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Application experience of modern tools of tribodiagnostic applications for air jets

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Abstract
The work represents the results of modern tools of tribodiagnostic applications for air jets maintenance based on complex use of X-ray and optic methods of accounting of metals and soot particles of different size groups. The work represents results of reduction of air jets wrong removals based on material identification and abnormal wear sources localization.
Key words: air jets maintenance, optic methods, metals, localization

Statement of a problem

For the last few years in the laboratory of diagnostics OAO "Aeroflot" (further in the text LD) the measures are taken directed to the increase of effectiveness of tribomonitoring of aviation engines (AE) with the purpose of the exception of the cases of switching off the engine during the flight while the alarm signal "chips in the oil" turns on (except the cases of false alarm) and the exception of the baseless disposal of the engine if the chips are found on the check elements of the oil system of the engine.

The structural scheme of the organization of works in these fields is represented in Fig. 1.

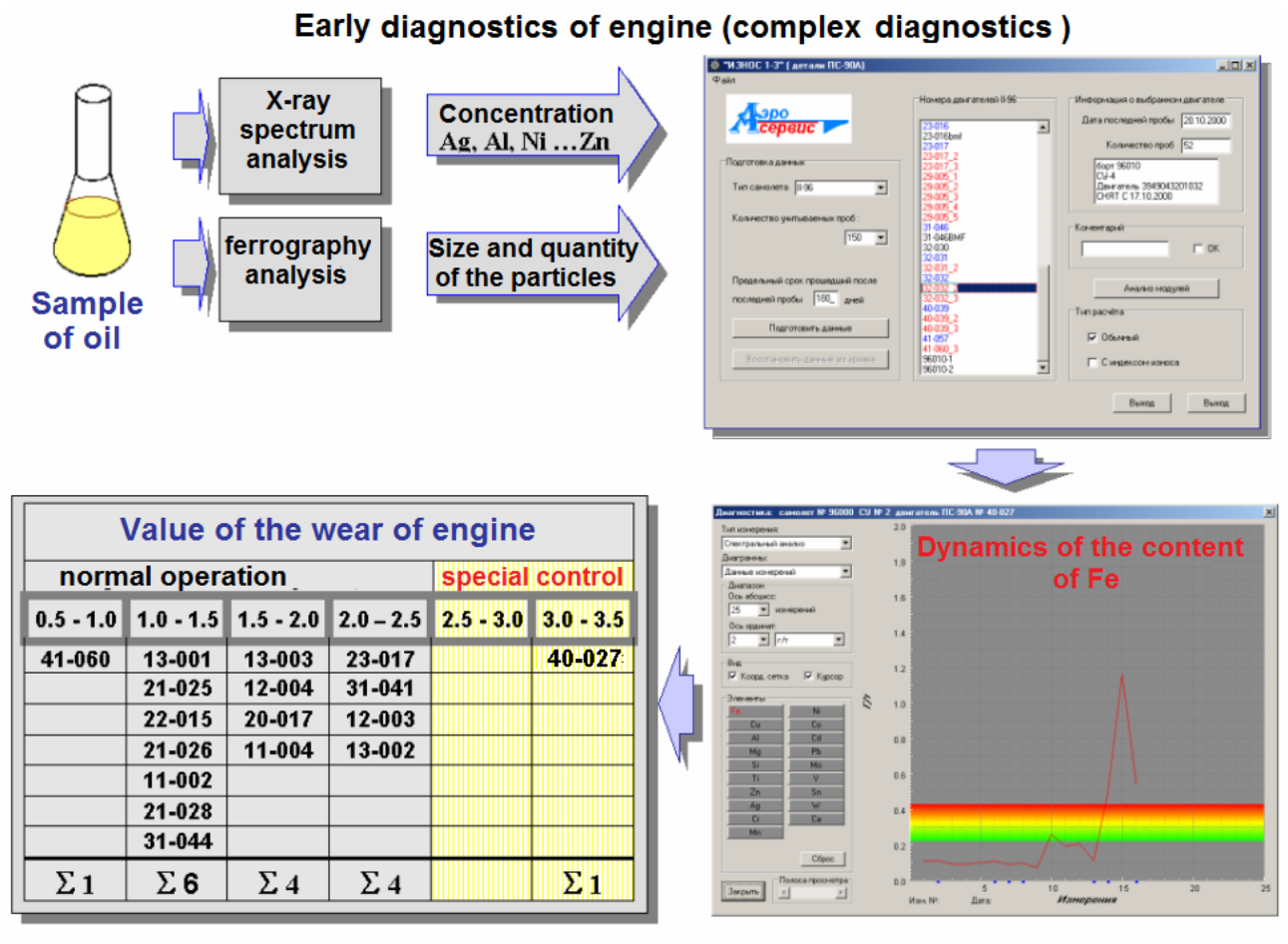


Fig. 1. **The structural scheme of the organization of the work (researches) in the tribomonitoring field**

1. X-ray analysis is based on 19 chemical elements: Fe, Cu, Ni, Cr, Zn, Pb, Ti, Mo, Sn, W, Al, Mg, Ag, V, Mn, Si, Co, Ca, Cd that is carried out by means of the analyzer «Spectroscan MAKS GV», the measurement results of which are directly put in the data processing of the program "Iznos 1-3" (further in the text the Program). The Program determines the conditional value of the intensity of wearing out (conventional "Index of Wear" J) and

makes sorting of the engines due to the value of J on the basis of the complex valuation of the intensity of the spectrum lines.

Such kind of a procedure is held for any type of the engine. The table that is represented in the left bottom of the picture is formed on the basis of the results of the data processing. Those engines that are in the yellow zone are potential dangerous and require profound diagnostics.

In the right bottom of Fig. 1 is represented the dynamics of the concentration change of Fe in the oil of the engine 40-027 that was put off after it was turn off in the flight when the alarm signal "chips in the oil" was switched on. Based on the formal characteristics in compliance with the acting documentation the engine is not to be charged to the "intensified control" since the content of the Fe particles in the last test was 1 ppm.

The norm of the Fe content to be charged to the "intensified control" is about 2 - 8 ppm.

2. The calculation of the quantity of the particles of metal and coke with the different size groups in the same test prints of oil with the use of optico-computer technologies provides additional control of the intensity of the ware based on the results of the successive measurements of trends of the indicated parameters and in the combination with the X-ray analysis of the spectrum of the metal in the same prints (especially in the lines of Volfram and Chrom). Let us evaluate the condition of most important junctions of the engine – bering of the main engine support. In Fig. 2 there is the main window of the Program of the calculation of the particles of metal and coke in the different size groups in the oil test of the examined engine 40-027.

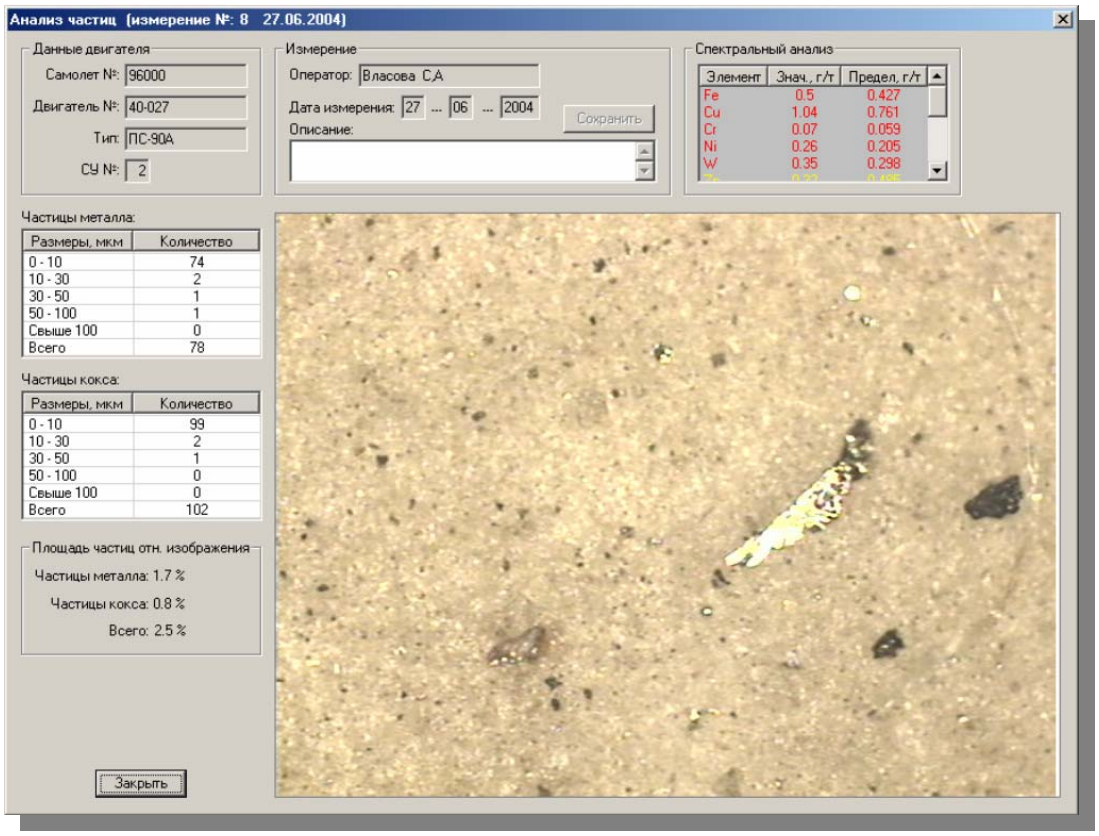


Fig.2. **Analysis of the particles wear**

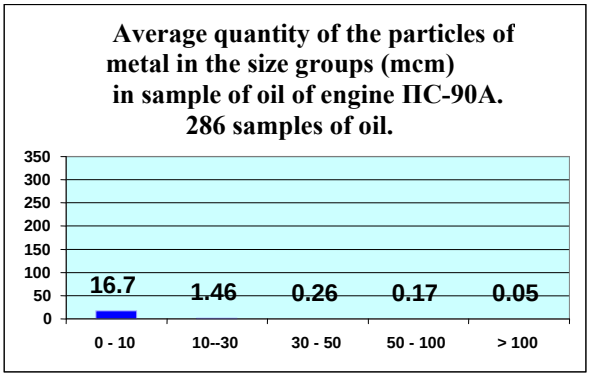
In the left upper light corner of the window the significances of the quantity of the particles of metal in the size groups (μm): 0 – 10, 10 – 30, 30 – 50, 50 – 100, over 100 are represented.

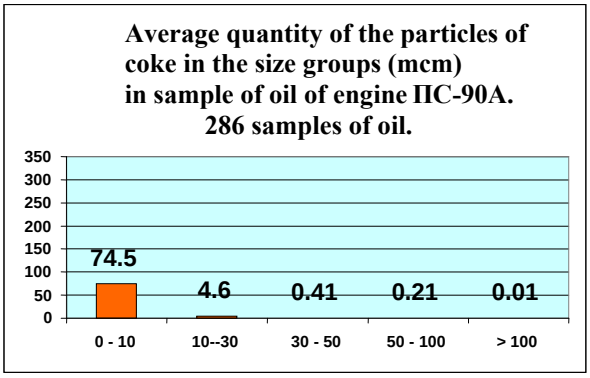
Such results for coke are represented in the lower window. On the gray field under these windows there are the significances of the area of coverage (in %) for metal and coke and also the combined area of coverage.

In the right upper corner there are the significances of the concentration of the metal, going out of the limits of the statistics admittance for this particular type of engine.

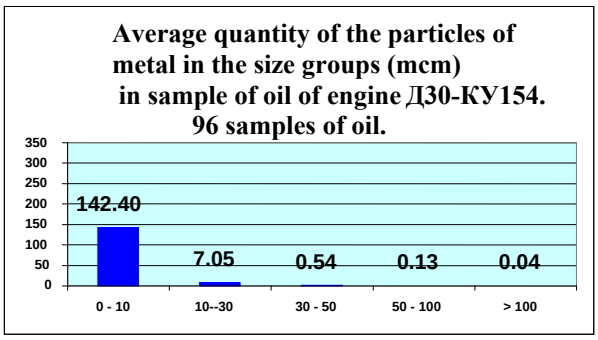
In the concerned case the measure of the concentration of the principal metal (Fe, Cu, Ni, Cr, W) exceeds the statistical limits more than in 1,5 times, that may be the evidence of the beginning of the destruction of the bearing of the main engine support. In the picture we can clearly see the particles of metal in the interval 50 – 100 μm, that can be the sufficient informative indication of the beginning of the intensive ware.

In Fig.3 there are the mean values of the quantity of the metal and coke particles on the indicated size groups for the engines of the ПС-90А and Д30-КУ154 types, and also the significances of the average concentrations of the principal metals.





Middle values of metals in sample of oil (ppm) of engine ПС-90А (analyzer Spectroscan J)								
Fe	Cu	Ti	Ni	Mo	Sn	Zn	W	Cr
0.16	0.39	0.03	0.09	0.08	0.16	0.22	0.19	0.02



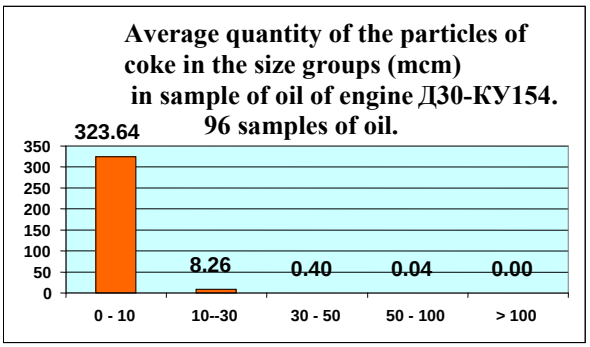


Fig. 3. **The mean values of the quantity of the metal and coke particles on the indicated size groups for the engines of the ПС-90А and Д30-КУ154 types**

Average values of metals in sample of oil (ppm) of engine Д30-КУ154 (Analyzer Spectroscan J)								
Fe	Cu	Ti	Ni	Mo	Sn	Zn	W	Cr
0.50	0.77	0.03	0.10	0.09	0.11	0.32	0.18	0.04

Due to the formal indications the examined engine goes beyond the scope of the cited statistics with the quantity of the particles in the test and also with the concentration of the principal metals and need to be exploited in the regimen of the profound diagnostics (PD).

In Fig.4 there is the measured dynamics of the concentration of the principal metals in the oil of the aero engine, that was put off on account of the increased vibration in the region of the back hanger. There can be clearly seen the splash of the concentration with the growth of the quantity of the gross (30-50 μm) particles of metal and coke as well throughout the whole range, that may witness the presence of the intensive ware with the local rise of the temperature of the fractioned couples. Due to the formal indications in compliance with the acting documentation the engine even could not be charged to the "intensified control" status.

In Fig. 5 there is the structural scheme of the exploitation of the engine in the regimen "PD" taking into account the recommendations to the additional investigation of the control elements of the oil system. If some chips are found in the control elements the additional analysis of the content of the alloy and the identification of its probable source takes place.

The analysis of the mark of the alloy is performed b y means of on the analyzer «Spectroscan MAKS GV» using the specially developed program "analysis of the chips". If the matter of the chips comply with the matter of the rings and the bearings of the main engine support, the engine goes off the exploitation.

If the matter of the chips complies with the matter of the starter details or the accessory box, than after the replacement of these details the engine is conceded to the further exploitation.

In Table 1 there are the figures of the change of the dynamics of setting off the engines ПС-90А due to the quantity of the chips on the control elements of the oil system.

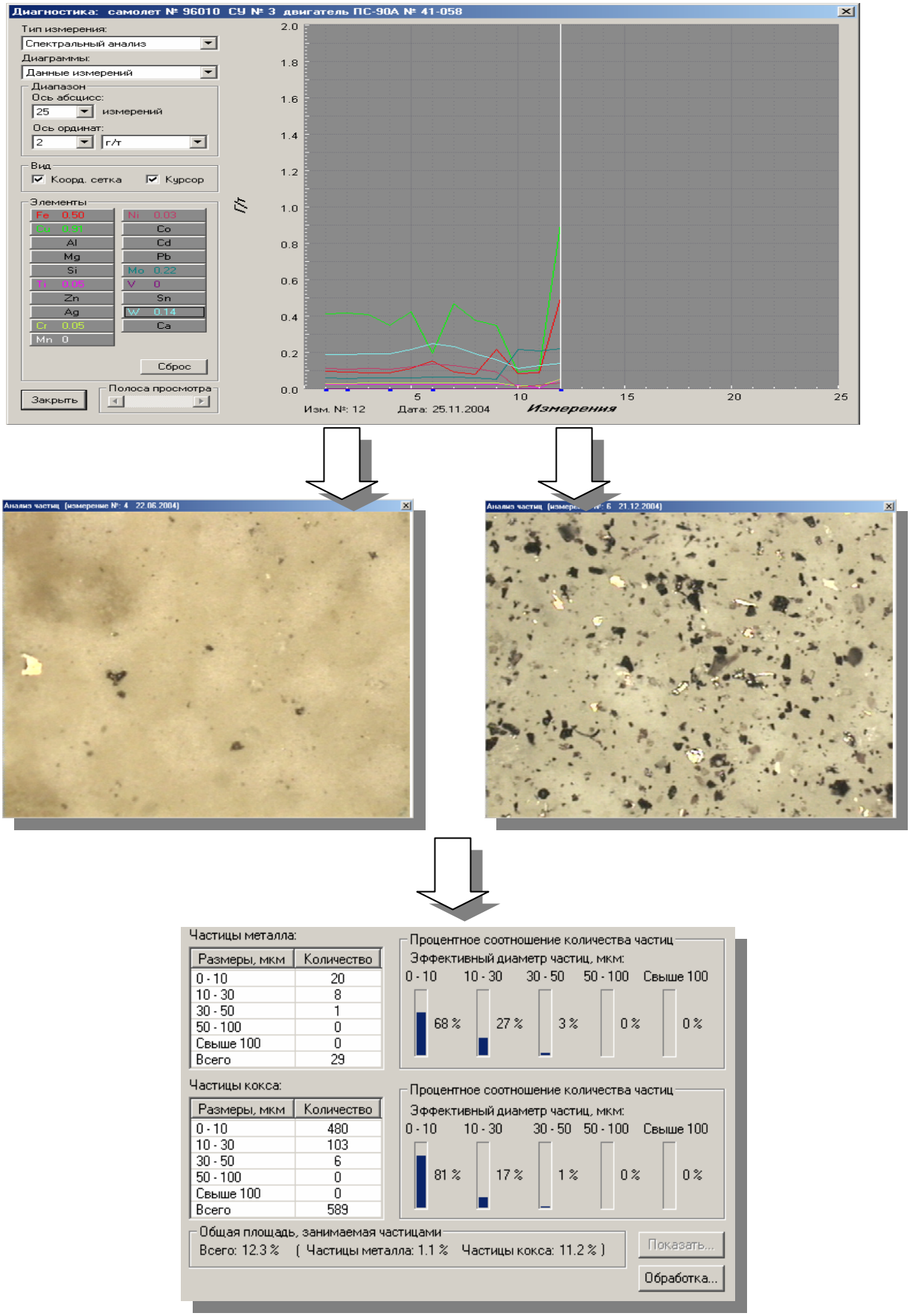


Fig. 4. **The measured dynamics of the concentration of the principal metals in the oil of the aero engine, that was put off on account of the increased vibration in the region of the back hanger**

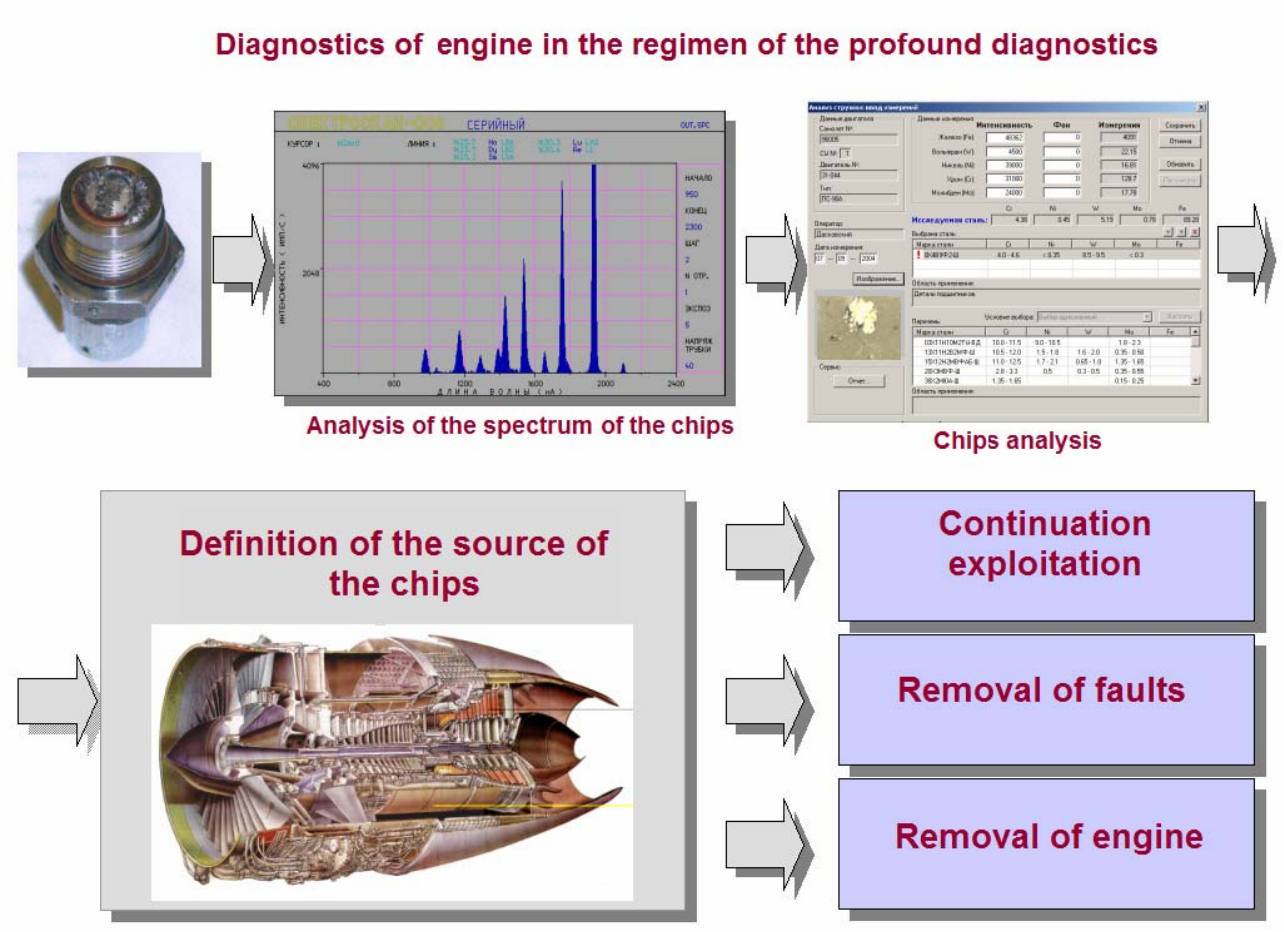


Fig. 5. **The structural scheme of the engine exploitation in the regimen "PD"**

Table 1

		1999	2000	2001	2002	2003	2004	2005
	The ratio of the number of engines removed for chips to the total number of withdrawn (%)	27	25	63	14	10	11	11
2.	Number of accidents with finding «chips»	5	8	21	7	9	16	17
3.	Removed engines in result of finding «chips»	4	5	19	2	2	3	3
4.	The number of the engines that continued exploitation	1	3	2	5	7	13	14
5.	Summary operating-time of park of engines ПС-90А (in hours)	57500	57800	62020	74327	80069	104092	92156
6.	Additional operating-time (in hours) of engines which continued its exploitation	-	-	-	19050	19450	20620	18540
7.	The ratio of additional operating-time to operating-time of park of the engines ПС-90А (%)	-	-	-	25.63	24.29	19.81	20.12

From this table it is obvious that since 2002 (the year of the beginning of the "chips analysis" usage) the number of the engines that continued exploitation after the fact of the exposure of the chips is over 80%, comparing with the 18% before the application of the program of determination of the mark of the alloy. The value of the net economical effect that won the proprietors of the engine and the operator can be compared with the value of one new engine ПС-90А.

The expenses of the operator on the perfection of the diagnostics is repaid in many times in the very first year of the exploitation of the hard warily-programmed complex.

The usage of the early diagnostics of the prevention of switching off the engine during the flight is restrained at the present moment by the absence of the normative documentation for its usage from the side of the aero engine developers.

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Šiuolaikinių tribodiagnostikos priemonių taikymo aviaciniams varikliams patirtis

Reziumė

Parengtas šiuolaikinių tribodiagnostikos priemonių kompleksinio taikymo aviaciniams varikliams tyrimas. Ištirtas rentgeninis spektrinės analizės ir optinis metodas metalo ir kokso dalelių dydžiui variklių alyvoje nustatyti. Be to, nustatytas nepagrįstai nutrauktos eksploatacijos aviacinių variklių skaičius naudojantis diagnostikos metodu ir taikant jį variklių diagnostikos laboratorijose.

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