A new approach to the design and manufacturing of saxophone mouthpieces, for unique tonal qualities

New Arts Venture Grant Proposal

April, 15th, 2015

Alex Buehler
Senior, Mechanical Engineering

Table of Contents

Executive Summary

As the current school year comes to a close, this will be the ninth year that I have been involved in a jazz ensemble. In jazz music, I have always appreciated the artistic freedom that the musician is given, both through what they play, as well as the sound they produce. As I listen to old recordings of myself, it is easy to hear how my sound has evolved over the years from a darker velvety sound, to now a more bright and edgy tone. The mouthpiece I was playing on and its design made a huge impact on how I sounded on the saxophone.

Mouthpieces are designed with different internal features to affect the quality of the tone being produced, as well as the ease of projection. The features that can be created in a mouthpiece are limited by the way that they are manufactured. Current mouthpieces are manufactured by using traditional means of manufacturing that remove material to create the desired shape.

I propose to design and manufacture mouthpieces using additive manufacturing. Using additive manufacturing's unlimited geometric complexity will allow for new designs to be attempted that have never been possible before, specifically, altering the internal geometries of the mouthpiece. I believe that these designs could then lead to new tonal qualities to be possible on the saxophone. For example, a standard mouthpiece has an internal cavity that is cylindrical. If it were desired to have an internal cavity that not only cylindrical, but was also tapered, that would be very difficult to manufacture by traditional means. Because additive manufacturing builds parts layer by layer, this cylindrical tapered design would be feasible to build.

For this project I will be under the supervision of Professor Krishnan Suresh in the Engineering Representations and Simulations Laboratory. Professor Suresh has an extensive knowledge of simulations and additive manufacturing, and will be able to help me design, simulate, and 3D print different mouthpieces.

I plan to enter this project into the American Society of Mechanical Engineers 2016 Innovative Additive Manufacturing 3D Competition (IAM3D) at the ASME International Design and Engineering Technical Conference & Computers and Information in Engineering and Additive Manufacturing 3D Printing Conference. At this conference I will be able to showcase the research as well as the collaboration between engineering and the arts at UW Madison.

Through exploiting additive manufacturing's ability to print complex structures, new designs for mouthpieces can be made, that never before would have been possible. Based on conjecture, these new designs could lead to completely new tonal qualities to be achievable on the saxophone. This project could give more artistic liberties to saxophone players through allowing them to achieve a wider variety of tonal qualities through simply altering the internal geometries of the mouthpiece.

Project Timeline

I have already begun the initial steps of this project. As a proof of concept, I have created a replication of a mouthpiece that I currently play on a computer aided design software called SolidWorks. Through using a 3D printer at the Wisconsin Institute of Discovery, I have printed a prototype of this model, which can be seen in the pictures below. Unfortunately, this prototype was unsuccessful at producing sound, however, adjustments will be made to the model and another prototype will be printed and tested.

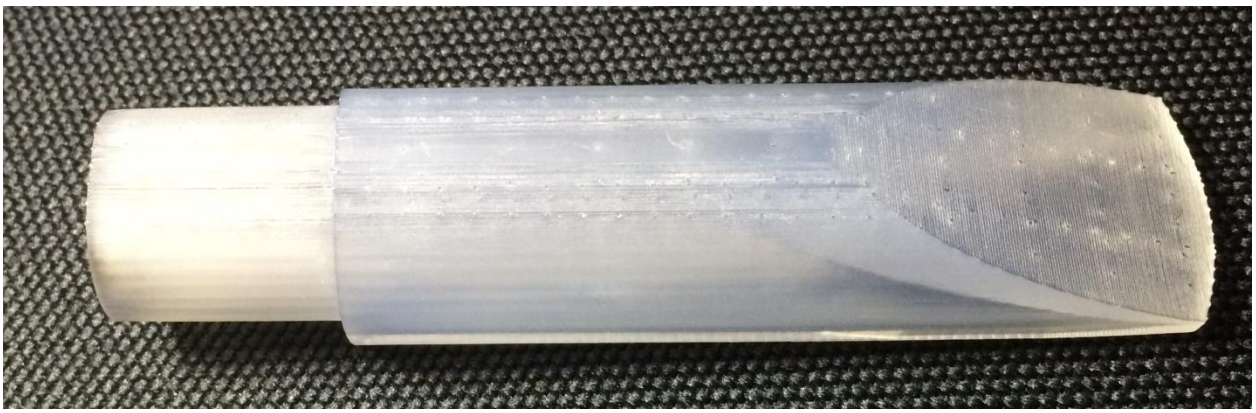

Figure 1: Top view of 3D printed mouthpiece.

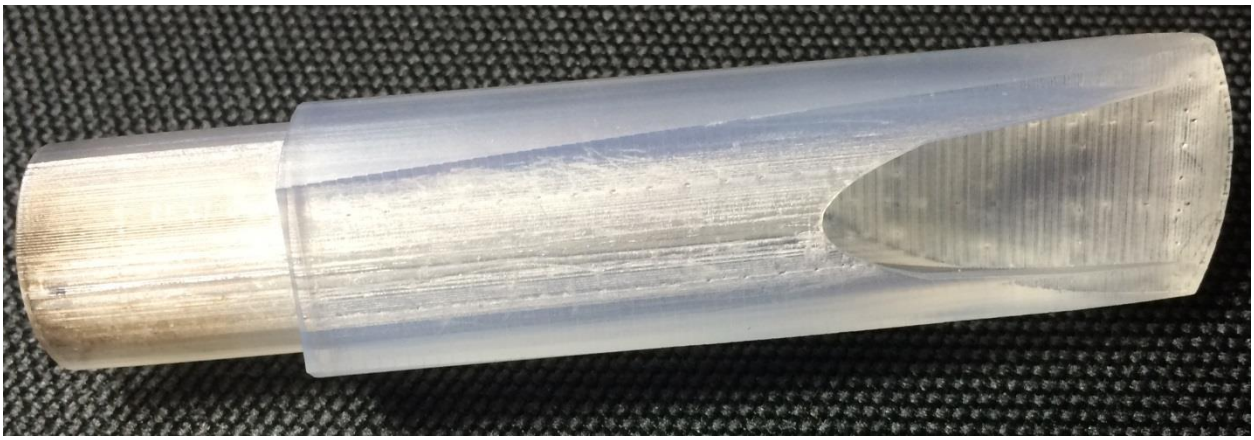

Figure 2: Bottom view of 3D printed mouthpiece.

Figure 3: 3D printed mouthpiece next to traditional metal mouthpiece.

The future timeline for this project would be as follows:

- May – October: Design and simulate mouthpieces.
- October- December: Print and test designs.
- January: Submit findings to IAM3D competition.

Key Personnel

Alex Buehler is a senior majoring in Mechanical Engineering at UW-Madison. He has been heavily involved in the music department at UW Madison through playing in the Jazz Orchestra (2012-2013), the Blue Note Combo (2013-2014), and also the Latin Jazz Ensemble (2014-2015). Alex has experience with computer modeling and 3D printing through the Faustin Prinz Undergraduate Research Fellowship through the Mechanical Engineering Department. Through this fellowship Alex has worked under Professor Krishnan Suresh in the Engineering Representations and Simulations Laboratory.

Professor Krishnan Suresh is an Associate Professor in the Department of Mechanical Engineering at UW-Madison. Professor Suresh performs research in high performance computing in different areas including topology optimization as well as solid mechanics and finite element analysis. Professor Suresh also develops algorithms for optimization of 3D printed parts. Professor Suresh will use his expertise to advise Alex, and help with simulations, modeling, and printing mouthpieces.

Budget

Item	**Amount**
3D printing	$2,000

Description of budget items

3D printing for this project will be done at the Wisconsin Institute of Discovery. The prototype mouthpiece that was printed cost approximately $50. With $2,000 I will be able to print and test up to 40 different mouthpiece designs.

Trouble shooting

The way that different designs will be tested, will be through using a spectral analysis of the sound produced by each printed mouthpiece. A spectral analysis shows the frequency vs. the amplitude. Using a spectral analysis will allow for the determination of different type of tones being produced. If there are more frequencies about the played frequency, then a brighter sound will be exhibited by that design. If there are more frequencies below the played frequency, then this will be a darker sound.

Recent Work

With regards to additive manufacturing and computer modeling, Alex gave a presentation at the American Society of Mechanical Engineers 2014 International Design and Engineering Technical Conference & Computers and Information in Engineering and Additive Manufacturing 3D Printing Conference. Alex Competed in the Innovative Design Simulation Contest and was the awarded best integrated design simulation. The following link is to an article written about the competition. https://www.asme.org/events/competitions/idsc-challenge/innovative-design-simulation-challenge-short

Attached

Alex Buehler Resume