Using Computational Fluid Dynamics to Test Air Flow and Heat Generation for a Four Bearing Test Rig

Alejandro Vail, James Aranda, Joseph Montalvo, Constantine Tarawneh, Ph.D.
Department of Mechanical Engineering, The University of Texas Rio Grande Valley

Abstract

For this research project, Computational Fluid Dynamics (CFD) was used in tandem with SOLIDWORKS to simulate the heat transfer and airflow in and around a new design of a four bearing test rig. The UTCRS research team ran more than twenty simulations testing different configurations of heat generation and fan arrangement. The results of these simulations will be taken into consideration in the fabrication of the four bearing test rig later this summer.

Introduction

The University Transportation Center for Railway Safety (UTCRS) is a research center at The University of Texas Rio Grande Valley that focuses on improving the protocols and diagnostic methods employed by the U.S. Rail Industry. One of the most severe incidents observed by the railroad industry are train derailments, which can cause millions of dollars in damages and the possible loss of lives. Past experiments have been performed on commonly used classes of double tapered roller bearings by utilizing the variety of dynamic test rigs available at UTRGV. The UTCRS is currently building a new four bearing test rig that will assist in expanding its current library of bearing data. A computer-aided drafting (CAD) model of the new four bearing test rig has been created on SOLIDWORKS, shown in **Figure 1**. The design specifications of the rig require the bearings to operate below a maximum temperature threshold. In order to ensure the safety of the rig and its operators, the CAD model was used along with CFD methods in order to verify that the design allowed for adequate airflow around the test rig.

Methodology

The airflow and heat transfer analysis of the four bearing test rig was performed using SOLIDWORKS Flow Simulation. In order to simulate real-case scenarios, a CAD model of the testing room was created. This room was assumed to be adiabatic, meaning that no heat transfer can occur across the boundaries of the room. Two fans were placed in the room to simulate the air flow. These were programmed to generate a volumetric flow rate of 10,000 cubic feet per minute (cfm), the value prescribed by the specifications of the fans currently in use by the UTRCS. The material used in the simulation is modeled as mild steel and included gravity, which assisted in accurately modeling the effects of free convection. The simulated room was set for internal fan flow using air as the fluid medium. The simulation accounts for both laminar and turbulent flow types. For the heat transfer simulation, the surface heat generation was placed on the rollers and raceway of the inboard side of the third bearing.

Figure 1: (Left) The test rig will be constructed and operate in this 90” x 132” x 90” room. (Right) CAD model of the new four bearing test rig.

Results

In **Figure 2**, the temperature profile shows the majority of the heat in the third bearing due to the heat generation being applied to this location. Large temperature changes can be observed only on the bearings, axle, and plate that this assembly rests on.

The air trajectory in **Figure 3** shows that the air velocities start at 5 m/s which quickly drops after the flow passes across the tester. Despite this, the air rises to the top of the room and is fed back into the fans, thus completing the flow cycle.

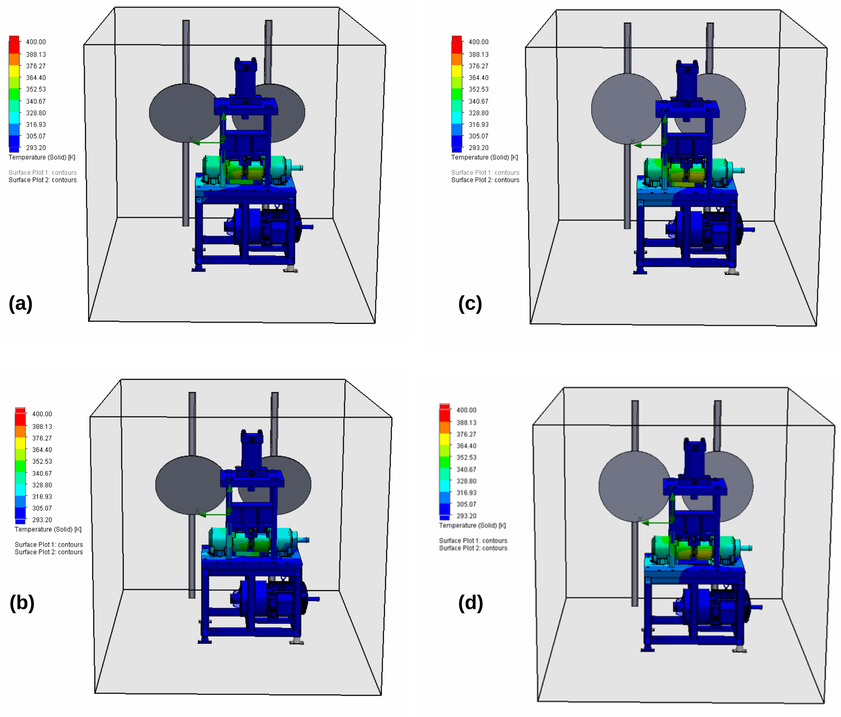

Figure 2: Screenshots of the heat generation of the four bearing design were taken with varying watts per roller and with the fans aimed at the bearing and aimed straight ahead. (a) Shows results with a heat generation at 560 watts and the fans pointed downward at a 25° angle. (b) Shows results with a heat generation at 460 watts and the fans pointed downward at a 25° angle. (c) Shows results with a heat generation at 460 watts and the fans pointing forward and parallel to the floor. (d) Shows results with a heat generation at 560 watts and the fans pointing forward and parallel to the floor.

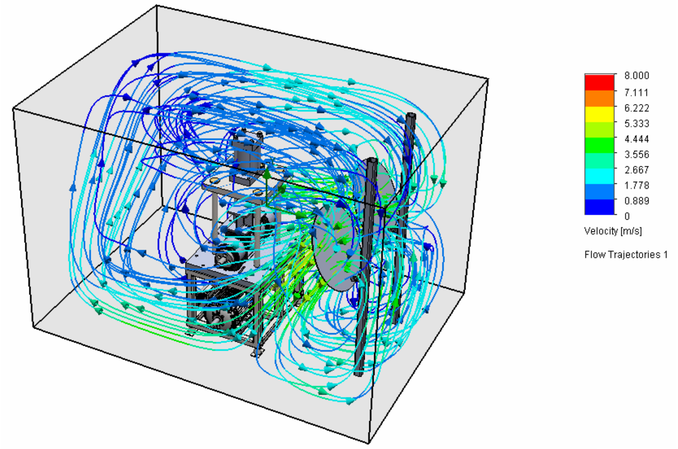

Figure 3: A simulation of the airflow trajectory showing the velocity of the air along each path.

Discussion

The results exemplify how great an influence air flow has on the cooling of a heated object. Although the heat generation was essentially the same in the first two experiments, the difference between temperatures from fans that were pointed at the bearings and from fans that aimed straight ahead ranged between 20-30 degrees Kelvin. When the fans are aimed straight ahead, it can be seen that more heat is transferred into the resting plate when compared to when the fans are aimed at the bearings. This can play a significant role on not only the lifespan of the bearing, but of the test rig as well.

Future Research

Fabrication is the next step in the four bearing test rig project. When the four bearing tester is built and experiments are conducted, the empirical data can be compared with the results of the simulations done on SOLIDWORKS. To test the temperature on different parts of the test rig, K-type and bayonet thermocouples will be used. Additionally, to test for air velocity, an anemometer can be implemented. It will be interesting to compare the results and identify the similarities in a real life experiment versus a computer simulation.

Acknowledgements

I would like to thank Dr. Constantine Tarawneh and the entire UTCRS research team for letting me work with them. I thank them for teaching me everything that I learned throughout this internship from learning about the computer programs to learning the machinery. I want to also thank the High Scholars Program for having this internship that I was able to be a part of. I am thankful for everything I was able to learn because of this internship. I would like to thank my parents who played a large role in supporting me and helping me complete the internship. Finally, I would like to give special thanks to the U.S. Department of Transportation for funding the University Transportation Center for Railway Safety and providing the students of the Rio Grande Valley with this great opportunity.

.