Product Specification and Project Plan

EML 4551C – Senior Design – Fall 2011 Deliverable

Group # 1

Air Bearing Upgrade for the Split-Hopkinson Pressure Bar Experiment

Department of Mechanical Engineering, Florida State University, Tallahassee, FL

Project Sponsor
Eglin Air Force Research Laboratory

Project Advisor
Dr. Kalu, PhD
Department of Mechanical Engineering

Reviewed by Advisor:

Table of Contents

Introduction -

The goal of this project is to create a working prototype of a split-Hopkinson pressure bar (SHPB) experiment or at least a very similar mechanism that displays the major characteristics of the pressure bar experiment. The prototype should be a table top version to show the most basic form of the experiment. The information gained from this prototype will be able to be implemented to the full scale version used by the Air Force Research Laboratory (AFRL).

Product Specification –

The SHPB mechanism will consist of air bushings with an air supply, an incident bar, a transmitted bar, strain gauges and a mechanism to initially move the incident bar. The main idea of this project is to implement the main components of the experiment, mainly five-eighths inch diameter bars and corresponding air bushings, into a table top version to gain information for the AFRL.

Air Bushings -

Although the name of this project implies the use of air bearings, what will actually be used in the final design will be air bushings. An example of an air bearing is the surface of a air hockey table which allows for reduced friction while still permitting 3 degrees of freedom (2 linear and 1 rotational) to an object passing over its surface. In contrast, air bushings are used to restrict a rod's movement to linear motion along and rotational motion about the rod's lengthwise axis.

Given the bars in the final SHPB experimental model must maintain tight, co-linear tolerances while significantly reducing friction, air bushings will provide the better solution. There are multiple types of air bushings, and the bushing most suitable to this project must be determined. One of the main distinctions between types of air bushings is the method by which compressed air is supplied to the 'contact' surface between the bushing and rod. The most basic method is the placement of one or more small outlets in the contact surface. This method can be modified to include shallow channels in the contact surface which guide the compressed air away from the outlets in order to achieve a more uniform pressure distribution. The method which provides the most even pressure distribution involve the use of an air-permeable material, such as porous carbon, to distribute the compressed air along the contact surface. Whichever type of air bushing is chosen and implemented in the final design, a significant reduction in the friction between the bushings and rods should be achieved when compared to the contact friction inherent in the use of more traditional metal or ceramic ball bearings.

Air Supply -

Given that air bushings are to be used in the completion of this project, the method by which those bushings are to be supplied with compressed air must also be addressed. The main portion of the air supply system will be a compressor; the size and rating of which will be determined by the requirements of the bearings. Assuming that not all bushings are created equal, those which could be selected for the project will have differing requirements as to the pressure and quality of air they must be supplied in order to properly function. As an example, New Way Air Bearings produces an air bushing for 0.75 inch diameter rods. This bushing requires a flow rate of 7.0 to 9.60 Standard Cubic Feet per Hour (SCFH) while other bushings of the same type require flows between 2.25 and 37.8 SCFH. Also, because this bearing utilizes a porous contact surface, it requires air that has been dried and cleaned using first a general-purpose filter, followed by a coalescing filter, and a desiccant dryer. This level of air purification would require higher air quality control than is available on the average shop compressor. The implementation of a filter and drying system between the compressor and bushings will likely be required. If so, the choice of this system may affect the usefulness of the final design as much as the choices of compressor or bushings themselves.

Strain Gauges -

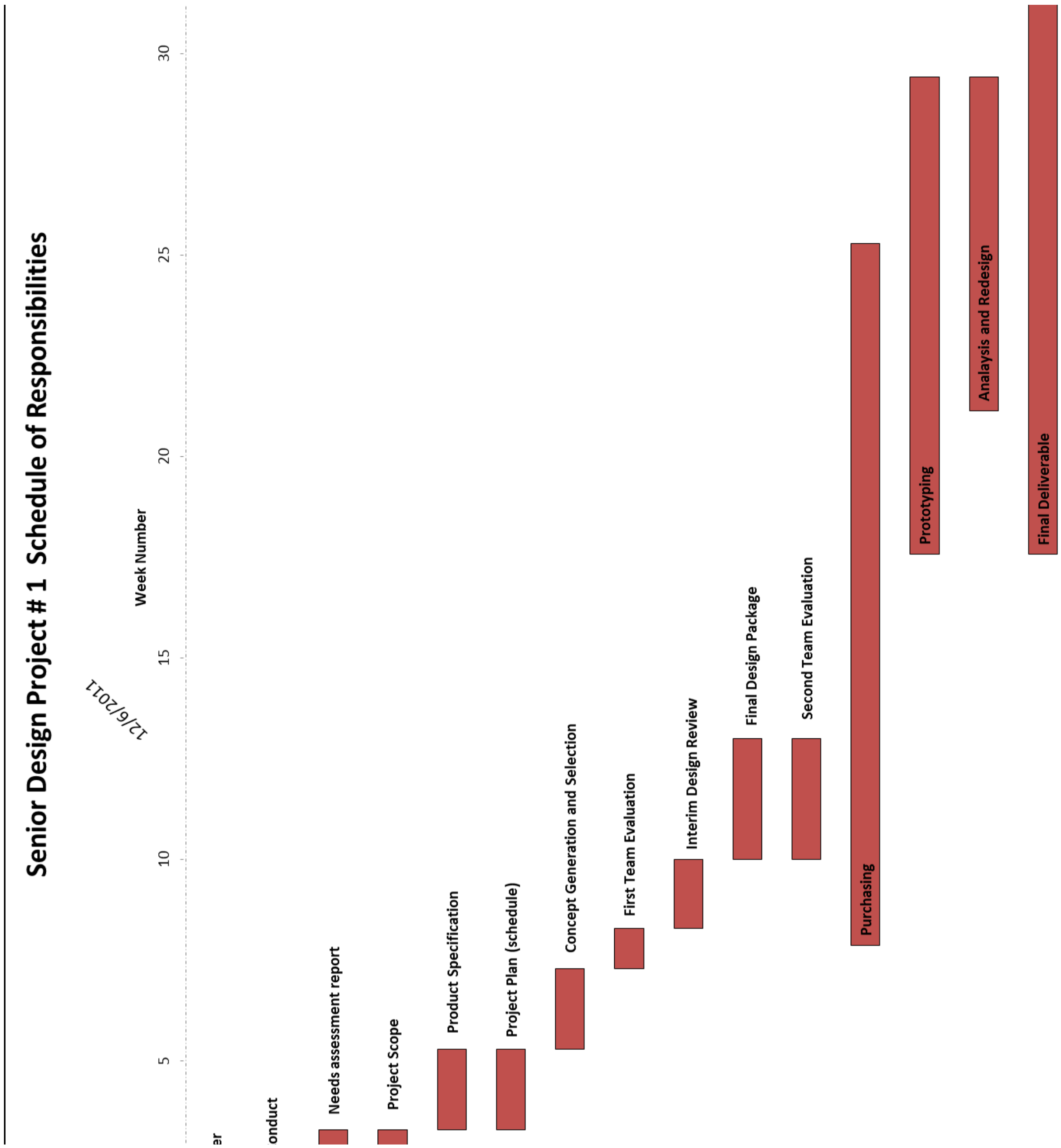
The strain gauge is a device used to measure the amount of deformation over the original length of a certain object after a force has been applied. The values for strain are usually less than 0.005 and are displayed in micro-strain units. Strain can be measured for tensile or compressive loads. The strain will be measured in compression for the purpose of this experiment. A strain gauge works by converting mechanical motion into an electrical signal. The sensor responds to a change in capacitance, inductance, or resistance. In this experiment the strain gauge will respond to the change in resistance. The strain gauge must be connected to an electrical circuit which will be a wheatstone bridge circuit for this case.

The strain gauges on the Split Hopkinson Pressure Bar measure the strain from the propagating wave. The strain gauges will be placed on the bars so that the waves do not overlap and cause disturbed signals. A factor for choosing the correct strain gauge is the degree of accuracy which will influence the results of the experiment.

Split Hopkinson Pressure Bar -

The Split Hopkinson Pressure Bar that will be used at the Eglin Air Force Research Lab is expected to have a diameter of 5/8 in. There is the possibility that the bar diameter will be slightly larger or smaller because of the air bushing sizes that are available at certain companies.

A diameter will be chosen by the group for the model that will be built at the FAMU-FSU College of Engineering. Some factors that will determine the selection of the diameter size for the mock-up include the material of the bar, the compatibility with air bearing bushing sizes, and the cost. Also, the length of the bar used in the model will be scaled down. The alignment of the bar is critical for obtaining accurate results. The bars will have to be interfaced to a support. The support used at Eglin is an I-beam. The support design that will be chosen for the model will be influenced by factors such as cost and strength.



References –

- NewWayAirBearings. "Porous Media Technology." *New Way Air Bearings*. Web. 09 Oct. 2011. <http://www.newwayairbearings.com/Porous-Media-Technology>.

- New Way Air Bearings, Inc. *Porous Media Air Bearing Solutions*. Aston: New Way Air Bearings, 2010. *New Way Air Bearings*. 2010. Web. 9 Oct. 2011. <http://www.newwayairbearings.com/adx/aspx/adxGetMedia.aspx?DocID=19,16,12,3,1,Documents&MediaID=5010&Filename=new_way_line_brochure_air_bushings_combined_nwab-10-m-037-v05-2010-05-17-2500 page.pdf>.

- "SCFM versus ACFM and ICFM." *Engineering ToolBox*. Web. 09 Oct. 2011. <http://www.engineeringtoolbox.com/scfm-acfm-icfm-d_1012.html>.

- "Care and Air." *New Way Air Bearings*. Web. 09 Oct. 2011. <http://www.newwayairbearings.com/Care-And-Air>.

- Omega Engineering. "The Strain Gauge". *Omega Engineering. 09 Oct. 2011*. <http://www.omega.com/literature/transactions/volume3/strain.html>