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UTILIZING ADDITIVE MANUFACTURING TO CREATE PROTOTYPE AND FUNCTIONAL BEAMLINE INSTRUMENTATION AND SUPPORT COMPONENTS

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Abstract

The world of beamline science is often fast-paced and dynamic. One of the major challenges in this environment is to be able to design, manufacture and then implement new items for use on the beamlines in a fast and accurate manner. Many times, this involves iterating the design to address unknown or new variables which were not present at the beginning of the project planning task. Through the use of additive manufacturing, I have been able to support the user programs of various (APS) Advanced Photon Source beamlines* across multiple scientific disciplines. I will provide a few detailed examples of Items that were created for specific beamline applications and discuss what benefits they provided to the pertinent project. I will also talk about why choosing consumer-level printer options to produce the parts has been the direction I went and the pros and cons of this decision. Primarily, this choice allowed for quicker turnaround times and the ability to make more frequent changes in an efficient manner. Currently, we are utilizing only the fused deposition modelling (FDM) type printers but I am exploring the addition of UV-activated resin printing, exotic materials that can be utilized using the current toolset, and the possibility of commercial metal printing systems. This technology has been a game-changer for the implementation of new support items and instrumentation over the last couple of years for the different disciplines I am supporting. I will discuss how the roadmap ahead and what the evolving technologies could potentially allow us to do.

INTRODUCTION

The Advanced Photon Source (APS) located at Argonne National Laboratory (ANL) has many user programs. In my daily function I am supporting a variety of these groups. Time is something that is very limited and budgetary constraints are always in the backs of our minds. With the adoption of Additive manufacturing (AM) I have been able to provide a cost effective and timely way in which to produce instrumentation and beamline support components. The approach I have taken is to utilize a consumer-grade machine, which allows me to support the devices, and run it at very low cost without the need for lengthy licensing agreements.

EXAMPLES OF USE CASES

Use case example one, as shown in Fig. 1, is a collimator holder for use on the 11-ID-D beam line at the APS. This is a Time Resolved Research (TRR) Group [1] Project. The scientist approached me as the existing holder was not functioning in a manner that was still optimal. The experiment was going to be happening in the following week. The task was design and print a holder for the collimator. Using Fused disposition modelling (FDM) I was able to produce the part from a 3d CAD model to finished fixture in about 3 days. Average turn around for an item such as this is around 2 to 4 weeks utilizing a traditional manufacturing route. There was also issues as the current collimator had taken on a non-cylindrical shape on the outer surface from the normal use by the staff over the years. The benefit of a printed part was I could then install the collimator in a semi clamped manner and hone it into a good fit using the rough surface of the outer diameter of the collimator. The fact that I could turn this around in about 3 days with a material cost of around ten Us Dollars (USD) was a huge benefit. It was also found that the stability was good enough that we did not see the immediate need to move forward with a traditionally manufactured setup.

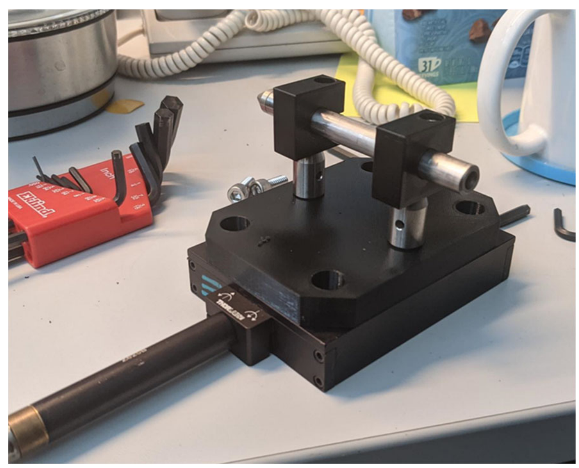

Figure 1: Collimator Mounting setup 11-ID-D.

Use case example two, as shown in Fig. 2, is a flight path to keep the beam scatter coming off the sample and directed to the detector in a vacuum or gas environment. The set up was done for 6-ID-B for the Magnetic Materials (MM) Group [2] , the item was originally quoted at twelve hundred USD and a 8 to 12 week lead time through a tradition manufacturing method. The Support staff at this beamline approached me and asked if it would be possible to create this using AM. We decided it was worth a try. The challenge on this is that it is about a meter long. The limitations of the tools I have at my disposal are about 9 inches of print height in the vertical. What this led me to do was to break the piece up into multiple segments and then epoxy them together. I used key features to help with alignment and the 5-minute epoxy which is readily available created the equivalent of a plastic seam weld. The total cost material wise was around fifteen to twenty dollars out

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side of the NW-40 flange which was purchased and epoxied in place, and the Newport clamps which were used to mount it to the rail on the device at the hutch. There were also two Kapton windows which were epoxied to either end of the flightpath to allow it to hold vacuum. The pint time for all parts was under 24 hours total and glue up took roughly one to two hours. This allowed me to have the item in the support staff's hands and installed in under a weeks' time. The item was able to be pumped down with a vacuum pump and was in service for the experiment without issue.

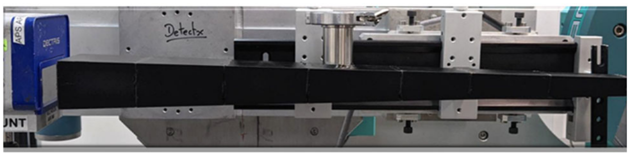

Figure 2: Flightpath 6-ID-B.

Use case three was a mount for microscope which needed to assemble into an existing diffractometer. The assembly area was constrained and there was a desire for motion so that a range of the magnifications could be used. The setup, as shown in Fig. 3, was printed on once setup with a total time of 8 hours to print. The item in which clamped the microscope into place was reprinted multiple times to adjust the feel to the liking of the support staff. The cost of this was around ten USD with the multiple iterations of the once clamping piece. The final result was able to adjust the microscope to utilize a 70X to 40X range. Time from initial design to parts ready for installation one week. This item also used some salvaged threaded rod to allow the vertical motion by driving a threaded feature in the one part.

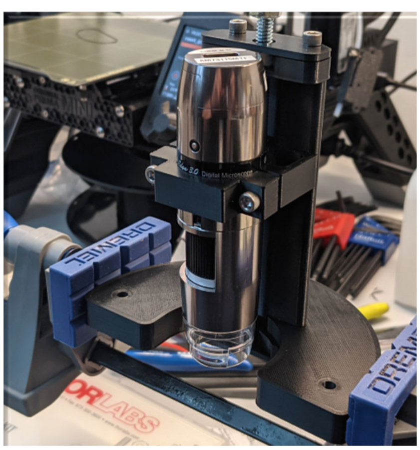

Figure 3: Microscope mount 6-ID-B.

Use case four was a prototype sample holder and sample holder mount for 8-ID-E Dynamic Structures group (DYS) [3]. With the implementation of remote user support Division wide the exploration of use for robots and automating sample exchange has become a more looked at option. There is currently a project underway to implement this at 8-ID-E. The Wheel (Fig. 4) will in the end be made of metal but the intended final design for the sample holding cubes, which are the grey parts in Fig. 4, would be that of a AM made part. Where AM became valuable here was that we could iterate wheel and sample holder designs to find the desired fit very quickly and at a low cost. After the fit we desired was found we then created a functional prototype and mounting assembly's so that the items could be tested in a real-world environment. This allowed the support staff to program the robot and then test the integration with a real-word object to see how it would act. These prototypes were and mounting fixtures were all printed a cost of under one hundred USD and has provided a vast amount of hands on feedback. The design also is utilizing an off the shelf isometric magnetic mount so do all the precision locating of the sample holder. it also provides the mechanical mount for the sample wheel once installed. An example of this set up can be seen in Fig. 5.

Figure 4: Sample wheel with Robot Gripper interacting 8-ID Lab test area.

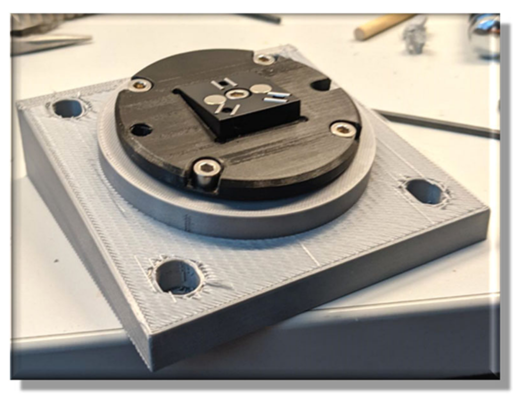

Figure 5: Sample wheel mount 8-ID Lab test area.

MANUFACTURING CHALLENGES

Because of the process of laying layers of material down upon each other design for manufacturing (DFM) should be considered. When wanting to place treads for example if the height between layers is set to large this can case the tap to wander well hand taping. Hand taping, I have found is also a must. Power taping has in my experience lead to the material building up to much head and gumming up the tap or turn the tap into a drill and boring out the hole. I have

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also found that doing 100% infill which can be time consuming is the best route for parts both tapped and untapped as this provides better stability to the part. One other challenge is utilizing this in the right way. It can be very easy to say I will print everything from now one. The application must be looked at in in some cases a highbred between AM and tradition manufacturing will work, and in other only traditional manufacturing will work.

CONCLUSION

Following the testing and implementation which I have been able to do over the following year I can see many more use cases for these lower cost FDM printers and the parts they create. The support staff in the groups I am working with has started to inquire about possible future uses and have become much more receptive to the suggestions of just printing many of the items they need. The road map ahead would be to start looking into possible creating some AM FDM metal parts and then moving towards some of the more commercial grade AM Metal printing process. The need and use for the consumer grade printer will be there but there are many other possibility's that these new tools could provide for our use.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Time-Resolved Research Group, `https://www.aps.anl.gov/Time-Resolved-Research`

[2] Magnetic Materials Group, `https://www.aps.anl.gov/Magnetic-Materials`

[3] Dynamics and Structure (DYS) group, `https://www.aps.anl.gov/Dynamics-and-Structure`