one of the numerous operations for engine repair [3; 4], and as the service is not provided separately, it is not easy to determine the amount of profit from the introduction of scientific development, so this issue requires a detailed feasibility study.

Analysis of recent research and publications.

Some authors suggest multiplying the difference in specific direct costs by the projected volume of production. In our opinion, this is not quite correct, since the increase in labor productivity caused by the proposed improvement of the stand leads to a reduction in cost. At the same time, the full annual effect should take into account changes in the amount of value added tax, as well as the environmental effect by reducing the consumption of diesel fuel and reducing the environmental tax [5].

Purpose.

The purpose of the work is to calculate interrelated technical and economic indicators (natural indicators, initial cost indicators, criteria for evaluating the effectiveness of investment in the project) and determine the feasibility of investing in the modernization of the control device of the rolling stand.

Research methodology.

The research methods used are General logical methods of cognition (analysis, synthesis), and the computational and constructive method. The information base of the study was made up of experimental data of the enterprise with an annual repair program for 737 automotive engines. The initial data is shown in table 1.

The project provides for the use of a new stand control device for running-in of diesels with control of their technical condition by the power of mechanical losses.

For the basic version, we take the Ki-5274 GOSNITI rolling stand, which is widely used in repair production [6].

The implementation of a stand control device for running in an internal combustion engine with control of their technical condition by the power of mechanical losses, taking into account the oil

temperature and the speed of changing load modes, allows automating the process and reducing the average duration of running in engines by 15%, saving fuel and energy resources and reducing environmental pollution [7; 8].

Table 1. Initial data for calculating the economic efficiency of upgrading the YAMZ-236M engine run-in control device*

Name of indicators	Ed. ed.	Table of symbols	Basic version (1)	Projected option (2)
Time of preparation and running-in of one YAMZ-236M Engine including:				
cold run-in	hour	t	2,98	2,75
hot run-in without load	hour	t_x	0,85	0,71
hot run - in under load	hour	t_{BH}	0,17	0,15
	hour	t_{TH}	0,58	0,49
The shift factor	-	K_{CM}	1,0	1,0
Running-in expense of 1 engine:				
- diesel fuel	liter	D_T	22,5	19,1
- M10B ₂ oils	liter	M	2,9	2,5
Conversion factor from liters to kg:				
- diesel fuel	-	$K_{\text{ГД}}$	0,84	0,84
- oils	-	$K_{\text{ГМ}}$	0,86	0,86
Installed capacity of current collectors	kW	N	160,0	160,5
Additional capital investments	rub.	ΔK	-	6800

*Source: author's development.

All indicators are calculated using the following formulas [9; 10] for two variants – basic (1) and projected (2).

Annual production program (V), units determined by the formula:

$$V = (t_{\text{CM}} \times k_{\text{CM}} / t) \times T_{200}, \quad (1)$$

where

t_{CM} – shift working time, hour (8);

k_{CM} – coefficient of working shift time utilization ($k_{\text{CM}} = 1,0$);

T_{200} – the number of working days in the year

The annual production program depends on the time of preparation and running-in of a single engine (including cold running-in, hot running-in without load, and hot running-in under load).

Labor costs of workers (3T), h, we define from the expression:

$$3T = \frac{n_p t}{k_{\text{CM}}}, \quad (2)$$

where

n_p – the number of workers, people ($n_p = 1,0$);

t – time of preparation and running-in of one engine, h.

Labor productivity (ПТ), PCs / h, we find from the ratio:

$$\text{ПТ} = \frac{V}{3T}, \quad (3)$$

where

V is the annual production program, PCs.

Increase in labor productivity, % :

$$\Delta \text{ПТ} = \frac{\text{ПТ}_1 - \text{ПТ}_2}{\text{ПТ}_1} 100. \quad (4)$$

Diesel fuel consumption (B_H), kg, is determined by the formula:

$$B_H = b_T \times V, \quad (5)$$

where

b_T is the consumption of diesel fuel for running-in of one engine, kg. oil consumption (B_M), kg, is determined by the formula:

$$B_M = b_M \times V, \quad (6)$$

where

b_M is the oil consumption for running-in of one engine, kg.

Power consumption (W), kWh:

$$W = W_{yd} V, \quad (7)$$

where

W_{yd} – is the power consumption for running-in of one engine, kW-h.

In turn,

$$W_{yd} = N \times (t_x + t_{гнн}), \quad (8)$$

where

N is the installed capacity of the current collectors of the rolling stand, kW.

Annual energy savings, kWh:

$$\Delta \mathcal{E} = (\mathcal{E}_1 - \mathcal{E}_2) \times k_p, \quad (9)$$

where

$\mathcal{E}_1, \mathcal{E}_2$ – electricity costs by options, kWh;

k_p – recovery coefficient, , $k_p=0,5$

Annual diesel fuel savings[^]

$$\Delta D = (b_{T1} - b_{T2}) \times K_{лд} \times V_2. \quad (10)$$

The cost indicators that serve as the basis for calculating the efficiency of upgrading the rolling stand include capital investment, operating costs, profit growth and investment income

When calculating the capital investment (K), the cost of the stand control device for running in diesels with control of their technical condition by power of mechanical losses, installation costs and transport costs are taken into account.

Current costs for options (C_1 and C_2) associated with the operation of the rolling stand are defined as the sum of cost elements from the expressions:

in the basic version:

$$C_1 = \mathcal{Z} + O_{C1} + T_1 + \mathcal{E}_1, \quad (11)$$

in the projected version:

$$C_2 = \mathcal{Z}_2 + O_{C2} + A + P + T_2 + \mathcal{E}_2, \quad (12)$$

where

\mathcal{Z} – salary of a test fitter, rub.;

O_C – deductions for social needs, rubles;

A – depreciation charges for equipment of the stand control device for running-in of diesels with control of their technical condition, rub.;

P – repair and maintenance costs, rub.;

T – fuel costs, rubles;

\mathcal{E} – electricity costs, rubles.

The cost of labor for a test fitter (\mathcal{Z}) is determined by the formula:

$$\mathcal{Z} = C_T \mathcal{Z} T k_3, \quad (13)$$

where

C_T is the hourly rate, in rubles;

$\mathcal{Z} T$ – labor costs, h;

k_3 – coefficient that takes into account the surcharge to the tariff.

Social security contributions (O_C), rub.:

$$O_C = \mathcal{Z} \frac{\alpha_o}{100}, \quad (14)$$

where

α_0 is the percentage of social contributions equal to 36 %.

Depreciation charges (A), rub are determined by the formula:

$$A = \frac{a}{100} \Delta K, \quad (15)$$

where

a is the annual depreciation rate for the stand, % ($a = 10,0$ %);

ΔK – investment in the control device of the upgraded stand, rub.

Similarly are determined the cost of repairs and maintenance (P), rub the automated control system:

$$P = \frac{p_1}{100} \Delta K, \quad (16)$$

where

p_1 – annual rate of deductions for repairs and TO ($p_1 = 3,5$ %).

The cost of fuel and lubricants (T), rub. is calculated using the formula:

$$T = \zeta_T \times B_H + \zeta_M \times B_M, \quad (17)$$

where

ζ_T – is the price of diesel fuel, rub/ kg ;

B_H – diesel fuel consumption, kg;

ζ_M – oil price, rub/kg ;

B_M – oil consumption, kg.

The cost of electricity (\mathcal{E}) in the compared variants is determined as follows:

$$\mathcal{E} = C_{\mathcal{E}} \times W, \quad (18)$$

where

$C_{\mathcal{E}}$ is the current electricity tariff, rub / kW×h;

W – power consumption, kW×h.

Current cost savings ($\mathcal{E}\mathcal{S}$) will be:

$$\mathcal{E}\mathcal{S} = (\mathcal{E}_1 + O_{C1} + T_1 + \mathcal{E}_1) - (\mathcal{E}_2 + O_{C2} + T_2 + \mathcal{E}_2 + A + P). \quad (19)$$

Results.

To compare the elements of current costs by options, we present the results of calculations in the form of a table 2.

Table 2. Changing elements of current costs during running-in of the YAMZ-236M engine*

The elements of cost, RUB.	Options		Changes, ±
	Basic	Projected	
Wages	10715,98	9890,54	+825,44
Deductions for social needs	3857,75	3560,59	+297,16
The cost of fuel and lubricants	23281,83	19832,67	+3449,16
Energy costs	42488,05	35766,7	+6721,35
Depreciation	-	680,0	-680,0
Repair and maintenance costs	-	238,0	-238,0
Subtotal	80343,61	69968,5	+10375,11

*Source: author's development.

Options Basic Projected

The increase in profit of the enterprise (Π) when implementing an automated management system is equal to saving current costs, rubles.

$$\Pi = \mathcal{E}\mathcal{S}, \quad (20)$$

the annual return on investment (D) is determined from the expression:

$$D = \Pi + A - H, \quad (21)$$

where

H is the change in the tax amount, rub.

However, this is not the full annual effect, since it does not take into account the environmental effect, and therefore, the full annual income is equal to, rub:

$$D = \Pi + A - H + \Delta \mathcal{E}_K, \quad (22)$$

where $\Delta \mathcal{E}_K$ – annual environmental effect, rub, in turn:

$$\Delta \mathcal{E}_K = \mathcal{E}y_1 - \mathcal{E}y_2, \quad (23)$$

where

$\mathcal{E}y_1$ and $\mathcal{E}y_2$ – annual damage from air emissions from diesel fuel combustion in the first and second variants, rub.

$$\mathcal{E}y = D_T \times K_{гд} \times H_D \times V, \quad (24)$$

where

H_D is the tax rate for the emission of pollutants from diesel fuel combustion.

In international practice, a system of indicators based on the principle of discounting is used to assess the effectiveness of investments.

To assess the effectiveness of investment, you should calculate the following indicators:

- net discounted income (ЧДД);
- investment return index (ИД);
- dynamic payback period for investments (T_0).

Financial and economic calculations are performed under the following conditions: settlement period (calculation horizon) $T = 10$ years; interest rate $E = 0,15$. The project efficiency is calculated over a long period of time (the calculation period), which is assumed to be equal to the standard service life of the equipment.

The obtained values of the criteria indicators of the efficiency of capital investments in the modernization of the control device for the rolling stand (table 3) indicate the feasibility of implementing the project.

Table 3. Indicators of economic efficiency of modernization of the running-in control device of YAMZ-236M engines*

Name of indicators	Before implementation	After implementation	+/-
Annual production program, PCs	680	737	+57
Specific consumption of diesel fuel, l / piece	22,5	19,1	-3,4
Annual savings of diesel fuel, t	-	2,1	-
Annual energy savings, kWh	-	13339,7	-
Direct labor costs for running-in of one engine, h / piece	2,98	2,75	-0,23
Increase in labor productivity, %	100,0	115,0	+15,0
Annual environmental impact, rub	1761,78	1495,55	-266,23
Annual income, rub	-	9453,82	-
Net discounted income, rub	-	4110,32	-
The profitability index	-	1,61	-
Term of return of capital investments, years	-	2,0	-

*Source: author's development.

Conclusions and discussion.

The net discounted income for YAMZ-236M diesel is 4110 rubles, the term of return of capital investments is 2 years, with an annual saving of 2.1 tons of diesel fuel and 13340 kWh of electricity, and an annual environmental effect of 266 rubles. The proposed method can be used by repair companies when justifying decisions on the modernization of rolling stands.

Since the factories are equipped with obsolete break-in stands that do not correspond to farm equipment, they require replacement. The absence of modern break-in-brake stands at repair facilities may cause a refusal to issue them a production license and product certification.

In further studies, it is important to establish the dependence of changes in the costs of

maintenance and repair during operation in production conditions of engines run-in on a modernized stand and on a non-modernized one.

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