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Numerical study of a set of screen-exhaust devices taking into account the influence of the helicopter main rotor

The results of a numerical study of the flow of exhaust gases in screen-exhaust devices tested on a helicopter with TV3-117 engines are presented. As a result of the study, an analysis of pressure losses and flow structure was performed. According to the results of calculations and modeling, the direction of further calculation and experimental studies aimed at improving the flow part of the screen-exhaust device was determined.

Experimental model of the screen-exhaust device

The characteristics of the output devices significantly affect the operation of the GTE, the level of thrust, determine the thermal visibility and dependence of the aircraft from being hit by missiles with infrared homing heads. Output devices, as one of the main elements of GTE, perform the following main tasks [1]:

– discharge of outgoing gases in the mode of maximum efficiency of their energy use;

– lowering the temperature of exhaust gases;

– discharge of outgoing gases in the desired direction with minimal losses;

- reducing the concentration of harmful emissions into the atmosphere

In a number of engine operating modes, the gas flow at the entrance to the exhaust channel can have a significant twist. Therefore, the quality of the exhaust tract, its characteristics, affect the characteristics of the entire engine.

The numerical study was performed in the universal built-in CAD system Catia5-CFD package/program FloEFD Mentor Graphics Corp.

The input parameters for the numerical experiment were taken from the performed thermodynamic calculation of the engine for take-off, nominal and cruising modes. The data are presented in table 1.

Table 1

Results of thermodynamic calculation

Parameter	Dimensionality	Takeoff mode	Nominal mode	Cruise mode
H	m	0	0	0
t	^{0}C	15	15	15
$G_{g.st}$	kg/s	8,38	7,87	7,54
P^*_{st}	kgf/sm^2	2,48	2,34	2,23
T^*_{st}	K	847	840	820
π^*_{st}	-	2,34	2,21	2,11
n	rev/min	14700	15000	15000

The main results of the gas-dynamic calculation of the TV3-117 engine turbine are presented in table 2

Table 2

Parameters at the output of the impeller of the last stage

Parameter		Takeoff mode	Nominal mode	Cruise mode
P*, kgf/sm^2	pheripheral	1.056589	1.057701	1.057323
	middle	1.059832	1.058833	1.056875
	sleeve	1.108452	1,092228	1.079329
T*,^{0}C	pheripheral	425.678	429.07	419.645
	middle	424.928	427.975	418.269
	sleeve	436.969	437.165	425.289
α_2 ,deg	pheripheral	5.75355	-2.31337	-8.33599
	middle	4.63021	-5.00366	-12.2789
	sleeve	19.4765	13.8194	9.01392
C, m/s	pheripheral	129.307	124.034	120.361
	middle	134.087	125.995	120.997
	sleeve	190.726	169.264	153.662

According to the results of the calculations, a geometric model of the exhaust pipe of the TV3-117 engine was built, presented in fig. 1

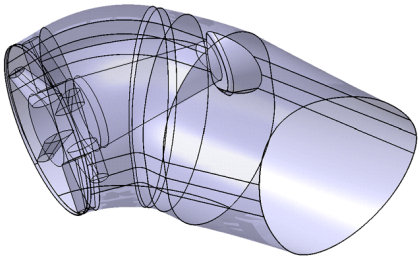

Fig. 1. Geometrical model of the exhaust pipe of the TV3-117 engine

The flow was assumed to be adiabatic, and the boundary condition of "sticking" was set on the inner surfaces of the walls. Calculations were performed using the *k-ε* turbulence model.

According to the results of the calculations, the total pressure loss, taking into account the effect of the helicopter's main rotor on the screen-exhaust device in the left exhaust nozzle, is 3.8%, and in the right exhaust nozzle - 3.4%.

Previous studies [2] show that the influence of the helicopter's main rotor on the screen-exhaust device on the loss of total pressure leads to its increase. In preliminary calculations, it is 3.1% in the left exhaust pipe, and 3.4% in the right exhaust pipe. In general, this increase is significant, which leads to total losses in the composition of the screen-exhaust device.

Visualization of the nature of the flow in the screen exhaust devices during the inflow of the helicopter main rotor is shown in Fig. 2.

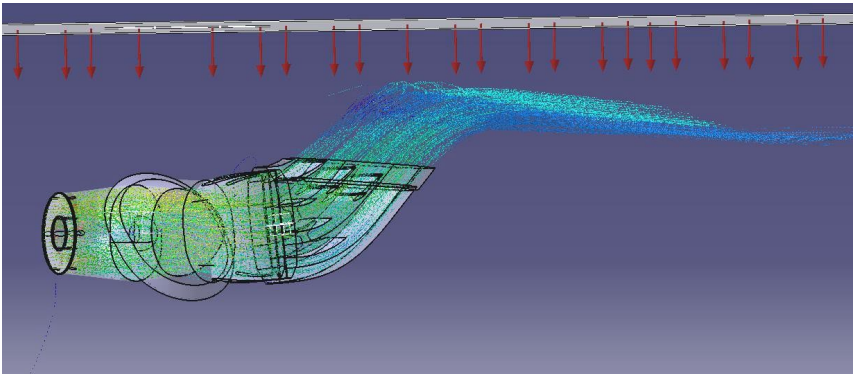

Fig. 2. The nature of the flow in the right screen exhaust device during the inflow of the main rotor of the helicopter.

The results of the calculations showed that the numerical simulation of the flow of exhaust gases in the screen-exhaust device at the inflow of the main rotor of a helicopter with TV3-117 engines in the CAD system Catia5-CFD package/program FloEFD Mentor Graphics Corp makes it possible to estimate total pressure losses in the heavy elements of the engine exhaust tract.

References

1. Kinashchuk, M., Kinashchuk, I. (2024). Determining infrared radiation intensity characteristics for the exhaust manifold of gas turbine engine TB3-117 in MI-8MSB-B helicopter. Eastern-European Journal of Enterprise Technologies, 3 (1(129)), 6–13. https://doi.org/10.15587/1729-4061.2024.303472
2. Kinaschuk, M. (2020). Numerical study of the exhaust gas flow of TV3-117 type engines in composition with a screen - exhaust device. ScienceRise, 4, 17–23. https://doi.org/10.21303/2313-8416.2020.001391