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Total Technical Life Extension of Undercarriage of Fighter Aircraft by Rejuvenation

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ABSTRACT:

During Maintenance, Repair and Overhaul (MRO) of an aircraft many components need to be replaced mainly due to lifting concerns. Undercarriage of a fighter aircraft is also one such component. In the present case there was a gross mismatch between the life of the undercarriage and the life of the aircraft, putting tremendous pressure on the supply chain resulting in improper exploitation of the aircraft. It was therefore necessary to study the technical and supply chain issues of the undercarriage (also referred and Landing Gear of simply LG) to get over this problem. The technical issues were sorted out using x-ray diffraction to find stressed layers. This was followed by carrying out other activities like sand blasting, magnetization / demagnetization, heat treatment, shot peening, etc. The supply chain managers ensured supply of spares and tools for this and finally the life of the LG was increased from 1500 landings to 2000 landings. The process was so satisfactory that it was adapted by a nearby PSU carrying out similar MRO activity for their aircraft successfully.

Keywords. *MRO, Total Technical Life Extension, Supply Chain Management, Rejuvenation.*

INTRODUCTION

The useful life (Total Technical Life) of aircraft is calculated based on various factors like, design parameters, various tests conducted during experimental stage to sustain stress and fatigue during operation, environmental conditions at which it operates, various periodical and non-periodical maintenance activities to be performed during the operation and finally factor of safety margin. The life is decided thereafter based on flying hours, calendar years and on landings depending on which parameter plays a major role in the life of aircraft or component. (Balachandran, P.R. Suresh, Vasudevan, & Kaushik, 2014)

Aircraft components provide the basic functionality for aircraft including aircraft control & navigation, communications, control surface movement, cabin air conditioning, electrical power, landing gear and braking. Most of the airborne equipment is manufactured ex-abroad with their life specified by manufacturers. Astronomical costs of new aviation equipment coupled with national constraints on resource have led thinking in terms of delaying phasing out of their current inventory. (Desai, 2001) The cost of landing Gear is typically about 25% of the cost of aircraft. (Global MRO Market Economic Assessment, 2013). The total technical life of the undercarriage (landing gear) of a fighter aircraft was 1500 landings. This put a severe restriction on the exploitation of the aircraft as its total technical life (TTL) was 1500 flying hours and with an average sortie time of 40-45 minutes this meant that a new landing gear (LG) was required in the end for about 300-400 hours of use of the aircraft. This put a load on the supply chain as well as the financial resource of the defence services

THE ISSUE

The time between overhaul (TBO) of the aircraft was 750-800 hours and the TBO of the LG was 1000 landings. While this matched, the problem was after overhaul when the aircraft could be used for 750 more hours with only 500 landings for the landing gear. There was thus a necessity to procure undercarriages (only new of course) at a huge cost. Since the procurement was from abroad there were issues related to time frame for procurement as well as management of the exploitation of the aircraft so that it does not go on AOG (aircraft on ground). Also since the life of a fighter ac is generally restricted, there would be issues of wastages (as opposed to obsolescence) due to non-utilization of new undercarriages. It was therefore decided to do a technical study to increase the post overhaul life of the LG to 1000 landings and match with the TTL of the aircraft. As some re-engineering was also required, a techno-logistic team was then formed to study and find a solution to the issue at hand.

THE SOLUTION

It was decided to start with a technical analysis of the LG with respect to stresses and methods to remove the stresses so that the LG is technically fit to perform the landings as required from a new LG. For this the areas which get stressed during landing were identified. Various techniques to check this were studied. It was found that in measuring residual stress using X-ray diffraction (XRD), the strain in the crystal lattice is measured and the associated residual stress is determined from the elastic constants assuming a linear elastic distortion of the appropriate crystal lattice plane. (Fitzpatrick, Fry, Holdway, Kandil, & Shackleton). By using x-ray techniques the depth of the stressed weakened area was thus identified. Photographs of the landing gear and the stressed areas are placed as Fig 1 and Fig 2. The average thickness (max) of the LG that had undergone stress was found to be 300 microns (0.3 mm). It was also seen from the technology that there was an additional 1.5 to 2 mm metal available on the undercarriage post original manufacture which could be utilized for rejuvenation of the landing gear.

The areas marked with dots in Fig 2 are the areas which are stressed and need to be cleared of the stress to enable use of the undercarriage for another life of 1000 landings. The undercarriage was constructed as a hollow cylinder, and the thickness of the wall of the cylinder was designed to be 12 mm. It was however found that even after removal of the stressed layer it would have been possible to meet the technological requirements of a new undercarriage due to the extra thickness available during original manufacture.

To start with the complete LG was put in a sand blasting machine to remove layers of paint to prepare the LG for magnetic crack detection. This was followed by demagnetisation. Dye penetrant was also required to be used in the crack detection process. (BEST PRACTICE FOR THE PROCUREMENT AND CONDUCT OF NON-DESTRUCTIVE TESTING). Re-engineering was used in manufacture of bushes which were required to be replaced as discussed later in this paper.

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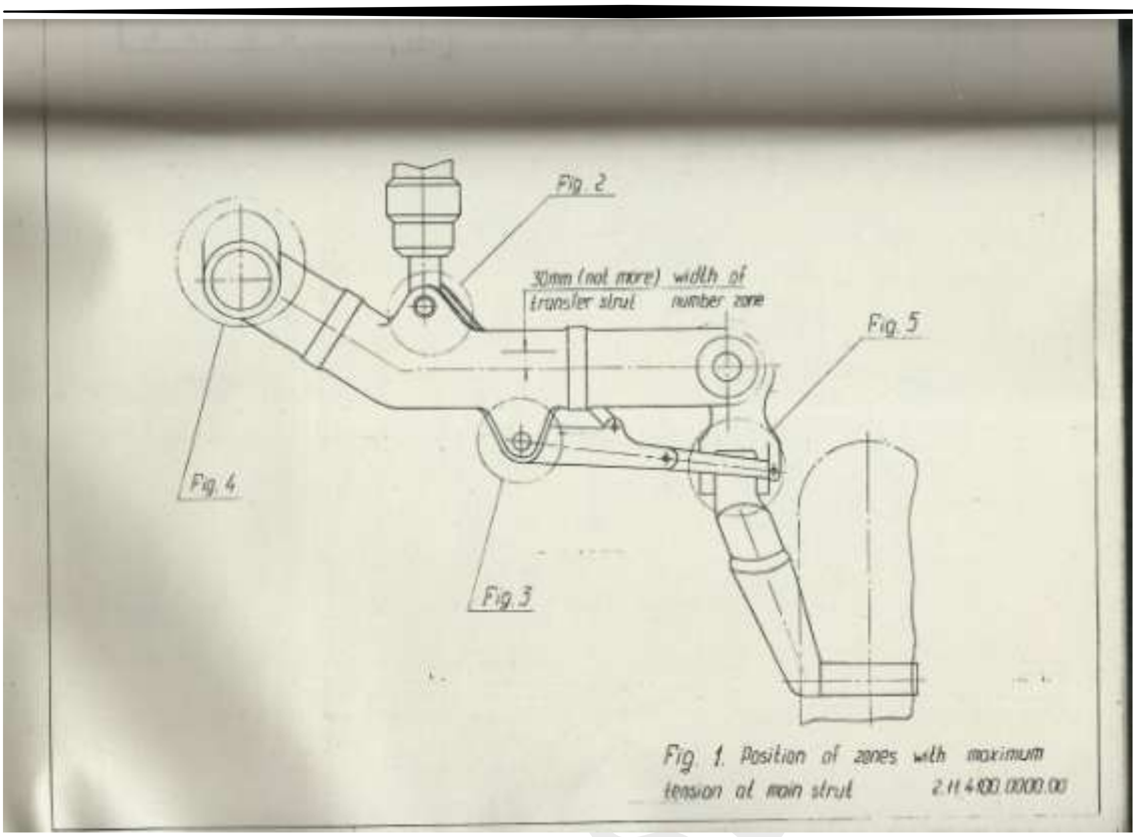

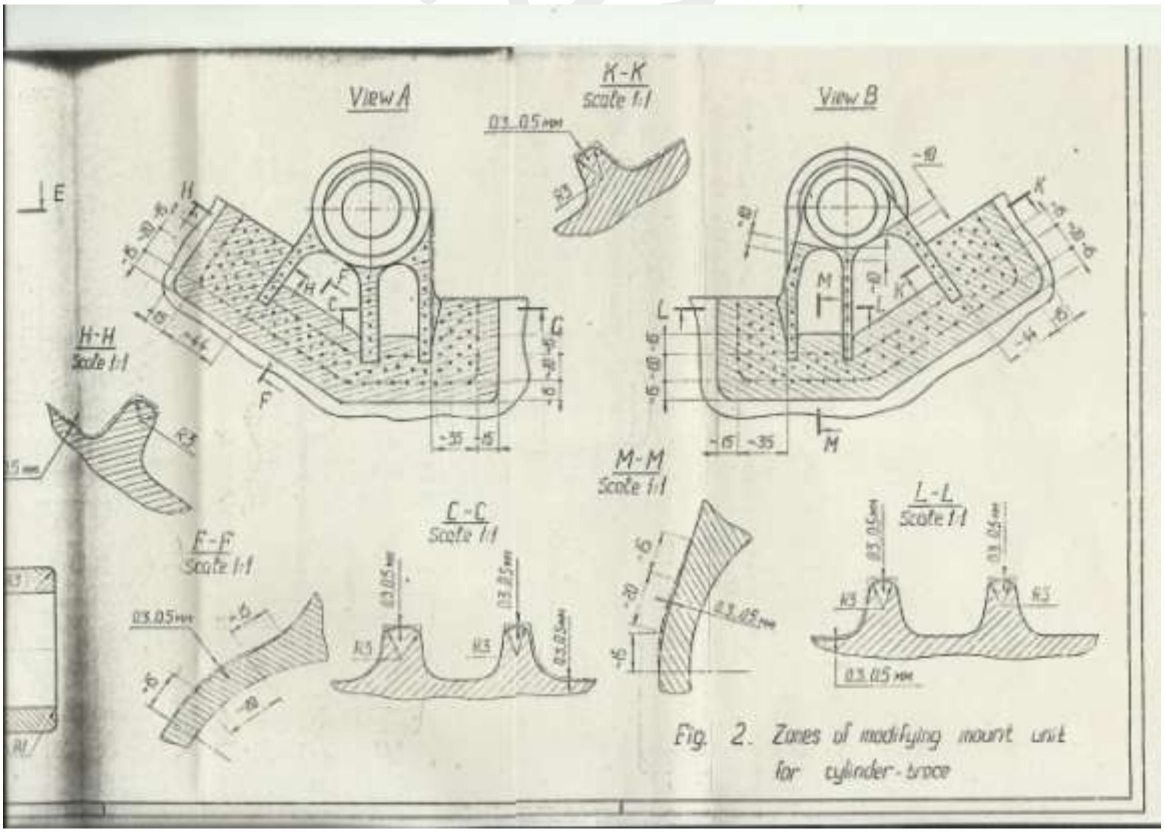

THE RECOVERY PLAN

The recovery plan consisted of two main streams Technology and Supply Chain. The technology stream ensured quality of product and meeting the specific technological requirements and the supply chain stream was required to get the necessary spares and tools required to carry out the rejuvenation. Various processes were studied for this and before implementing these, the personnel were made to undergo rigorous training especially in the areas of Non-destructive testing. Personnel were also sent abroad to study similar processes carried out on similar components. Documents regarding some special tools and testers required were also procured and the supply chain team located similar indigenous tools for using during this process.

TECHNOLOGY ISSUES

As mentioned, for rejuvenation, the main activity was to remove the stressed layer and then bring back the landing gear to meet the original technological requirements. The X-ray of the undercarriage indicated the areas which were stressed. These are marked in the above figure. To remove 0.3 mm of this stressed layer was the first challenge. For this a special attachment was made which was fixed at the tip of the drilling tool of a drilling machine. Several points were marked with a pencil on the stressed area and then 0.3 mm holes were drilled at these points. This is also indicated in Fig 2. With a fine grinder the whole area was then ground so that the holes were removed and not visible. A repeat X-ray confirmed that the stressed layer was completely removed.

A number of bronze bushes exist in the undercarriage, which take the load of various axles like axle for attaching the landing gear to aircraft, axle for attaching the wheel, and axles for the various linkages which support the undercarriage. These bushes were found to be generally worn out and needed replacement during the rejuvenation. While removing the old bush was not a problem, it was the replacement which was a challenge. The solution was however simple. The new bush was immersed in liquid nitrogen, which shrunk the bush. It was then simply placed at the location required and allowed to come to room temperature. The finishing effects for the bush were done by a honing tool manually so that the size of the bush matched that of the axle.

The work however started with sand blasting of the LG to remove external coatings. This was followed by magnetic crack detection of the LG to ensure that no cracks have developed during the exploitation of the LG. After repair the LG was again demagnetised and heat treated to remove working stresses. The LG was required to be preloaded with compressive strength which was achieved by shot peening of the LG with steel balls impinging on the LG at high speeds. SHOT PEENING is a means of cold working the surface of metal parts by means of a hail or blast of round metal shot directed against the surface. (LEGHORN, 1957)

After the processes were completed the LG again went through X-ray and micrometry to confirm that there are no residual stresses and the LG meets the technological and dimensional requirements. Layers of primer and fresh coat of protective paint was then put on the undercarriage. The LG was then certified fit for a further 1000 landings, thus achieving a saving of more than $10000 per LG for the Defence services.

SUPPLY CHAIN ISSUES

The supply chain issues were mainly concerning procurement of Tools, Testers and Spares. A study of the tools required revealed that most of the tools were generic and were available readily. Some of the tools which were not available were manufactured from local vendors through indigenous designs. A survey revealed that many of the testers required were available in a local aviation PSU. Most of the time required for procurement was actually to find out the availability of the items, and once that was done the items were procured on highest priority.

CONCLUSION

Life of undercarriage was a major issue during overhaul of the fighter aircraft. However, the technology and the supply chain teams worked together to find a solution to the problem. This finally resulted in Foreign Exchange savings of over $1,000,000 due to rejuvenation of more than 100 undercarriages. It was proved that out of the box thinking will always result in a solution that benefits the organization to a very great extent.

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