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ABOUT OPERATING PROBLEMS OF HELICOPTERS FLYING IN CORROSIVE AND SANDY ENVIRONMENT

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ABSTRACT

The multi-purpose uses of military Helicopters may frequently include operations in dusty and/or corrosive environments which can severly reduce the Helicopter performance, increase maintenance costs and shorten life of many components. In spite of the anti-corrosion treatments and erosion-preventive measures,many technical problems arising during Helicopter operation are still caused by erosion, corrosion or their mutual effect .

In the present paper an attempt is made to bring into light some problems of Helicopters operating in severe environments, as experienced during service, hoping to stimulate further investigations of effective solutions. Types of corrosion observed in naval Helicopters are described in broad general terms. Some technical problems that occured due to erosion by solid particles are also discussed. This includes problems in engines, main rotor head, rotor blades and other parts of Helicopters.

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INTRODUCTION

The use of Helicopters is becoming increasingly important for fulfilling various and demanding military missions. Helicopters are used for armed reconnaissance, search and rescue, troop transport, laision and commande, electronic warfare, R.P.V operation and anti-tank warfare. Helicopters are also suited to a wide range of naval operational roles such as submarine search and strike, coast patrol and anti-surface vessel warfare. Inevitably, therefore the military Helicopters will operate in severe environmental conditions .

As may be expected, naval Helicopters always operate in highly corrosive salt-laden envirnments. When the Helicopter hovers over the sea, in a mission of search or rescue, the air cussion is ladened with sea water which enters the engine and covers the whole fuselage. On the other land, when a Helicopter hovers, lands or takes - off from a desert area the air cussion is ladened with dust and sand. The situation is even worth for multi-role Helicopters operating from an airbase located in a desert area in vicinity of the sea.

Normally, the difficult environmental conditions may cause many problems which can have direct effect on the Helicopter performance. For example , a Helicopter was emergency landed suffering from a loss of engine power . The inspection of the engine inlet and first stage compressor blades, revealed the existance of a viscous humid layer. After cleaning the compressor, the overall engine performance had improved considerably (the turbine inlet temperature was decreased from 820 ^{o}C to 780 ^{o}C and the turbine rotating speed was reduced from 99 % to 96 %).

Also , severe envirnments can dramatically reduce the service life of many components of the Helicopter. In some cases, a serious damage of compressor rotor blades had been observed after only eight landings in a desert area (see Fig. 1) .

In spite of the anti-corrosion treatments and the erosion-preventive measures, the mutual interaction of the two phenomena (erosion-corrosion) may complicate the problem and intensify the damage. For example, erosion by sand particles may hasten the corrosion attack considerably due to the elimination of the surface protective coatings.

The purpose of the present paper is to review the corrosion types observed in naval Helicpters. Some technical defects that had occured due to operation of Helicopters in sandy environment are also discussed.

It is hoped that this paper, by bringing into light some real problems in various Helicopter components encountered during service, will stimulate interested researchers for finding adequate solutions .

CORROSION IN NAVAL HELICOPTERS

Corrosion of metals may be defined broadly as the result of chemical action of their environment which frequently produces deterioration and possible destruction . Many metals are inherently unstable and tend to change to a more stable state, of which the metalic ores found in nature are typical examples [1-2]. Deterioration by corrosion is largely proportional to the degree of contamination of the atmosphere .
It is well known that an atmosphere containing severe corrodants, e.g. salt water or exhaust products, will hasten the corrosion attack considerably.

Cossorion can arise from many causes and the mechanisms of attack may be complex. However, some types of corrosion have frequently been observed in naval Helicopters during service . In subsequent paragraphs, these types of corrosion are briefly described .

Surface Corrosion

It is the most common form of general surface corrosion and results from direct reaction between metal surface and oxygen. It will also occur when a bare metal is exposed to a salt laden atmosphere and/or engine exhaust gases resulting in general etching of the exposed area, see Fig 2.

It was frequently observed on the outer casing of the engine compressor.

Pitting Corrosion

It is a local attack which takes place on surface of metals, particularly in case of non-regularity of cathodic electro-plating of high-finished steels. It is found on Helicopter skin where the surface protection was broken down locally. Also it was usually found in areas around rivets.

Crevice Corrosion

It occurs when a corrosive liquid gains access to crevices in or between components. If there are differences in concentration (of dissolved salt or oxygen) between two points of the entraped liquid , anodic and cathodic areas may result. The anodic area is attacked. This type was found in battary compartments and between riveted metal sheets of the Helicopter skin.

Dissimilar Metal Corrosion

As its name implies, this form of attack occurs when two dissimilar metals, of different electro-chemical properties, come in contact in the presence of a conducting liquid. This type was found on some parts of gear box made of magnesum alloys at the areas of contact with steel bolts .

Fretting Corrosion

It is the result of micro-movement between two heavily loaded surfaces. The rubbing effect destroys the protective layer and additionaly removes fine particles from the surface which are oxidized and form abrasive materials. The presence of sand particles considerably exaggerate this effect. It was often found on drive shafts of pumps and generators.

The previously mentioned types of corrosion are easily detected by visual inspection. However, in some other types, the amount of visible corrosion may be very small indeed with a little or even no external indication to the naked eye. Hence, careful inspection is needed for allocating the corrosion attack in such cases. These types of corrosion include intergranular corrosion, fatigue corrosion and stress corrosion .

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Intergranular Corrosion

It is the form of corrosion where the attack is concentrated at the grain boundaries in the metal. It may produce a network of corrosion or cracking on the metal surface which can be better seen under a hand lens. This type of corrosion is usually found in casings of gear boxes made of magnessium alloys and in some forged alluminium alloys.

Stress Corrosion

The combination of static stresses and a corrosive environment may produce a form of metal failure which is known as stress corrosion craking. Many metals used in Helicopters are susceptible to this form of corrosion, particularly stressed parts of the skin and other parts subjected to initial stresses during assembly .

Corrosion Fatigue

It is the form of stress corrosion which attacks the parts subjected to cyclic stresses from external loading. Cracking often starts at shallow pits. This type was frequently found on pitch change rods of main rotor head .

PROBLEMS OF HELICOPTERS OPERATING IN SANDY ENVIRONMENT

In the following paragraphs, some technical problems occured in Helicopters operating in sandy environment, as experienced during service, will be discussed .

1- Impingements of leading edges of inlet guide vanes and compressor rotor blades by sand particles may cause considerable decrease in the compressor rotor blades by sand particles may cause considerable decrease in the compressor efficiency. Before mounting the sand filter engines of Helicopters were removed at only 40 % of their prescriptive service life .

2- The sand filters which is designed on the vortex-generator theory are not effective against dust and minute sand particles. These particles can enter the compressor and accumulate in the roots of the swivelling stator blades , see fig. 3 , thus restricting their movements.

This phenomenon is quite dangerous as it may cause surging of compressor. For example, an engine failed to attain the take-off regime with the turbine inlet temperature exceeding the permissible limit . Inspection of the compressor indicated the existence of gummy material restricting the motion of the compressor inlet guide vanes to the extent that the actuating lever mechanism was bent .

3- Restriction of inlet guide vane motion can also be caused by sand particles accumulated in the outer pivot of the inlet guide vane mechanism situated on the external surface of the compressor casing.

4- Fine dust may precipitate gradually on the inlet guide vanes and on rotor blades of the compressor front stages, particularly the first stage, thus changing the airfoil shape. This defect was observed to be intensified in humid conditions and when using detergents for cleaning the compressor. Obviously, the change of the blade air-foil shape has a direct effect on reducing the compressor efficiency and in degrading the engine performance .

5- Leading edges of the main rotor blades of the Helicopter were severely deteriorated by erosion . This effect decreases the lift forces and may even lead in some cases to main rotor stall.

6- Abrasion of the swach-plate of the main rotor head caused noticable increase in the Helicopter vibration level .

7- Leakage in main rotor blade dampers and in actuating cylinders was attributed to the existence of sand particles forming an abrasive layer inside the cylinder. During the piston motion, this layer destroys the sealing rings and damages the cylinder walls .

8- Accumulation of dust and sand in the fine mechanism of the blade folding system resulted in many problems due to the malfunction of the sequencial valves .

9- Filters of the hydraulic system were frequently blocked by sand and dust .

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10- Accumulation of sand on the guiding rollers of the tail rotor control wires, restricts their movement in addition to the erosion effect which may even cut the wire .

EROSION- CORROSION INTERACTION

In spite of the well known corrosion-preventive treatments [3] and the anti-erosion measures [4] , the mutual erosion - corrosion effect may significantly increase the damage . It is essential therefore to pay more attention to this phenomenon. Hereinafter, the erosion-corrosion interaction, as observed during service, will be discussed .

Sand and dust start the attack by removing the protective coatings, stressing the metal grains and blocking the drain holes and vents. These conditions facilitate corrosion initiation , whilst the atmosphere containing some severe corrodants, e.g. salt water or exhaust gas products, will hasten the corrosion deterioration considerably. An attempt to partially rectify the apparent corrosion, by removing the corrosion products and recoating the corroded area, may not be effective as it will soon break out again in case of a severe deep attack .

It is noticed that some actions taken to prevent corrosion (or erosion) can have some reversal effects on erosion (or corrosion). For example, the installation of the sand filter to reduce sand erosion, complicates the process of compressor washing and hinders the complete cleaning of the compressors of Helicopters. This results in increasing corrosion of compressor blades and inlet guide vanes.

Also, the temporary protective agents against corrosion are acting as suitable media for sand accumulation. On the other hand, sand or dust that block the drain hole, may create suitable conditions to initiate corrosion.

CONCLUSION

The present paper has outlined some problems arising in military Helicopters operating in corrosive and / or sandy environment. Emphasis has been placed on the observed types of corrosion and the technical

problem caused by erosion. Mutual interaction of corrosion erosion, as experienced during service, has also been discussed .
It is believed that further work is still needed to cover the following aspects :

- Complex mechanism of corrosion-erosion .
- More effective sand filtration, particularly against fine sand particles .
- Better sealing and protection against sand for fine mechanisms , main rotor head and actuating cylinders .

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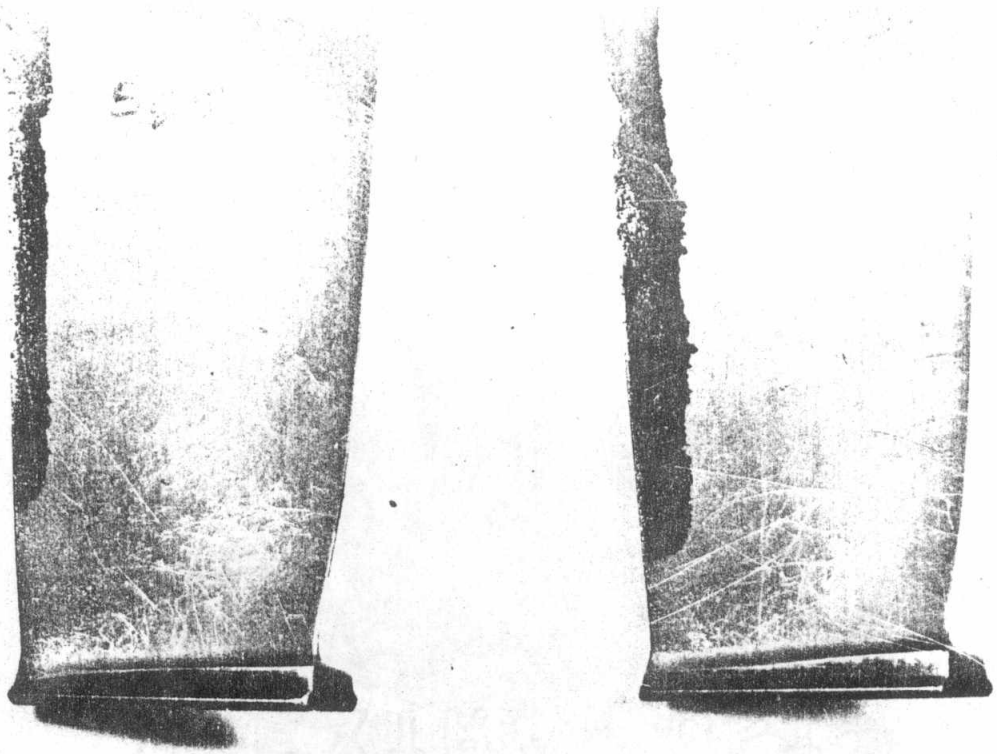

Fig. 1 Erosion in first stage compressor blades

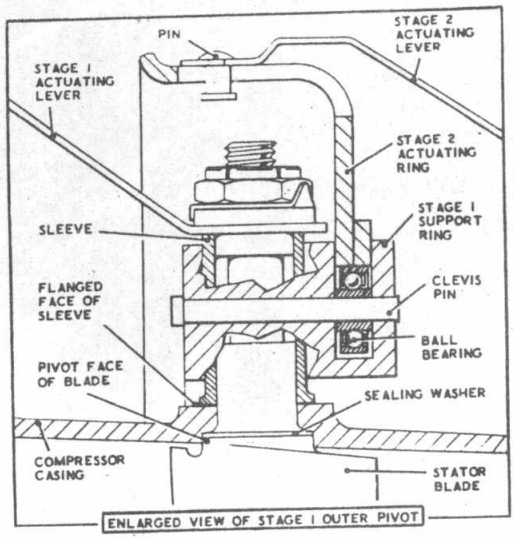

Fig. 3 Inlet guide vane actuating mechanism .

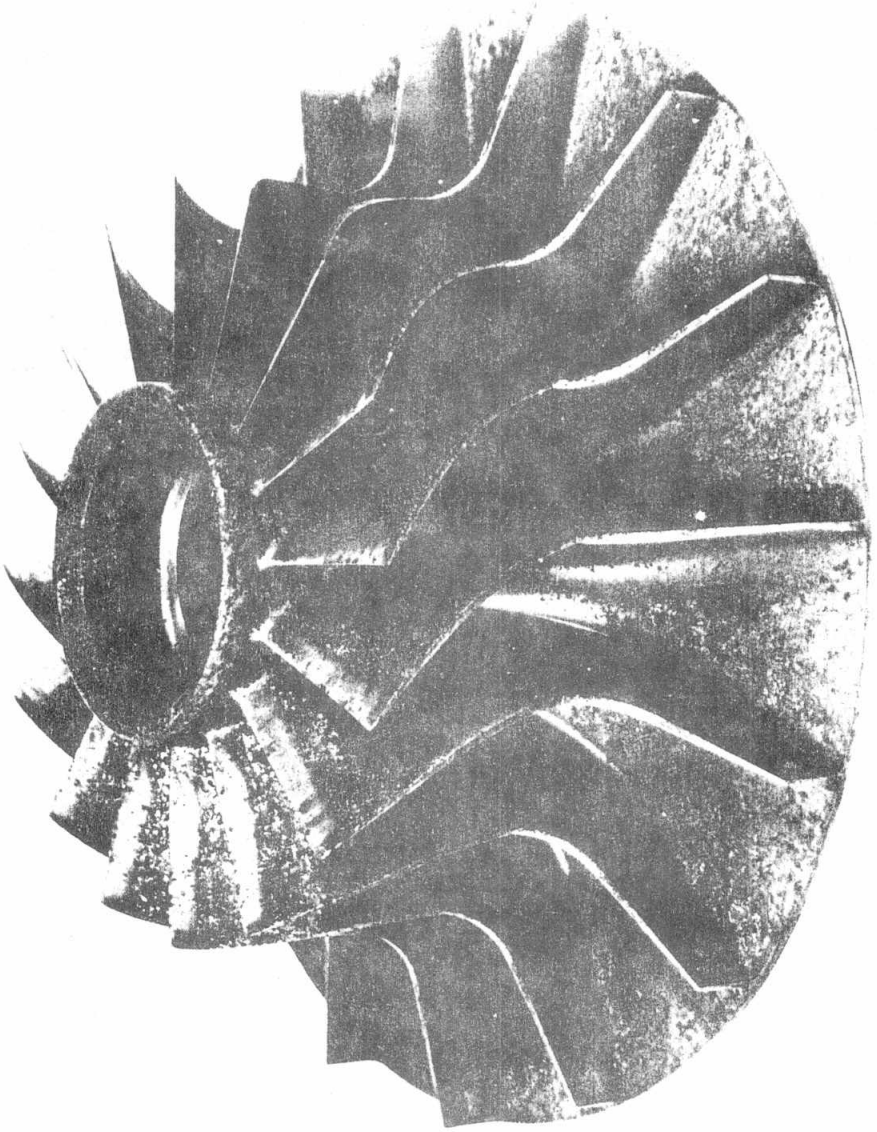

Fig 2 Corrosion in radial compressor impeller .