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TO A QUESTION ABOUT HELICOPTERS TURBOSHAFT ENGINES SAND EROSIAN PROTECTION

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TO A QUESTION ABOUT HELICOPTERS TURBOSHAFT ENGINES SAND EROSION PROTECTION

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During helicopters application on field and unprepared aerodromes, turboshaft engines usually can't use its retirement life completely. It make operational reliability improvement problem as topical. It demand as new engine sand erosion protection methods development, also existant methods improvement.

It is shown here air and sand flow around helicopter analysis method major traits for usual and coaxial main rotor scheme helicopters.

It is done helicopters with different main rotor schemes comparison by engine air intake area sand level, also by engine sand protection degree.

It is shown here, during the same helicopters operation regimes, engine sand protection degree coaxial main rotor scheme helicopter is higer than one usual main rotor scheme helicopter.

Helicopter operation features in ground proximity environment consist of sand atmosphere. It is arized as a result both natural reasons also helicopter operation. The latest one is main rotor inductive air flow action on the ground. Sand concentration in the air in that case may greatly exceed one in natural conditions.

It is known, helicopter engine sand protection is described by engine reliable operation time value in sand air environments and is definited by number of reasons (factors), such as: sand protective device presence and its perfomances, compressor units erosion resistance etc. To esteem each of them influence is quiet difficult task.

In that work take place some different task - to definite main rotor scheme influence on turboshaft engine sand protection degree. It should be menthioned, that esimate is accomplished for the same engine type, the same helicopters gross weight and the same operation conditions.

Main factors, are determinating engine sand protection as follows.

1. Sand (mass) level in engine air intake area.
2. Sand particles composition, and mineral one in engine air intake area.
3. Engine regime, necessary for definite main rotor trust providing. It determinated by engine rotation speed istallation and engine air mass flow rate.
4. Design values of compressors blades tip speed.
5. Compressor scheme.
6. Compreccor blades and erosion - resistant coating

wear resistance.

7. Sand protection device perfomances.
8. Compressor surge margin design value.

In this article, as was menthioned before, is realised engine sand protection degree comparison for the same type engines, have installated on different helicopters, one of helicopters has coaxial main rotor scheme, and the second - usual main rotor scheme. Beside it, comparisson has been realized for the same sand particles size compositions and the same ground state. In connection with it, from foregoing factors the most singificant are.

1. Sand level in engine intake area.
2. Engine operation regim, which is definited by rotation speed, also by air mass flow rate.

To analyse engine intake area sand level have been developed special methods, have been built experimental test benches, have been carried out bench tests, also tests on real helicopters in real operation environments have been done. It provides possibility of following.

1. Analyse air flow structure around helicopters as usual also coaxial main rotor schemes helicopters on different operation regimes.
2. Analyse different size particles movement trajectory in definited air flow speed fields, particles distribution in sand rising zone and in probable engine intake location zone also.
3. Estimate ground surface erosion coefficient.

4. Definite sand level in engine air intake probable location zone for particles every sizes.

It should be me menthioned, that ground surface erosion coefficient, and therefore corresponding zone sand level, also was calculated when be based on 100 % contens particles of each size in ground.

For real operation environment computation is realized with real ground sand particles size compositions.

For examples, if in the ground contens X % particles d_i sise, then its relative concentration makes up

$$K_i = K^{100} * X_i , \qquad (1)$$

here K^{100} - sand particles size d_i concentration in the air while 100 % one concentration in the ground.

To be based on different size sand particles motion computation for both main rotor schemes helicopters, have been received sand distribution graphs in engine intake zone for actual helicopter base region. Example of such graph for Lubertsy town region is shown on pic. 1 and 2.

5. Build up particles distribution graph along radius and azimuth for every particles size in engine air intake zone, to be based on the engine air intake probably location has uniform probability distribution law relatively all possible helicopters relative velocity directions in forward hemisphere (relativ velocity V_{OTH} - resultant vector of taxi veloci-

ty and wind speed) during operation.

6. Apply have been obtained results to solve the task of engine sand erosion protection increase.

Are obtained dependences make it possible answer following questions:

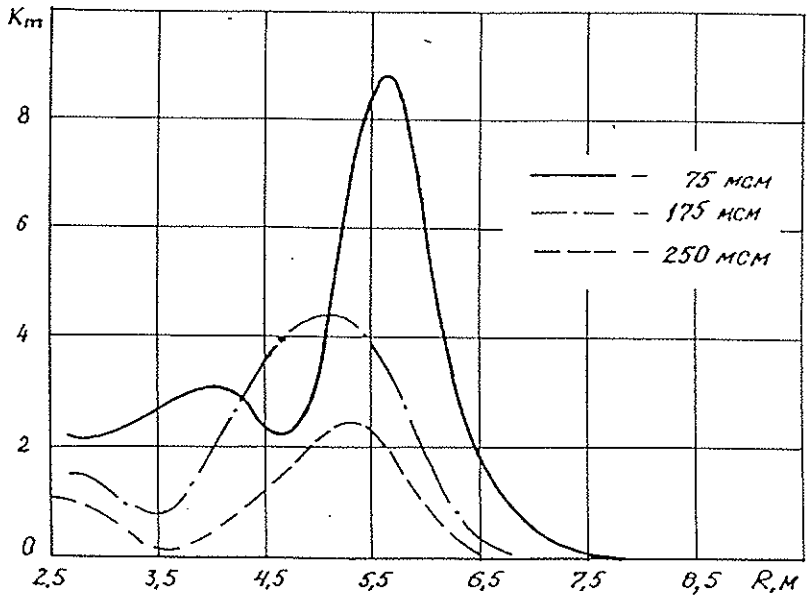
how is engine air intake zone sand level variation along radius and azimuth for every helicopter for definit operation regime;

what is sand particles sizes composition in engine air intake zone;

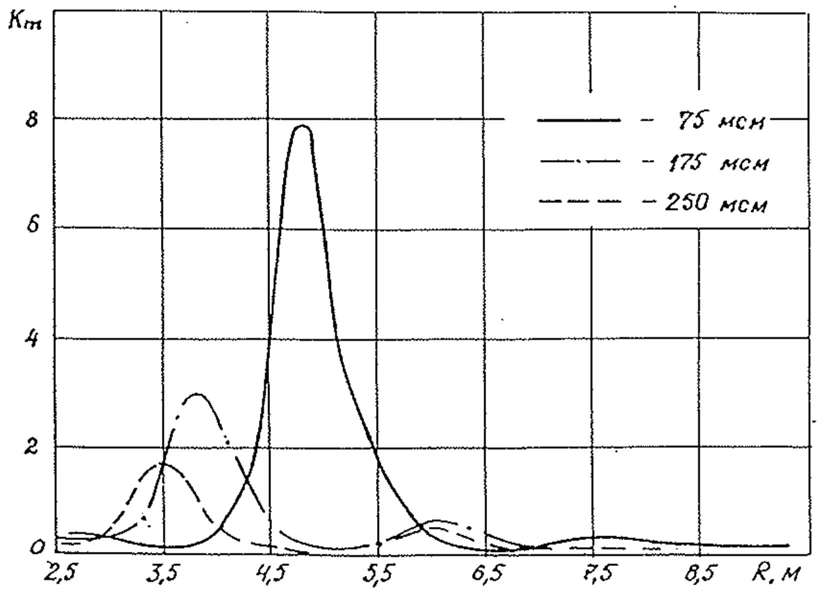
where is the best engine intake location place in accordance with the least sand flow level.

For example on pic. 3...6 are shown dependences sand particles of every size distribution along radius and azimuth in engine air intake zone for usual and coaxial main rotor helicopters. As seen, for both helicopter schemes on taxi regime with 5.5 m/s velocity value, is taking place clear zones the best and the least sand level. It permit during helicopter designe stage determinate zones of the best engine air intake location place in accordance with engine sand protection requirement.

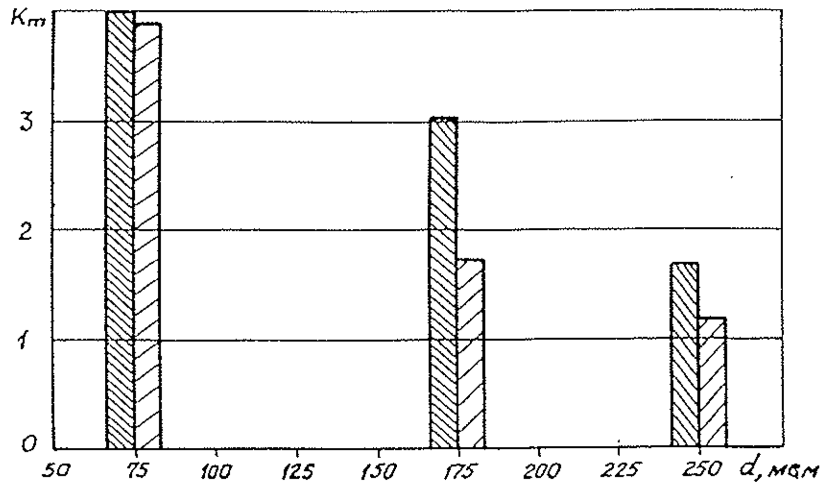
Then, to be supposed that engine air intake location place has uniform probability distribution among all possible V_{OTH} vector directions, let's definite sand level average among all directions (pic. 7). It follows from this, that on taxi regime with V_{OTH} value equal 5.5 m/s, sand level for all particles sizes is higher in engine intake location zone coaxial main rotor helicopter.



Pic.3. Different size sand particles distribution along radius for coaxial main rotor scheme helicopter on taxi regime with velocity value 5,5 m/s.

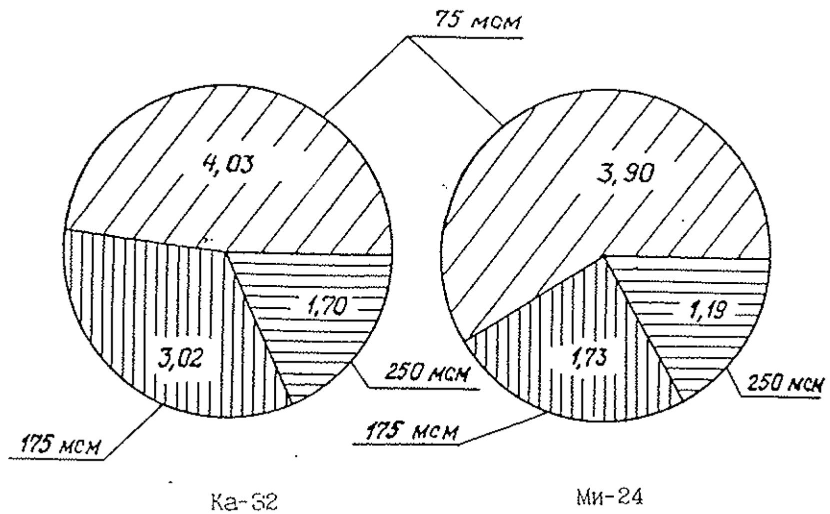


Pic.4. Different size sand particles distribution along radius for ordinary main rotor scheme helicopter on taxi regime with velocity value 5,5 m/s.

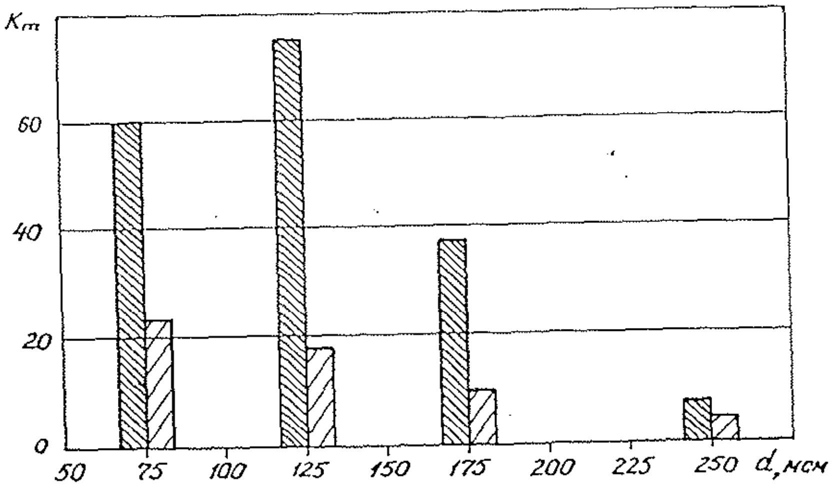


Pic.1. Sand particles distribution on its size in engine air intake zone during operation on landing Lubertsy town:

- Ка-32 ; - Ми-24.

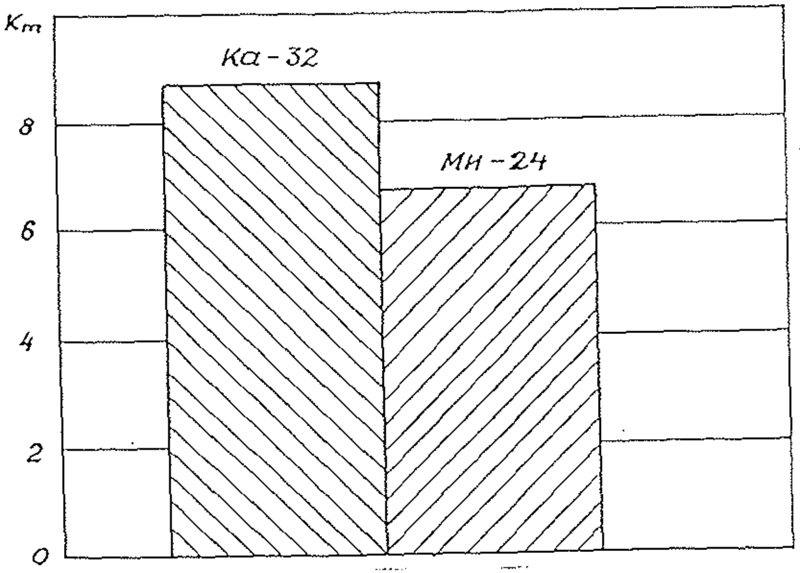


Pic.2. Sand particles distribution on its size in engine air intake zone during operation on landing Lubertsy town.

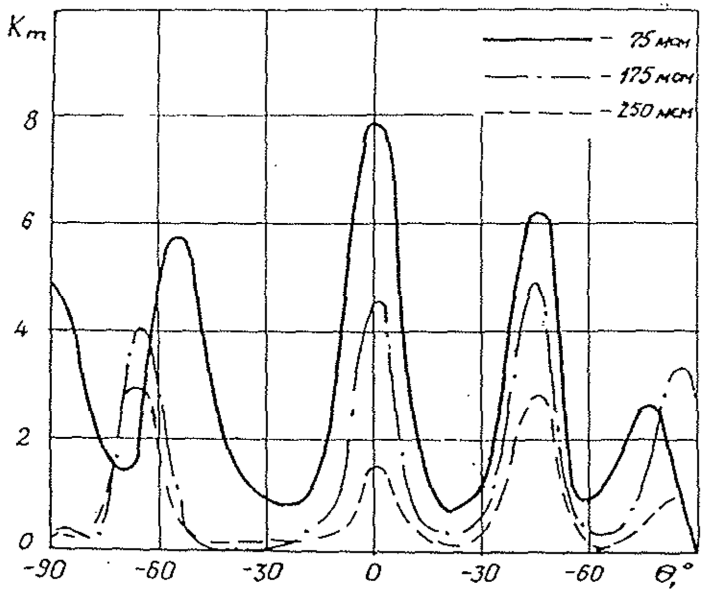


Pic.7. Mean sand level in engine air intake zone for all directions and different main rotor scheme helicopters on taxi regime with velocity value 5,5 m/s:

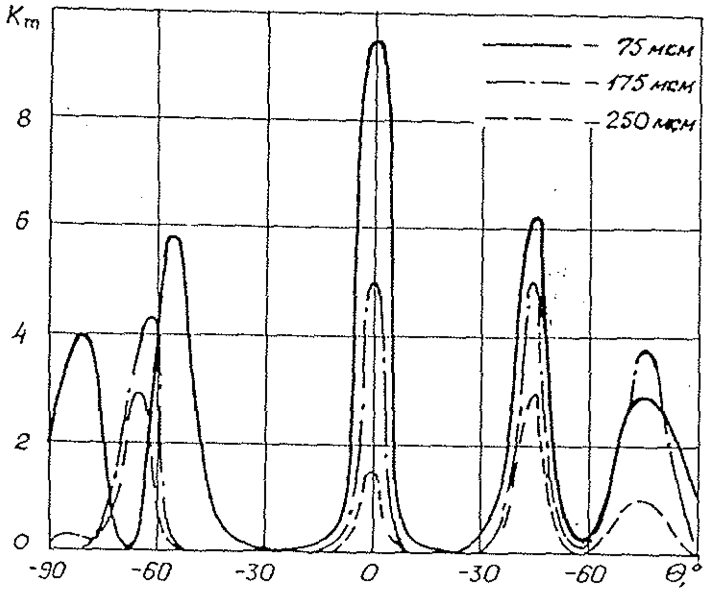
- Ka-32 ; - Ми-24 .



Pic.8. Sand level in engine air intake zone helicopters Ka-32 and Ми-24 during taxi with velocity 5;5 m/s in real conditions (Lubertsy town landing ground).



Pic.5. Different size sand particles distribution on azimuth for coaxial main rotor scheme helicopter on taxi regime with velocity value 5,5 m/s.



Pic.6. Sand particles different distribution on azimuth for ordinary main rotor scheme helicopter on taxi regime with velocity value 5,5 m/s.

Let's compare engine intake sand level Ka-32 and Ми-24 helicopters on taxi regime with velocity value 5.5 m/s.

To be used received dependences sand level for all forward hemisphere, mark out engine air intake location zones foregoing helicopters. For Ka-32 helicopter engine air intake lokation radius R_{BY} makes up 2,6...4,2 m, for helicopter Ми-24 R_{BY} forms 2,8...5,2 m.

Analysis show, that sand level in engine air intake zone Ka-32 helicopter is higher. To be choosed any real base region, Lubertsy, for example, makes up recalculation sand concentration for real environment. Generrally, sand level helicopter Ka-32 in enqine air intake zone is 1.3 times higher than one Ми-24 helicopter in the same operation reqime (pic. 8).

Beside it, is seen from dependence of particles distribution on its size, that in enqine air intake zone helicopter Ka-32 are conducted more large size particles, while in the same zone helicopter Ми-24 are conducted more small size particles.

As was shown before, beside sand level in engine air intake zone, also engine operation reqime (G_B-air mass flow rate; n-engine rotation frequensy) infiuences on engine sand ptotection.

Engine air mass flow rate and sand level in engine air intake zone determinate engine sand mass-flow rate, then compressor blades erosion wear intensity. Rotation frequency definites particles and blades impact speed. It is possible to consider impact angles to be the same for both engines when compressor variable stator automatic control system is applied. It is possible don't mention also difference betwe-en size of particles are conducted into engine.

It is stipulated by turboshaft engine surge margin (pa-rameter, which limit engine TB3-117 serviceability in sand atmosphere) on rotation frequency near to design one, depen-dence on compressor middle and latest stages erosion degree [1]. In engine rotation relative frequency n_{TK} over 85% as a result from large and small particles different crushing, sizes of particles change from stage to stage differently, and reach in compressor exit practically the same value [1].

Let's compare two engines TB3-117,are installed on he-licopters Ka-32 and Ми-24 to its sand protection when taxi velocity makes up 5,5 m/s.

As was mentioned before,for helicopter Ka-32 it is ne-cessary to create engine regime with relative rotation fre-quency n_{TK} about 89% (air mass flow rate in this case makes up about 6 kg per second), and for the same regime providing for helicopter Ми-24 it is necassary n_{TK} value about 95% (air mass flow rate in that case makes up about 8 kg/s).

Engines sand protectoion degree relationship is defini-ted by magnitude, is inversed to engines blades erosion in-tensity relationship. The latest one is definited by engine sand mass-flow rate and engine rotation speed values. Ratio of sand mass flow rates is definited as follows:

$$\bar{m}_П = \frac{K^{32} * G_В{}^{32}}{K^{24} * G_В{}^{24}} ; \qquad (2)$$

here k-sand mass concentration (in engines air intake zones); marks "32" and "24" definite type of helicopters Ka-32 and Ми-24 conformably.

As is known from P.N. Velikanov's works compressor blades erosion degree is nearly in proportion to engine relative rotation frequency squared. Then relative erosion degree is definited by formula:

$$\bar{\Delta} = \left(\frac{n^{32}}{n^{24}} \right)^2 . \qquad (3)$$

Altogether, engine ТВ3-117 is installed on helicopters Ka-32 and Ми-24 relative sand protection degree is definited as follows:

$$\bar{П} = \left(\bar{m}_П * \bar{\Delta} \right)^{-1} = \frac{K^{24} * G_В{}^{24} * (n^{24})^2}{K^{32} * G_В{}^{32} * (n^{32})^2} . \qquad (4)$$

Then, use is got before sand level in engine air intake zo nes relationship during taxi regime with velocity value 5,5 m/s, receive

$$\bar{П} = 1.16 .$$

So, in spite of greater sand level in engine air intake zone Ka-32,engine ТВ3-117, has mounted on it sand protection degree is higher, than one of engine, has mounted on helicopter Ми-24. When taxi velocity descend, engine sand protection degree helicopter Ka-32 become even more higher.

Literature

1. Cherenkov S.V., Vlasov K.V. About helicopter turboshaft axial multistage compressor engine serviceability and state control improvement during operation in sand atmosphere. - The 1-st Forum of Russian helicopters Society materials collection. - M., 1994.