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Deliverable 4.2 **Test rig design documentation**

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EXECUTIVE SUMMARY

1. Introduction

The purpose of this document is to present the design documentation of a test rig for the development of health monitoring capabilities for the differential of an IDG. The information included in this document refers to a test rig capable of reproducing the mechanical failures of the differential of an IDG used in airplanes of the Airbus A320 family. While the working principles are common to other IDGs, the dimensions and power are tailored to this particular application.

2. Choice of component for WP4

As specified in D4.1 "Test Rig Requirements Document", the system of choice for the development of health monitoring capabilities for components produced using additive manufacturing is the input shaft if the differential of the IDG. Additional information has become available since the submission of D4.1.

The IDG extracts mechanical power from the jet engine and transforms it into electricity to feed all the elements of the electrical system. The IDG chosen for this project produces 90kVA that are distributed using a 3 phase A.C. circuit with a constant frequency of 400Hz. The electric generators operate at speeds of 12,000rpm, with older models spinning at 24,000rpm. While the input speed range of the differential is 4,500-9,200, under normal operational conditions the range is actually 4,500-7,500rpm. Speeds above 7,500 correspond to operating conditions during which the IDG is over speeding. This is a transient state that can accelerate the degradation of the components of the differential. However, this does not affect the nature of the degradation mechanisms of the differential, it simply accelerates them. This project will focus on the degradation suffered by the carrier shaft on which the planetary gears are mounted (Figure 1). The shaft itself is divided into two parts to allow for the assembly of the planetary gears and their bearings. The carrier shaft presents a complex geometry due to the numerous geometric constraints imposed by the IDG and the need to accommodate the planetary gears. At the same time, the carrier shaft needs to be drilled to allow for the oil to flow to the bearings of the planetary gears.

Figure 1 Assembled carrier shaft of the CSD (left) and parts considered for additive manufacturing (centre and right). Source: CU

Currently, IDGs do not have any health monitoring capability apart from overheat detection and over speed disconnection. Whilst there are systems in place to disconnect the IDG to prevent more serious damage, they do not provide any indication as to what caused the symptoms or the level of the damage sustained by the IDG.

3. Configuration of test rig

The test rig has been designed with the purpose of conducting the following types of tests on IDG differentials:

- Seeded fault test: These tests involve using components with faults (e.g.: cracks, severely damaged tooth) to develop a diagnostic algorithm.

- Seeded incipient fault tests: These tests involve using components with incipient faults (e.g.: initial pitting, wear due to friction, mild misalignment) to develop a prognostic algorithm.

- Lubrication system pressure drop test: It has been brought to our attention that some of the most important failures are caused by excessive friction between parts rotating at high speed. While the causes of the drop of pressure are diverse and not fully understood, its effect on rotating components can be monitored.

The test rig will use an electrical motor to produce the input torque for the IDG differential. The load will be provided by an electric generator. This setup allows for electrical parameters to be read from the generator. Whilst this would not be necessary to test any other kind of transmission, the fact that the Generator Control Unit (GCU) collects mainly electrical data justifies the use of a separate electrical load rather than using a torque loop.

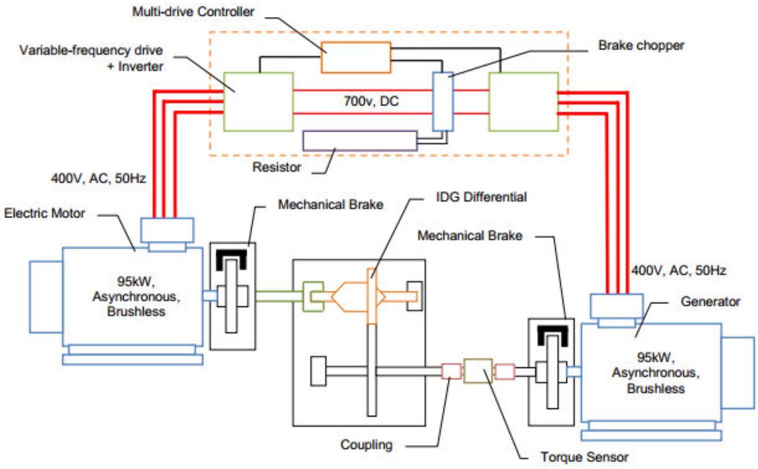

Figure 2 Basic configuration of test rig for IDG differential

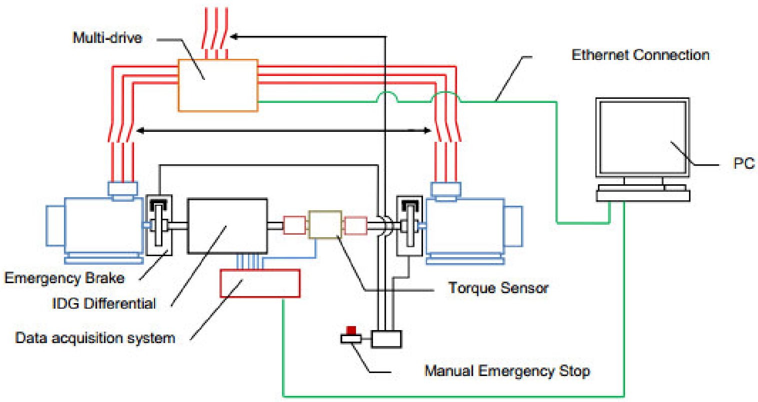

Figure 3 Control system connections diagram

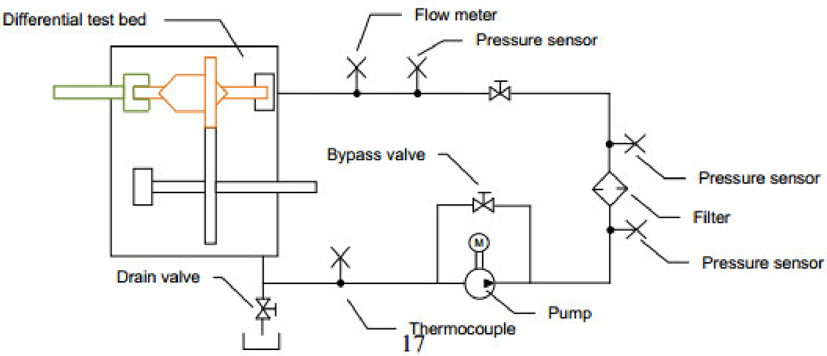

Figure 4 Lubrication System Diagram

4. Final design

The layout of the test rig can be seen in Figure 5. The footprint of the mechanical components of the test rig is 4.6x1.1m. Electrical control elements like the multi-drive will be installed in an independent “bookcase” rack.

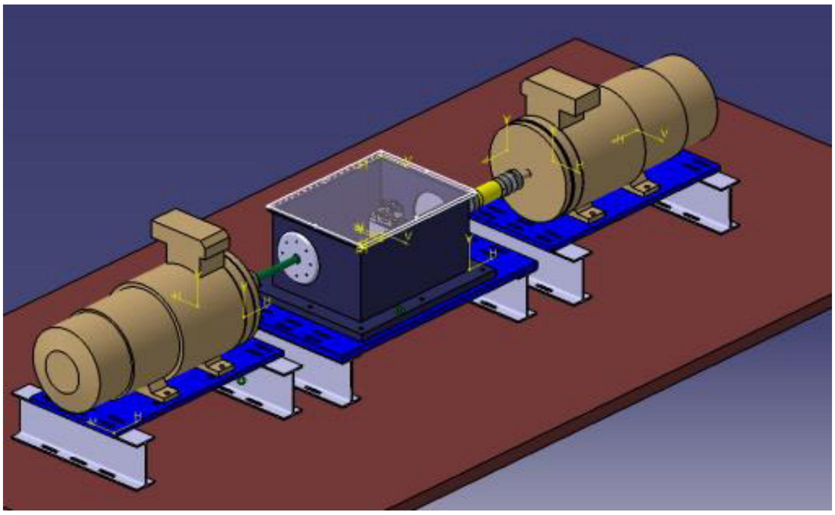

Figure 5 Final layout of test rig

Specific technical requirements for each subsystem can be found in the main body of this report. The technical documentation of some of the different elements of the test rig is included in Appendix A and the technical drawings of the final assembly and components can be found in Appendix B.