6-DOF Test Frame Experimentation of Additive Manufacturing Materials

Sean Fry
Mechanical Engineering
Clemson University
stfry@g.clemson.edu
Dr. Cameron J. Turner

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Biography

I completed my undergraduate work at Clemson University from 2011 to 2015 and received my BS in mechanical engineering. During my undergraduate studies, I worked four semesters under the Cooperative Education Program. Two semesters were completed in the research and development area of Bosch Rexroth. It was there that I developed my interests in design work and experimentation which later developed into interests in my proposed research.

Overview:

A small scale multiaxial robotic test frame can be used to calculate the constitutive material properties of additive manufacturing materials. There has been a need to calculate the "real time" material properties using full field strain measurements to allow less usage of material for testing, a more in-depth understanding of the material, overall reduction in costs of characterization and production, and less time needed for characterization and testing. Past research has been conducted addressing these needs for composite materials, below is a test frame developed at the Naval Research Laboratory (NRL), the NRL 66.3. An optimized design of the robotic frame will allow the needs above to be met. We present our current findings of the design optimization process of the Stewart-Gough platform designated for material characterization and what we have learned based on the results. Below 6-DOF robotic test frame designed for characterizing composite materials.

Motivation

While a robotic test frame for composite materials has been developed by NRL, a frame of that scale is not needed for additive manufacturing material as they are not as strong. Developing a small scale robotic frame will save money, space, resources, and allow easier transportation. A working platform will allow characterization of the constitutive material properties of additive manufacturing materials.

State of the Art

In the past the Naval Research Laboratory has developed a robotic test frame to characterize the material properties of composite materials. While the problem addressed is quite similar to the research proposed here, a small scale platform is desired [2,3]. NRL is also currently working on a small scale platform that is focused on testing stronger materials than that of the proposed research.

Intellectual Merit

Some questions that are to be answered are the following:

- Is this design sufficient?

- What can be improved?
- How much can the singularities be understood?
- Are bulk materials results different from 3D printed specimen results?

Optimizing a design for a Stewart-Gough platform for testing and characterizing the nonlinear nonisotropic properties of additive manufacturing materials will allow a better understanding of the material properties. Better understanding the singularities involved with a Stewart-Gough platform will also allow better designs that can be made specific to the end goal.

Broader Impact

Developing a small scale robotic test frame will save money, space, resources, and allow easier transportation. There will be an overall reduction in costs of characterization, testing, and production, and less material will be used with the ability to calculate the "real time" material properties using full field strain measurements.

Research Approach

Since a Stewart-Gough platform's performance is based heavily on the geometry. The main focus is to study geometries and relationships with singularities that may be present and their relationships with designing for additive manufacturing materials.

Since several issues arise from the original design of the platform, a redesign is underway.

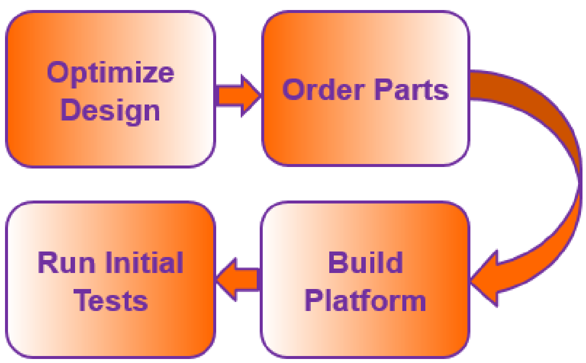

Figure 1: Path forward to complete research.

Findings to Date

So far, analyses have been conducted on the singularities involved of inverse kinematics in completing pure tension, bending, and torsion tests with different geometries assuming the worst case scenario of completely solid specimen. The current design has been analyzed as far as components and functionality, and a "map" of singularities in the x-y plane has been developed using a normalization method of the Jacobian matrix.

Conclusions

The major results include an optimized design in which singularity issues are addressed and present the best design specific for testing additive manufacturing materials. It is expected that initial tests will show a difference in material characterization between bulk materials and 3D printed materials.

The results are also expected to result in the characterization of additive manufacturing materials to be nonlinear and nonisotropic.

References

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