Bell Helicopter Transmission Thermal Management Project

Overview

Bell helicopters are widely used for both military and commercial applications where main transmission operation after failure of the main gearbox’s lubrication system is desired. The lubrication system’s primary purpose is to provide cooling to the gear meshes and ball bearings. In the event of a loss of lubrication accident, the US Department of Transportation requires that the helicopter be able to maintain flight for 30 minutes. This extra time allows pilots to safely attempt an emergency landing.

Objectives

The purpose of our project was to investigate various techniques to increase the heat transfer of a helicopter gearbox after a loss of lubrication accident. Methods for improving the thermal management should, without the cooling aid of the primary lubricant, decrease the temperature increase for the gears and bearings by 50% relative to the baseline design configuration. Considerations must be made to minimize the impacts of the cost, weight, and reliability of the system.

Approach

- To start our project, background information was gathered. This was completed via initial teleconference meetings with Bell Helicopter engineers and reviewing journal articles.
- It was determined that the existing techniques currently being used by Bell are: maximizing the component surface area and mass, using a collected lubricant system, and adding an additional secondary lubrication system.
- Our team generated 4 concepts that could possibly be researched. These concepts were adding fins to the outside of the gearbox, adding heat pipes to various locations in the gearbox, developing an external coolant spray system, and to add a coating to the gears to decrease heat generation.
- Through discussions with Bell and our concept selection process, our team decided to investigate how much water would be necessary to cool the gearbox during the 30 minute accident scenario.
- An experiment was created to simulate spraying coolant on the outside of the gearbox. Different nozzles were purchased that produced different flow rates.
- To set up our experiment, a silicone heater was attached to the back of an aluminum plate. Using a variac, the heat output of the plate was able to be adjusted.
- Various tests were performed using this experimental setup. The first test was to calibrate the different nozzles. The second test was to heat the plate up to 450 F and then spray the plate until an equilibrium temperature is found.
- The final and most important test was an accident scenario test. During this test the water was turned on when the temperature reached 475 F and turned off once the temperature fell to 350 F.

Outcomes

Using the data from the accident scenario test, it was determined that for the entire gearbox to be cooled for 30 minutes, 20 lbs of water must be used. Twenty pounds in addition to the cooling system was determined to be too much additional weight. To decrease the amount of water used during the accident scenario, we suggest Bell investigate using misting nozzles, a lower flow rate, and various nozzle placement.