Designing of a Beam Position Monitor for Additive Manufacturing

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Introduction

This research explores the potentials of additive manufacturing (aka 3D printing) as a fabrication method for parts used within Fermilab's particle accelerator. This study includes the feasibility of using 3D printed metal parts in an ultra-high vacuum environment. 3D printing allows the production of parts with complex geometry; it permits flexibility and freedom in designing parts that are not achievable through conventional manufacturing methods, such as casting and machining.

When designing parts for additive manufacturing, topological optimization software packages may be utilized to improve the design. This is achieved by determining how to create a part that is sufficiently strong using the least material possible. Benefits of topology optimization includes cost, weight, and time reduction.

Objectives and Impact

Redesigning a Beam Position Monitor (BPM) to be additively manufactured offers these advantages:

1. Minimal material waste for custom parts
2. Reducing time to acquire the needed parts
3. Reducing supply chain problems
4. Decreasing the work being done by manufacturing three parts into one simplified assembly
5. Minimum support structures
6. Cost-effective customization

Materials and Methods

- Stainless Steel 17-4 PH & Stainless Steel 316L
- Additive manufacturing using Laser Powder Bed Fusion (LPBF) technology.
- Utilizing Autodesk Fusion 360 software to develop a design for BPM.
- Analyzing the topology optimization through the Siemens NX Software.

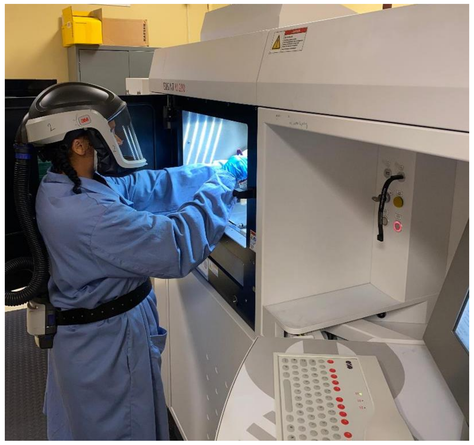

Figure 1: EOSINT M280 3D Printer

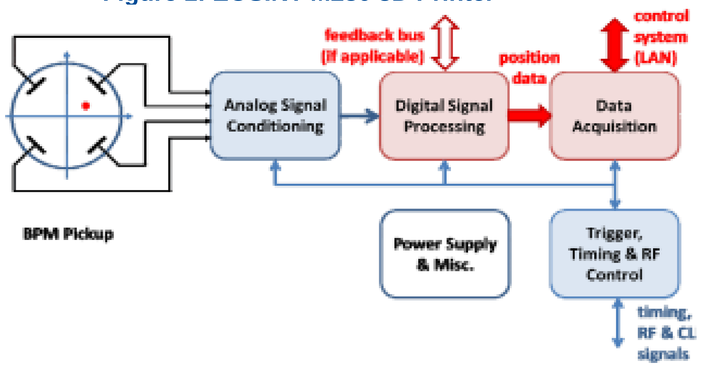

Figure 2 : Schematics of a beam position monitor

The BPM pick up is a part of the accelerator vacuum system and its purpose is to convert the electromagnetic field of a passing beam into an electrical signal.

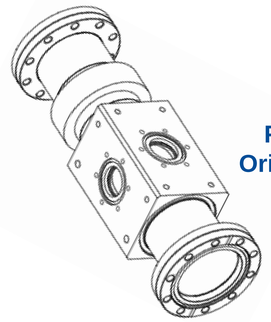

Figure 3: Original BPM design

Figure 4: Final BPM design

Conclusion

Additive manufacturing permits greater design flexibility and reduces the creation time. This technique will save material and can provide the tool of manufacturing multiple and different parts. Additive manufacturing can become a very useful tool in building parts for particle accelerators. Parts for particle accelerators are custom made; therefore, using additive manufacturing will reduce the lead time to acquire the needed parts. In addition, these parts can be manufactured into one assembly.

Topology optimization results in a design that has disrupted the traditional model, bringing maximum performance in the shortest period. The optimized model allows rapid prototyping which is achieved by the additive manufacturing process.

Future Work

To continue, the next steps are:

- Measure the vacuum outgassing rates
- Measure the surface roughness
- Stretched Wire Tests
- Beam Tests

References

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