



## International Journal OF Engineering Sciences & Management Research

### “RECONDITIONING OF JET PIPE OF ADOUR MK 871 ENGINE”

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#### ABSTRACT

The HAWK 132 aircraft used in Indian Air Force Indian Army and Indian Navy which is used to train the pilot is powered by an ADOUR MK-871 Engine which is a Turbofan Engine. One of the very important parts of this engine is jet pipe which performs the function of transferring the exhaust gases of the engine safely outside.

The duct attached to the rare end of aircraft engine through which the hot exhaust gases are discharged is called as jet pipe. Jet pipe will guide the hot exhaust gases out of the aircraft. It also angled such that it helps during take-off of the aircraft.

In this paper we discuss to repair a jet pipe of ADOUR MK 871 engine which has developed cracks due to thermal stresses beyond the limit of acceptance with reference to the overhaul manual. This problem is frequent in the life cycle of the engine, therefore with the ADOUR MK 871 department we will discuss to repair this component and hence save the part from getting rejected and save costs. This will be done by coordinating with various departments like assembly shop, quality, methods, Design Liaison Engineering, progress, manufacturing, test bid of the HAL Engine Division and later updated in Manual

#### INTRODUCTION

HAL is the manufacturer of ADOUR 871 engine which is used in the trainer Hawk air craft. Adour engine is a turbofan engine which is similar to turbojet engines with additional by pass system. Here the fully compressed air enters combustion chamber section while uncompressed enters by pass unit which either joins at turbine or is exhausted to atmosphere via hot zone. The advantage of by pass system is that it increases turbine efficiency and decreases turbine gas temperature thereby increasing the lift and efficiency of turbine. It also cools combustion zone and hot end section of engine. Common jet engine used in the most of the aircraft is turbo fan engine type.

#### Study On Jet Pipe

A jet pipe is duct that guides the exhaust gas outside the engine. A jet pipe converts the gas turbine or gas generator into a jet engine. Energy available in the gas turbine exhaust is converted into a high speed propelling jet by the nozzle. Turbofan engines may have an additional and separate propelling nozzle which produces a high speed propelling jet from the energy in the air that has passed through the fan. In addition, the nozzle helps to determine how the gas generator and fan operate as it acts as a downstream restrictor.

Propelling nozzles accelerate the available gas to subsonic, transonic, or supersonic velocities depending on the power setting of the engine, their internal shape and the pressures at entry to, and exit from, the nozzle. The internal shape may be convergent or convergent-divergent (C-D). C-D nozzles can accelerate the jet to supersonic velocities within the divergent section, whereas a convergent nozzle cannot accelerate the jet beyond sonic speed.

Propelling nozzles may have a fixed geometry, or they may have variable geometry to give different exit areas to control the operation of the engine when equipped with an afterburner or a reheat system. When afterburning engines are equipped with a C-D nozzle the throat area is variable. Nozzles for supersonic flight speeds, at which high nozzle pressure ratios are generated, also have variable area divergent sections.

#### PROBLEM ON HAND

Engines are tested in test bed to check the performance of the engine. The tests are carried out to evaluate the engine performance. The engines built that do not pass through the performance test due to snags in the jet pipes are caused due to following reasons

- High Jet pipe temperature
- Pressure variation
- Due to angled design of the jet pipes



*Jet Pipe To Be Reconditioned*

High jet pipe Temperature is a phenomenon where exhaust gas temperature of the engine is more than limit (550 °C).

The high JPT is in turn related to turbine inlet temperature. If JPT becomes more than the Specified limit, there is a danger of turbine blade damage. The high JPT can be due to rich fuel mixture. It is governed by airflow, fuel flow and design of engine.

JPT is measured by four thermocouples located in Jet pipe and the average is indicated in the gauge which is located in the cockpit. JPT can be attributed to the malfunctioning of the burner and variation in throat area of the combustion chamber and less air flow, compressor efficiency and compressor surge. It is the most frequently occurring snag in Adour MK871 engine.

In our project we are faced with a very frequent problem in the Adour MK871 engine. Cracks have been observed in the crank section of the jet pipe, there is a repair scheme provided by Rolls Royce and Turbomeca but due to some factors the schemes are limited. Due to the high JPT the cracks occurred are beyond the limits that are provided in repair manual but this can be extended so that parts can be repaired and saved from getting rejected.

### **RELAVENT LITERATURE REVIEW**

**Adour MK 871:** The Adour is a family of turbofan engines developed in conjunction between Rolls-Royce and Turbomeca. These engines are available with or without afterburner. They were selected to power Jaguar, Hawk. It powers single-engine Hawk 100/200 aircraft. Originally, it was rated at 5,845 pounds of thrust but the latest 871 engines deliver up to 6,000-lb. Adour Mk871 engines are not provided with afterburner.

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Adour engine is a bypass jet engine of modular construction. The Adour has a two-stage low pressure and five-stage high pressure axial flow compressors which are driven by a separate, single stage high pressure and low pressure turbines connected through co-axial shafts, with low pressure shaft passing through high pressure shaft.

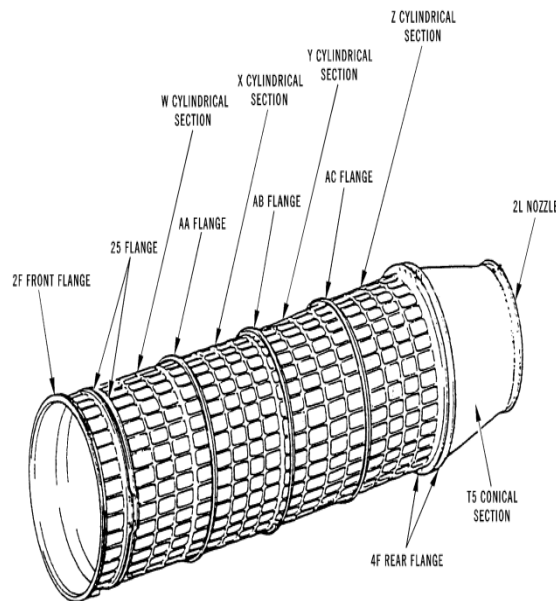
### Engine Specifications

1. Type of engine – turbofan
2. Arrangement- two spool axial flow
3. Bypass ratio- 0.80:1
4. Thrust- 5900Lbs
5. Normal length- 1997 mm
6. Weight- 658 kg
7. Working principle- Newtons III law

### Jet constructions

The Adour MK - engine jet pipe consists of the following sections.

- W cylindrical section
- X cylindrical section
- Y cylindrical section
- Z cylindrical section and
- Conical section



It also consists flanges at different locations.

- 2F front flange
- 25 flange
- AA flange
- AB flange
- AC flange
- 4F rare flange
- 2L nozzle

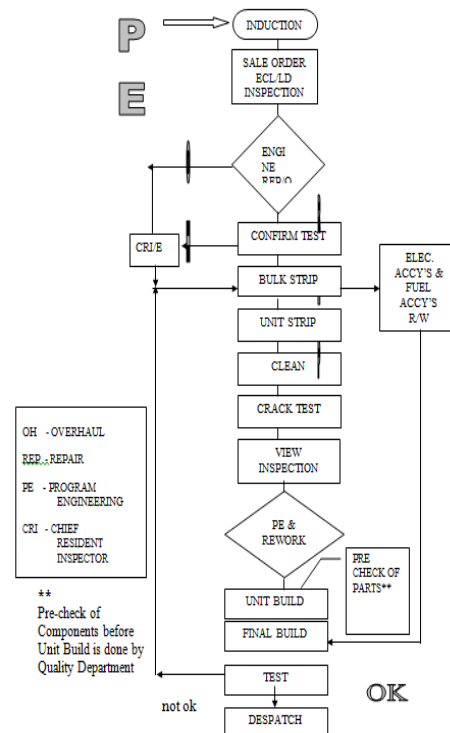
The jet pipe also associated with the thermal blanket, these thermal blankets are provided so that the heat generated by hot gases should not be transmitted to aircraft. Since the jet pipe is subjected to high temperature to withstand the hot conditions the material must be chosen carefully.

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The jet pipe are made by the mild steel material, and the seam welding and TIG welding process done for the manufacturing of the jet pipe.

After sheet metals are rolled into the specified diameter they are joined by longitudinal welding by inert gas, then each sections are joined by circumferential welding process, then pockets are formed by chemical machining process, since the corner radius of the pockets should be accurate LASER cutting is done to remove the coating material from the surface where the machining should be carried out.

### Procedure for overhauling



### OBJECTIVE

- Establish a new repair scheme for the cracks present on Jet pipe and recommend implementing in all such cases.
- Use the scheme to repair the jet pipes.
- Use the new welding technique on the cracks.
- Service the jet pipe for the best reuse and hence prevent financial losses which would occur on a rejected part.
- To study and understand the various department of industry working together for a common goal.
- To succeed in exploring the innovative ideas.

### RECOMMENDATION

By the relevant data collection and data analysis of repair scheme. The cracks that are observed above are beyond the acceptable limit as per the available scheme on manual, so on extensive rework is undertaken to weld beyond the scheme limit by forming a committee comprising of various concerned departments to carry out further welding

In complete technical terms and also test and prove it successfully and clear for further exploitation in the actual conditions as we were involved process throughout along with experts team .

We would like to give the recommendation as follows:



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- After view inspection, in case of the cracks beyond the acceptable limits. The experts team involved in repair activities can take up some of the cases which are considerably remarked.
- The team has to follow the part meticulously at all stages and all work stations upon successful completion the rework without any deformation or flaws. The jet pipe may be subjected to test on test bed.
- Subject to clearance from all departments, the jet pipe may be put in serviceable condition.
- It is observed that the material used in jet pipe is stainless steel. It is also known through the internet most of the jet pipe is made of Nymonic material. We also recommend that this problem can also be overcome by changing the material.

### CONCLUSION

The above repair was carried out successfully and the jet pipe for put on serviceable condition. This case may be considered as a reference for the further repair work.

Thus the following advantages can be obtained

- The jet pipe is saved from rejection and it has big impact on cost saving.
- HAL can minimize Aircraft operationally grounded with respect to the jet pipe.
- Fleet support

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