Mechanical Forging for the Construction of a Standardized Steelpan Instrument

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Abstract— The steelpan drum is an instrument native to Trinidad and Tobago, with a history dating back to the early 19th century. The process to create the instrument is long and difficult, taking upwards of two weeks for a trained professional to complete. During this time, the manufacturer is subjected to repeated vibrations along their arm and high noise levels, both of which are dangerous to the manufacturer. The purpose of this project is to discover a method of automation that could reduce the time needed to create a steelpan instrument, along with reducing the potential harm towards the manufacturer of said instrument. The proposed method incorporates incremental sheet forming (ISF) technology to reduce the time required to hammer the initial concave shape of the instrument. This process involves a significant portion of the time required to fashion a steelpan instrument, and as such would be beneficial to the creator.

I. Introduction

The steelpan drum is an instrument originating from Trinidad and Tobago in the Caribbean. The creation of a steelpan drum has largely remained unchanged since its invention, involving the deformation of used oil drums to create a concave surface with note indentations. This process is performed with handheld hammers and can cause a great deal of harm to manufacturers over time. The noise level of hammering steel can damage the ears, and the repetition of hammering steel can damage the arms, muscle, and skeletal structure. These harms have forced manufacturers into early retirement, despite the need for trained professionals.

The most prominent improvement to the process is the application of pneumatic hammers, but this does not address the physical harm potential of the process. The existence of a faster, safer process would mean that creating steelpan instruments would no longer be dangerous to the manufacturer. Additionally, this would result in an increased rate of production and a decrease in production cost for the instrument.

II. Desired Results

The goal of this senior design project was to develop a method of reducing the time required to form a steelpan drum. This would increase the production rate of manufacturers and reduce the danger to the manufacturer. With this in mind, the chosen path was to have a system of incremental sheet forming automate the deforming of a scaled down drum in the form of a steel bucket to fit the design of a steelpan instrument. This would involve the designing of a model to base the deformation path on, the conversion of this model and actions to G-Code, and the use of a CNC machine that could interpret the code into action.

III. Methodology and Materials

A. Deformation Programming

Incremental sheet forming is based on the application of G-Code with CNC machine technology to automate manufacturing. Because of this, the creation of G-Code was the most important aspect of this project.

To complete this, the basis of the G-Code was created in SolidWorks 2020 to match a scale model of a typical steelpan instrument. This model was imported to Autodesk FeatureCAM, where a milling operation was created to simulate the results of the model. This operation produced G-Code from which the results could be tested.

B. CNC Machine

The type of machinery used to conduct the forming of the steelpan was a CNC machine. This machine can read the incremental forming G-code and form the steelpan according to the code using a custom round-tip forming tool.

Since great forces are required to form steel, it is important to secure and support the steelpan firmly to prevent any unintended damage to the pan or machine. The use of a thick lubricant is also critical for the process to reduce the development of heat from the substantial frictional forces between the forming tool and steelpan. By doing this, the life of the tool can be extended and steel hardening on the surface of the drum can be prevented.

C. Deformation Mold

The use of a mold was considered to help maintain the bucket's position during the deformation process. The mold would be placed beneath the bucket and be fastened to both the bucket and the machine, securing both the mold and bucket in place. While a hard plastic or metal material would have been the ideal material for its resistance to deformation, the hardwood mahogany was chosen due to its relative strength and greater availability.

IV. Results

A. G-Code Testing

The production of the G-Code underwent numerous stages, with challenges met at each iteration of the tested code. Starting with a 4”-diameter scale deformation to be tested on sheet metal, the working code successfully shaped the sheet metal exactly as desired. This test and all subsequent tests for the G-Code were performed in the NIU Machine Shop, using the HAAS CNC machine.

The final test using the HAAS machine included the full scale of the steel bucket (9.5” diameter), more accurate note indentations to better reflect real steelpan designs, and a decreased step increment to result in a smoother surface finish. This last step was hindered by the lack of memory in the HAAS machine, requiring the reduction in smoothness for the finishing pass. Despite this, the test worked as predicted, resulting in a half-scale steelpan drum. This was done within three hours of testing.

Figure 1: 9.5" scale deformation test results

B. CNC Machine Production

The designing of the CNC machine was performed in SolidWorks. It was required to have a spindle tool that could be moved in three separate axes and follow commands provided to it through an Arduino uno. Along with this, it needed to support the drum as it was being deformed.

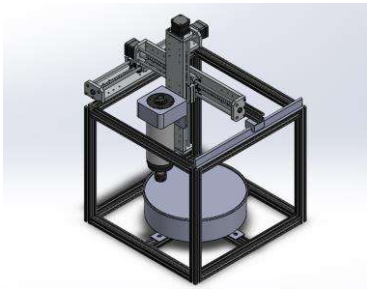

Figure 2: Designed CNC Structure

The construction of the CNC machine was a difficult process, ensuring that the materials needed were correct for the design. The frame was constructed, and the linear actuators were successfully attached. Unfortunately, due to time restraints the project could not be completed, and the results of the HAAS machine could not be replicated with the CNC machine.

Figure 3: Created CNC Machine Structure

C. Wood Mold Production

With the design’s approval by Mike Reynolds, once the material arrived it was given to the machine shop to be formed. Because of the testing with the G-Code in the HAAS machine, it was demonstrated that the mold was not necessary to form the drum to the specified design given a strong enough supporting bracket.

Figure 4: Completed Wood Mold Product

V. Conclusions

The purpose of the project was to have developed a method of shortening the time to construct a steelpan drum from beginning to end. Based on the conclusions of the G-Code experimentation using the HAAS machine, this appears to have succeeded. The process of creating the initial curve and notes for a half-scale model was done in a matter of hours. The half-scale model proves that the concepts of CNC machining and incremental sheet forming can be used to aid in the process of steelpan manufacturing, reducing the amount of time to create an individual drum. This process is also able to greatly reduce the amount of harm manufacturers risk in the process by removing the hammering of steel from the creation of the instrument. To further the tests of this project, the use of a larger CNC machine capable of containing a real oil drum and testing on a fully-sized scale would be the next step.

Acknowledgment

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