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The Redesign of a Galvanometer-Based Fast X-ray Shutter

ABSTRACT:

The Galvanometer-based fast X-ray shutter used for high energy X-ray experiments has been redesigned. Several CHESS beamlines currently use this galvanometer-based X-ray shutter designed at the Advanced Photon Source (1). In the original design, the tungsten stopping blades were glued to an aluminum base making it unreliable with repeated use. In the redesigned shutter, the glued blades have been replaced by a single piece of tungsten that can provide stopping power for high energy X-rays. The maximum aperture of the shutter is 1.5mm with a path length of 4.66mm. Its moment of inertia is minimized to ensure smooth switching. The shutter is very compact and switches smoothly. In addition to that, it is able to survive higher heats load.

METHOD:

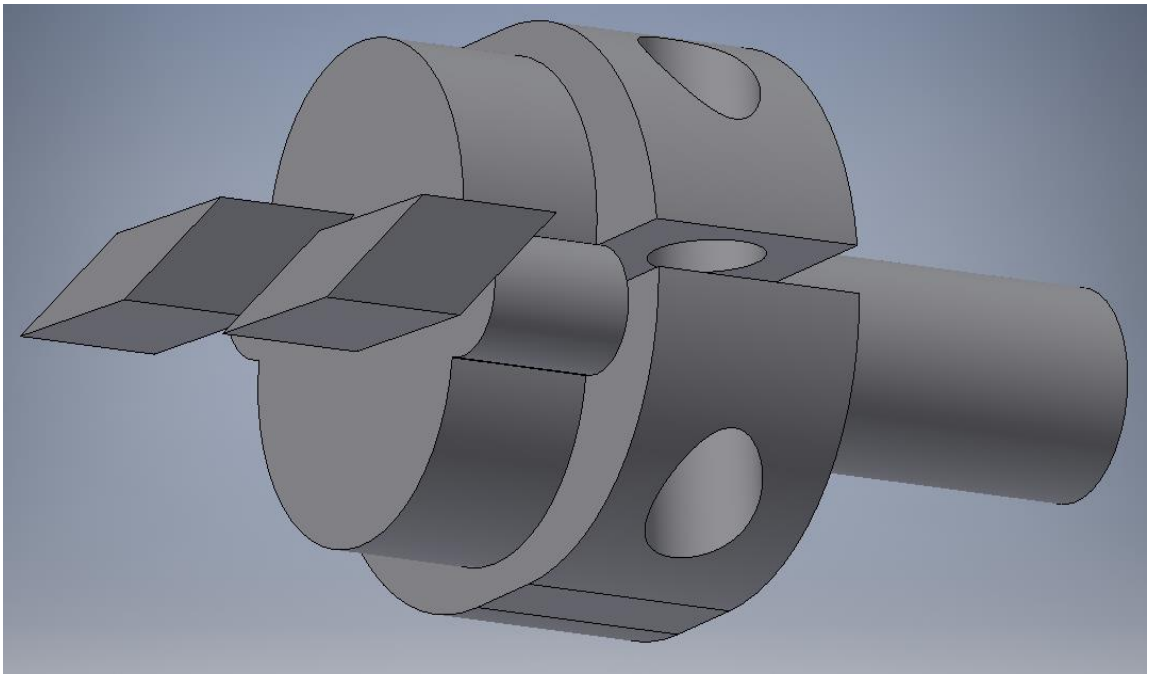
A computer aided design (CAD) program was used to the design the shutter. Several attempts were made in order to have the possible best design. I first watched tutorials on Autodesk Inventor which helped me get started with the basic concepts on how to navigate the program. I was able to follow up the tutorials while practicing with Inventor. By the time I finished watching the tutorials, I was able to apply the basics of Inventor. I tried several possible sketches when I started designing the shutter. The idea was to get familiarized with the program given that it was my first time using it. I learned how to create simple 2D sketches and then change these

3D components by using extrusions. From there, I learned how to add holes into an extrusion and add fillets depending on the part design. I also learned how to assemble multiple parts using constraints.

ANALYSIS:

The order of the design was as follow; the blades were fixed at a reference position then the connection attaches to the backside of the blades followed by the clamp that connects to the shaft. In order to create the blades of the shutter, I first did a sketch of a parallelogram setting each angle at 20 degrees. I set the aperture opening between the two new blades plates to be 1.5mm. With that known along with the angle, I had to figure out the distance between the two centers of the blades which I found to be 4.5963mm. This allowed me to find the distance of each side of the blade (2.3336mm). I then extruded it after making sure I had the right dimensions. After doing that, the next step was to assemble these parts. I had to put that in a fixed position based on the reference. Then I made a connection portion of the shutter that would connect to the backside of the blades. I set the distance between the side of the connection based on the distance between the blades, so that the connection was centered behind the blades. After having the correct sketch and dimensions, I then extruded it, then I placed it to the assembly part to connect it to the blades. I connected it from the back to ensure the blades faced the front sides. By adding constraints, I tilted the connection, so it was at an angle of 10 degree to the horizontal. The next step was to build a shaft that would fit to the backside center of the connection. I made the sketch of the shaft with radius 2.5mm, then extruded it. I placed it into the assembly part and constrained its center to the backside center of the connection. The last step was to build a clamp that would hold the shutter to the shaft. The idea was to make the distance of the shaft, so it can be larger than the radius of the connection. I made a sketch of the clamp with a width of 7.5mm.

I extruded it and added holes to it in order for a screw to go through and apply clamping force. I then placed two clamps into the assembly. I constrained one of the clamps to the top of the shaft and the other to the bottom of the shaft producing the final part (See Figure).



Final assembly of the galvanometer-based fast X-ray shutter. All the design process was done using a computer aided design (CAD) program Autodesk Inventor.

CONCLUSIONS:

The redesigned shutter will have long-term reliability due to being made from a single tungsten piece. This is because there are no longer portion of the shutter that are glued together, allowing the shutter to survive high heat loads for long periods of time.

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REFERENCES:

1) Advanced Photon Source, Argonne National Laboratory, Argonne, IL 60439