



Designs for a Small-Scale Grain Thresher for Australian Native Rice

Technical Report

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Acknowledgements

The thresher designs developed in this project build on a prototype (Mark 1) developed as part of a Master of Engineering program at CDU, by Zhenyang Frederick Hou, Yafei Gary Ge and Felix Sunderland. This team was then commissioned to scale up the prototype.

Dr Stefanija Klaric, Mechanical Engineering, and Dr Sean Bellairs, Environment Discipline, College of Engineering, IT & Environment, Charles Darwin University conceived of this project.

Input to the project brief, design requirements and modifications throughout the project was provided by Dr Stefanija Klaric, Dr Sean Bellairs and Dr Penny Wurm, Environment Discipline.

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Introduction

Native Australian rices have long and brittle awns that can grow to be up to 10cm long. As a part of the rice processing procedures, these awns ought to be removed prior to further processing of the grains. Otherwise, the awns would clog the processing equipment. These awns tend to break easily under low normal stress perpendicular to the awns. Therefore, it is effective to manually rotate the awns in a colander resulting in the awns snapping off the grains as a result of the rotation. Most awns will fall through the colander and the grains will be retained within. However, this method is economically inefficient. In an attempt to commercialise native Australian rices, this project aims to devise a product that efficiently removes the awns from the grains.

Concept

The design concept is akin to manual removal of the awn spikes in a colander. The product's main parts are a rod, a paddle blade and a mesh drum. Freshly harvested rice grains are to be put in the mesh drum. The paddle blade is attached to the rotating rod, resulting in rotation of the paddle blade with the rod. The revolving of the paddle blade inside the mesh drum stirs the rice grains, resulting in low pressures on the grains and the awns. These low pressures cause the awn spikes to break from

the grains without damaging the grains. The thin awns can fall through the holes in the mesh drum and grains are retained in the mesh drum, thus separating the awns from the grains.

Mark 1

| Component | Material | Dimension |
|--------------|-------------------------------------|--|
| Hand wheel | Nylon | Diameter: 100mm |
| Rod | Poly(methyl methacrylate) / Acrylic | Diameter: 12mm Length: 271mm |
| 2 Bearings | Steel | Inner diameter: 15mm Outer diameter: 35mm Thickness: 11mm |
| Cable ties | Nylon | Length: adjustable, larger than 110mm |
| Mesh drum | Stainless steel | Drum diameter: 220mm Drum height: 180mm Hole diameter: 1.4mm*1.4mm |
| Paddle blade | PolyTetraFluoroEthylene / PTFE | Length: 210mm Height: 180mm Thickness: 2mm |
| Bottom plate | Poly(methyl methacrylate) / Acrylic | Diameter: 220mm Height: 5mm |
| Top plate | Poly(methyl methacrylate) / Acrylic | Diameter: 220mm Height: 5mm Area of four circular sectors: $17592.91mm^2$ |



Figure 1: Mark 1 native rice thresher

Mark 2

Mark 2 thresher aims to contain approximately twice as many rice grains as Mark 1 thresher. Also, Mark 2 thresher should be designed to be easier to load and unload rice grains.

| Component | Material | Dimension |
|----------------|-------------------------------------|--|
| Hand wheel | Acrylic | Diameter: 100mm |
| Shaft | Poly(methyl methacrylate) / Acrylic | Diameter 1: 15mm Diameter 2: 20mm Length: 427mm |
| 2 Bearings | Steel | Inner diameter: 15mm Outer diameter: 35mm Thickness: 11mm |
| Mesh drum | Stainless steel | Drum diameter: 260mm Drum height: 280mm Hole diameter: 1.5mm * 1.5mm |
| Paddle blade | PolyTetraFluoroEthylene / PTFE | Length: 250mm Height: 280mm Thickness: 2mm |
| Bottom plate | Poly(methyl methacrylate) / Acrylic | Edge length:305mm Height: 12mm |
| Top plate | Poly(methyl methacrylate) / Acrylic | Edge length:305mm Height: 12mm |
| 5 x M3.5 screw | Stainless steel | Diameter: 3.5mm |
| 10 x M4 screws | Stainless steel | Diameter: 4mm |
| 2 Washer | Stainless steel | Inner diameter: 260mm Outer diameter: 300mm Thickness: 3mm |

Area of circular sector on the bottom plate is approximately

$$s = \frac{80}{360} \times 110^2 \times \pi - 45 \times \frac{70}{2} \approx 6868mm^2$$

Achieved Modification from Mark 1 to Mark 2

| No. | Modification | Reasons |
|-----|---|--|
| 1 | Addition of washers and screws | To better fix the mesh drum with top and bottom plates |
| 2 | Rigid mesh drum | The friction between paddle blade and the mesh drum is thus theoretically uniform around the mesh drum. This makes the awn removal process more efficient and less labour intensive. |
| 3 | Bigger hand wheel | A bigger hand wheel has a larger diameter so will require less force for rotation according to conservation of momentum. |
| 4 | Larger drum volume | Mark 2 thresher can contain approximately 2.17 times the volume of Mark 1 thresher. |
| 5 | Smaller opening area | A smaller opening area make the rice grains less likely to escape from the thresher during processing. |
| 6 | Replacement of acrylic shaft with metal shaft | Acrylic shaft broke during operation. |

Intended but Not Achieved Modification from Mark 1 to Mark 2

A door was initially designed to cover the opening area. The door was damaged during transport.

Mark 3

Objective of Mark 3 is to make the thresher approximately twice as large as Mark 2 thresher. In addition, an effort is to be made to further improve the thresher design for the loading and unloading process of rice grains as the attempt to do so for Mark 2 has failed.

| Component | Material | Dimension |
|---------------------------------------|---|--|
| Hand wheel | Nylon | Diameter: 125 mm |
| Shaft | Poly(methyl methacrylate) / Acrylic | Diameter 1: 15mm Diameter 2: 20mm Length: 472mm |
| 2 x Bearings and 2 x Bearing housings | Bearing: Stainless steel Bearing housing: Zinc alloy | Bearing Inner diameter: 15mm Bearing Outer diameter: 35mm Bearing Thickness: 4mm Bearing housing inner diameter: 15mm Bearing housing length: 67mm |
| Mesh drum | Stainless steel | Drum diameter: 320 mm Drum height: 330mm Wire diameter: 0.55mm Hole size: 1.4mm * 1.4mm |
| Paddle blade | PolyTetraFluoroEthylene / PTFE | Length: adjustable, larger than 160mm Height: 330mm Thickness: 3mm |
| 2 plate (plastic) | Poly(methyl methacrylate) / Acrylic | Edge length:380mm Height: 4mm |
| 2 plate (metal) | Stainless steel | Edge length:380mm Height: 4mm |
| 5 x M4 screws | Stainless steel | Diameter: 4mm |
| 13 x M6 screws | Stainless steel | Diameter: 6mm |

Note: Mark 3 was not functional and was decommissioned and replaced by Mark 4.

Achieved Modification from Mark 2 to Mark 3

| No. | Modification | Reasons |
|-----|----------------------------------|---|
| 1 | larger hand wheel | A bigger hand wheel has a larger diameter so will require less force for rotation according to conservation of momentum. Also, because the diameter of the mesh drum has increased, the diameter of the hand wheel ought to increase accordingly. |
| 2 | Unintentional soft mesh drum | The mesh drum was bought from another supplier. It is softer than that of Mark 2 and was deformed during transport. |
| 3 | Larger drum volume | Mark 3 thresher can contain approximately 1.79 times volume of Mark 2 thresher. |
| 4 | Larger opening area | A larger opening area enables effective transporting of grains into and out of the thresher. This is achieved by installing an extra sheet metal to fix the bearings so the acrylic sheet can be completely removed resulting in larger opening area. |
| 5 | Installation of bearing housings | Bearing housings support and fix bearings so no glue is required anymore. |
| 6 | Thinner acrylic plates | This is to reduce the total weight of the thresher for easier transport. |

Intended but Not Achieved Modification from Mark 2 to Mark 3

The initially planned lid and a handle were not achieved because of the thin acrylic plates. Instead, 4 bolts and nuts are used to seal the opening of the opening of the thresher. The mesh chosen deformed prior to use and resulted in the Mark 3 being completely replaced.



Figure 2: Mark 3 showing base plate arrangement. Note deformed mesh.



Figure 3: Mark 3 showing top and handle arrangement.

Mark 4

Purpose of Mark 4 is to repair Mark 3 as Mark 3 is non-functional due to mesh drum deformation during transport. Additionally, shaft of Mark 2 and Mark 4 are to be replaced with metal as the acrylic shaft of Mark 2 broke during operation. A replacement metal shaft is to be ordered for Mark 2. Also, binder clips will be used to facilitate the loading and unloading of rice grains.

| Component | Material | Dimension |
|---------------------------------------|---|---|
| Hand wheel | Nylon | Diameter: 200mm |
| Shaft | Stainless steel | Diameter 1: 15mm Diameter 2: 20mm Length: 472mm |
| 2 x Bearings and 2 x Bearing housings | Bearing: Stainless steel Bearing housing: Zinc alloy | Bearing Inner diameter: 17mm Bearing code: KFL003 |
| Mesh drum | Stainless steel | Drum diameter: 320 mm Drum height: 330mm Hole size: 1.4mm * 1.4mm Mesh wire diameter: 0.55mm |
| Paddle blade | PolyTetraFluoroEthylene / PTFE | Length: adjustable, larger than 160mm Height: 330mm Thickness: 4mm |
| 2 plate (plastic) | Poly(methyl methacrylate) / Acrylic | Edge length:380mm Height: 4mm |
| 2 plate (metal) | Stainless steel | Edge length:380mm Height: 4mm |
| 5 x M4 screws | Stainless steel | Diameter: 4mm |
| 5 x M6 screws | Stainless steel | Diameter: 6mm |
| Binder clips | Stationery supply | |

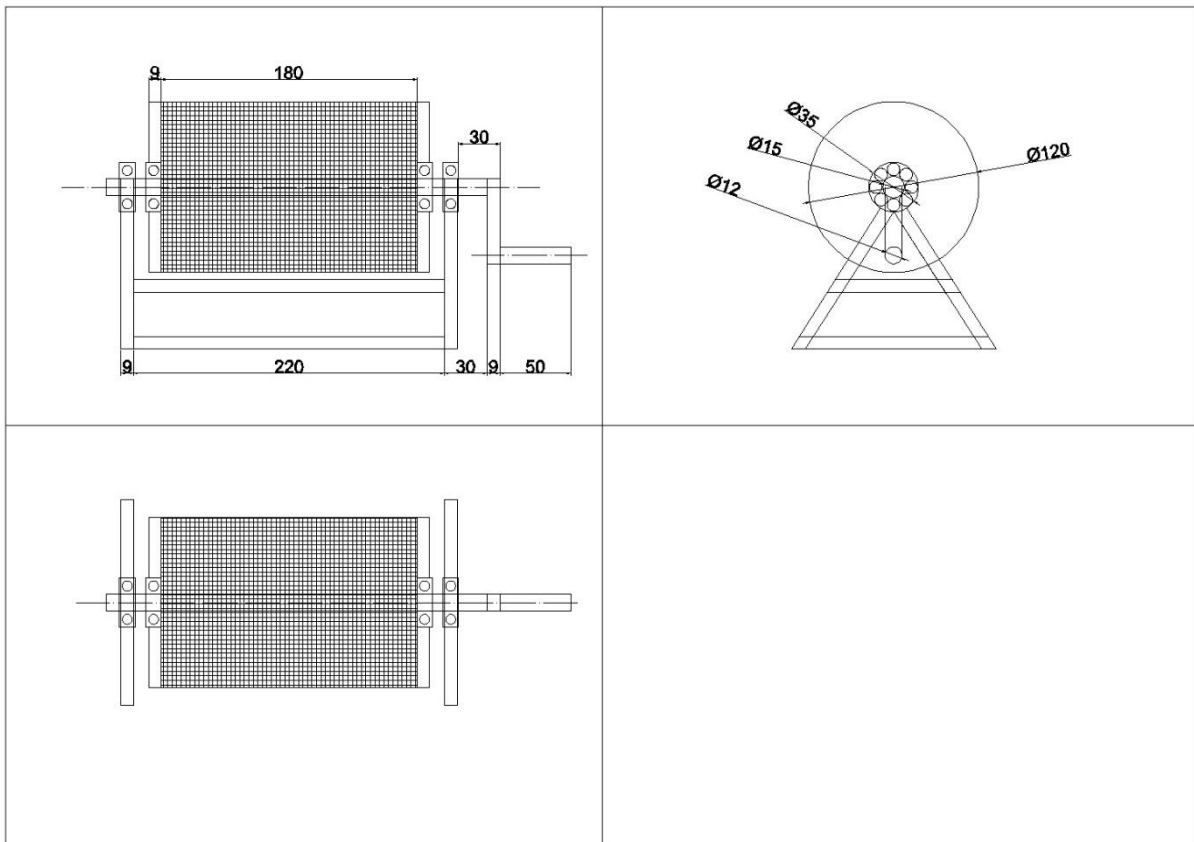
Achieved Modification from Mark 3 to Mark 4

| No. | Modification | Reasons |
|-----|---|---|
| 1 | More rigid mesh | Mark 3 mesh sustained deformation during transport and was therefore not strong enough to function. New mesh has a larger mesh wire diameter. |
| 2 | Use of binder clips | Binder clips are used to replace screws and washer so the process of loading and unloading rice grains can be sped up. |
| 3 | Replacement of acrylic shaft with metal shaft | Acrylic shaft of Mark 2 broke during operation so the acrylic shaft of Mark 4 has also been made with stainless steel. |

Appendices

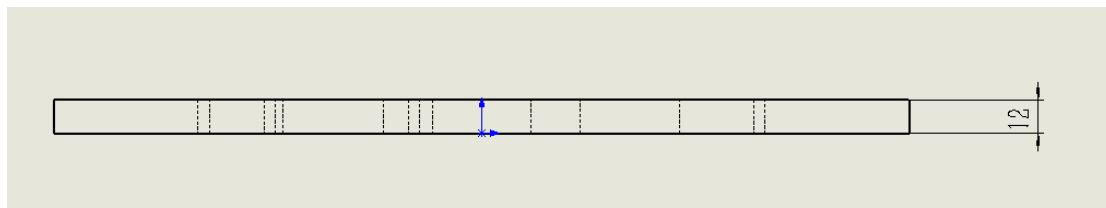
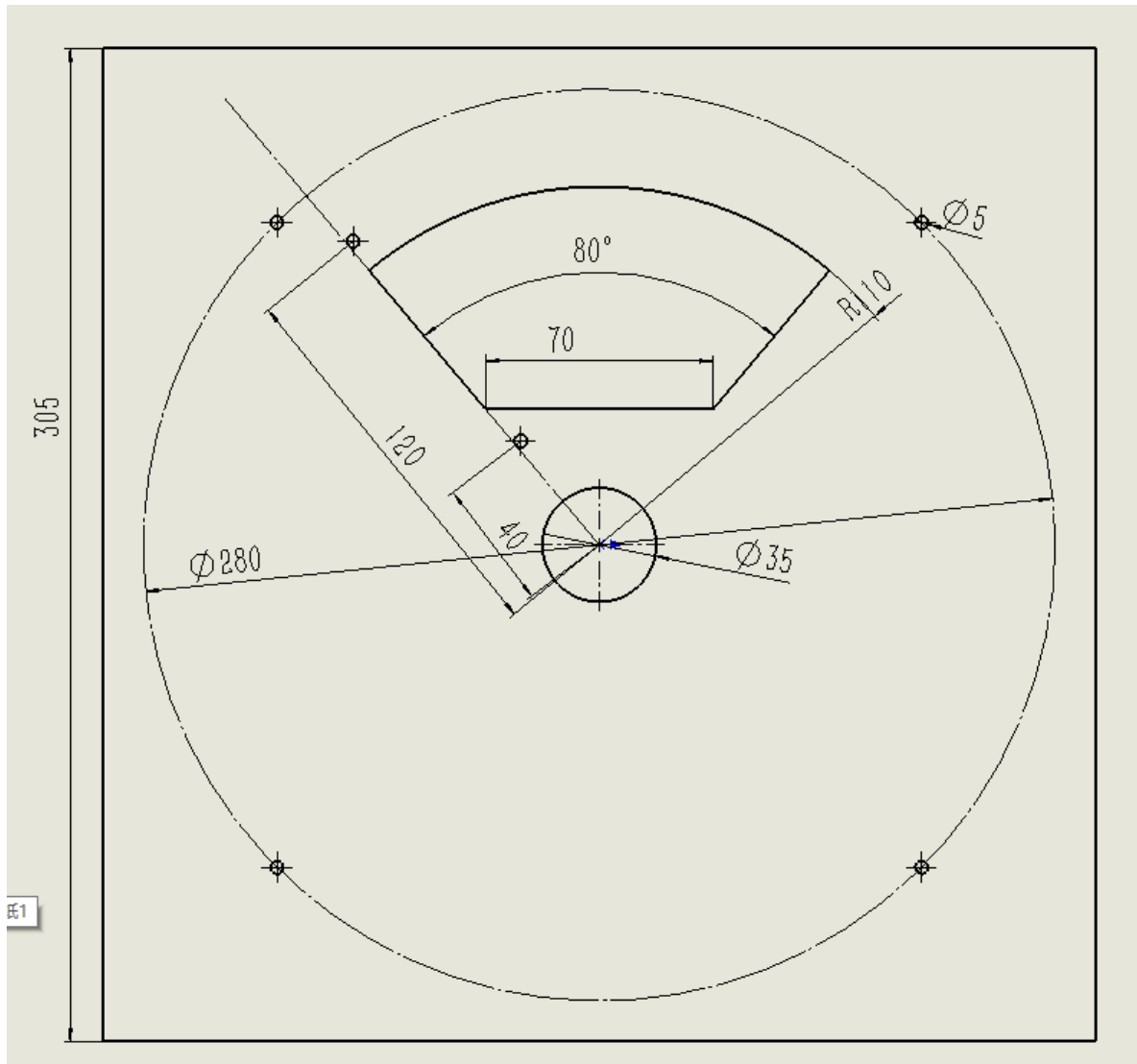
A. Technical drawings

Mark 1

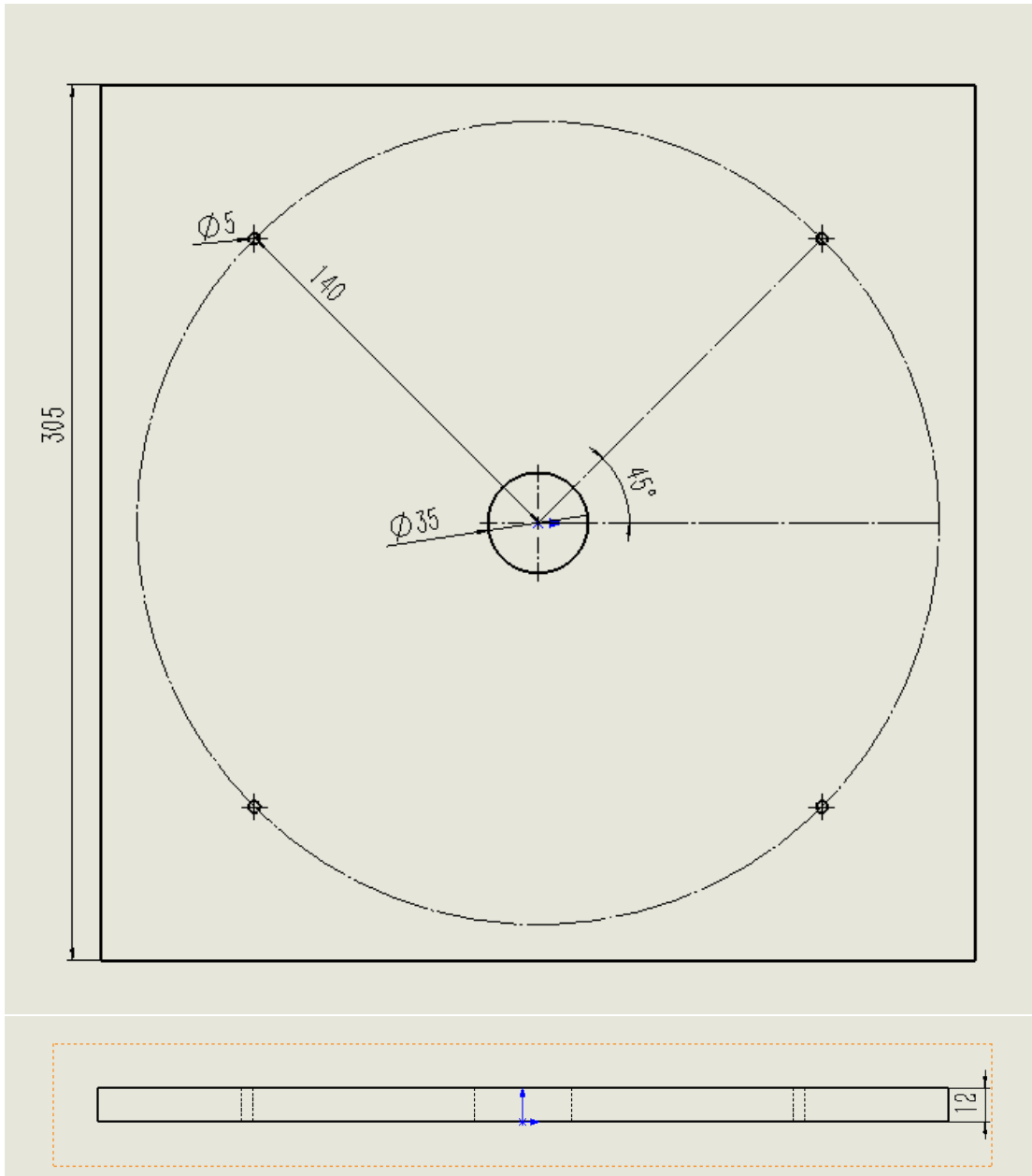


Mark 2

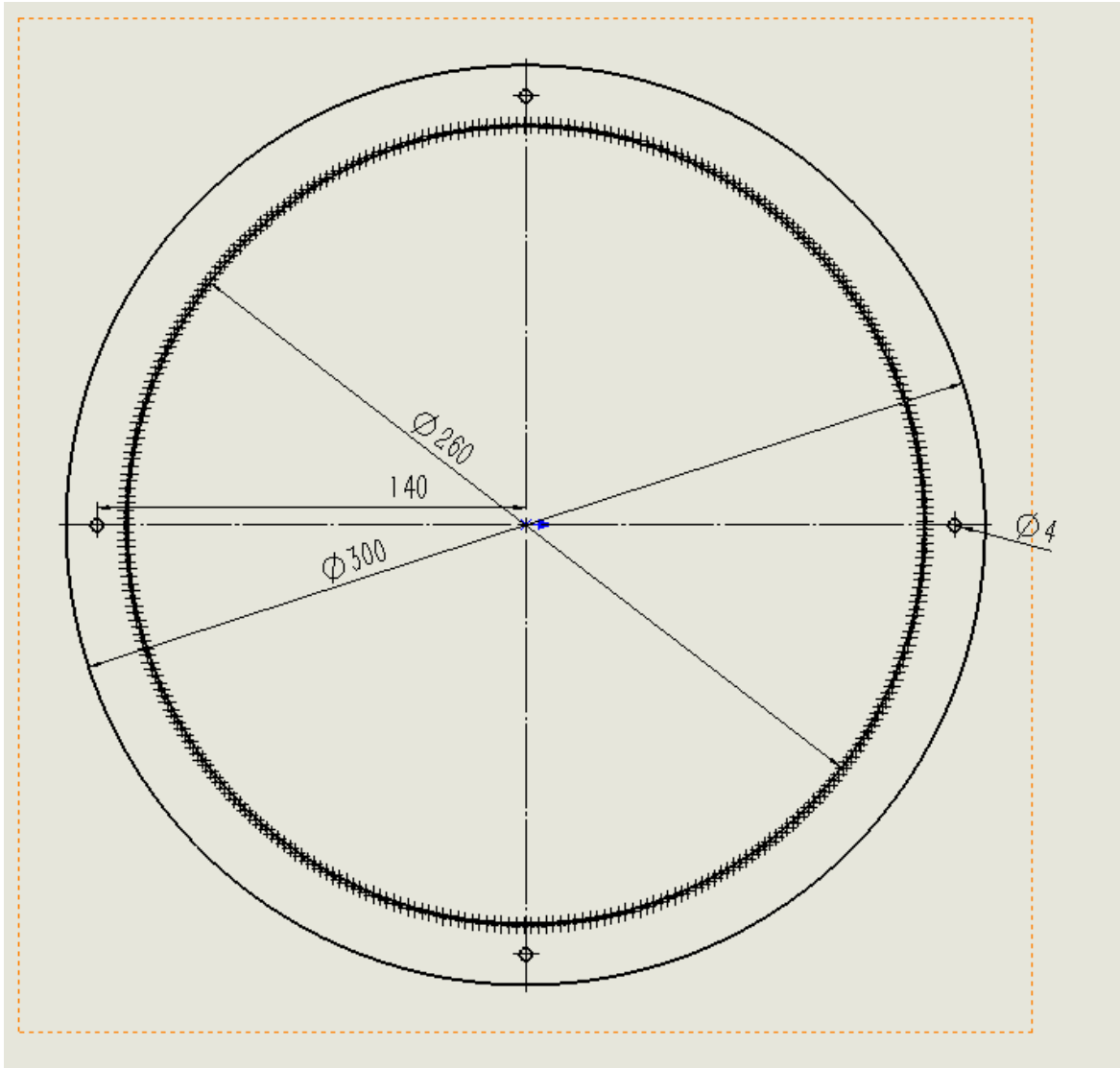
Bottom Plate

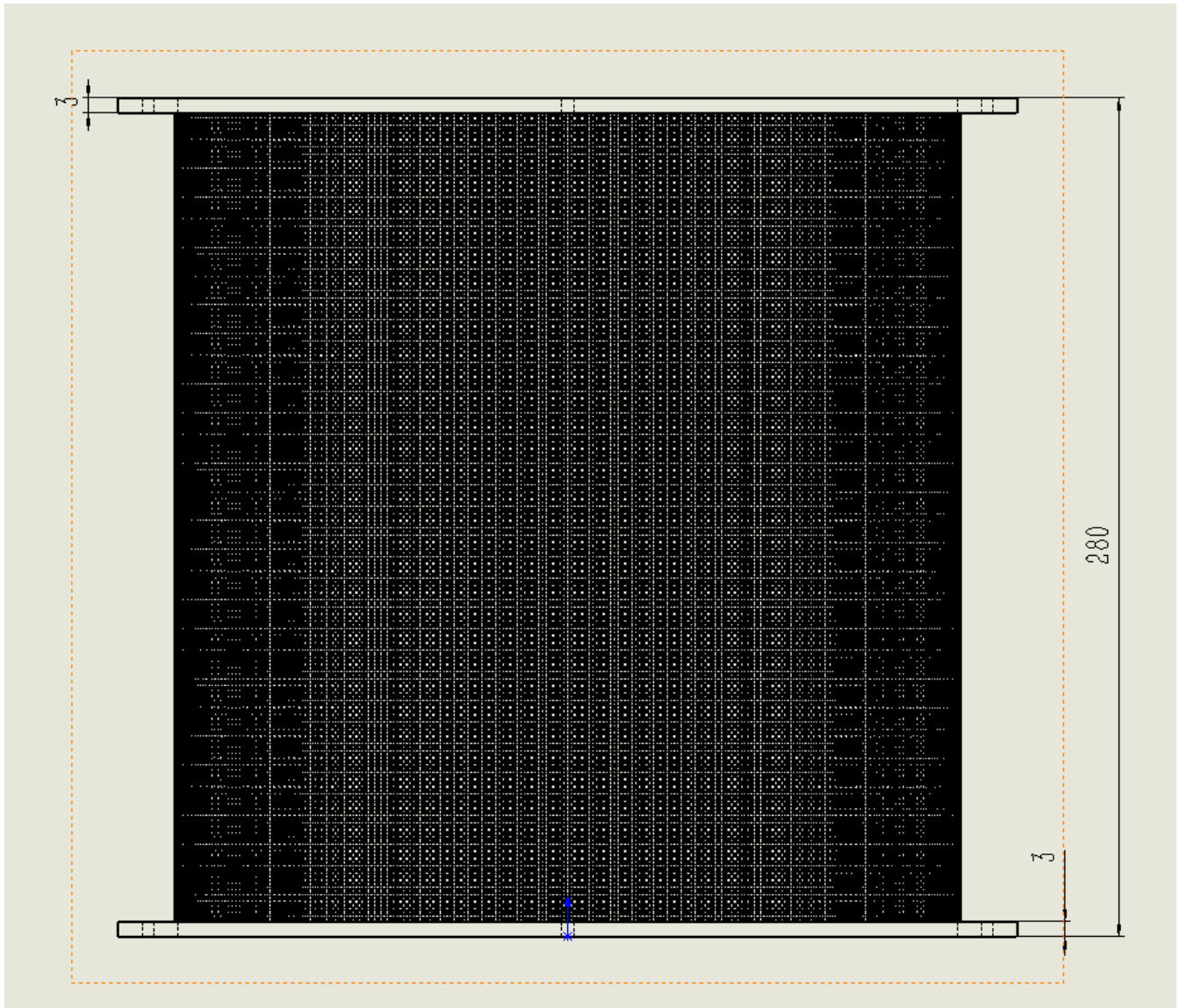


Top Plate

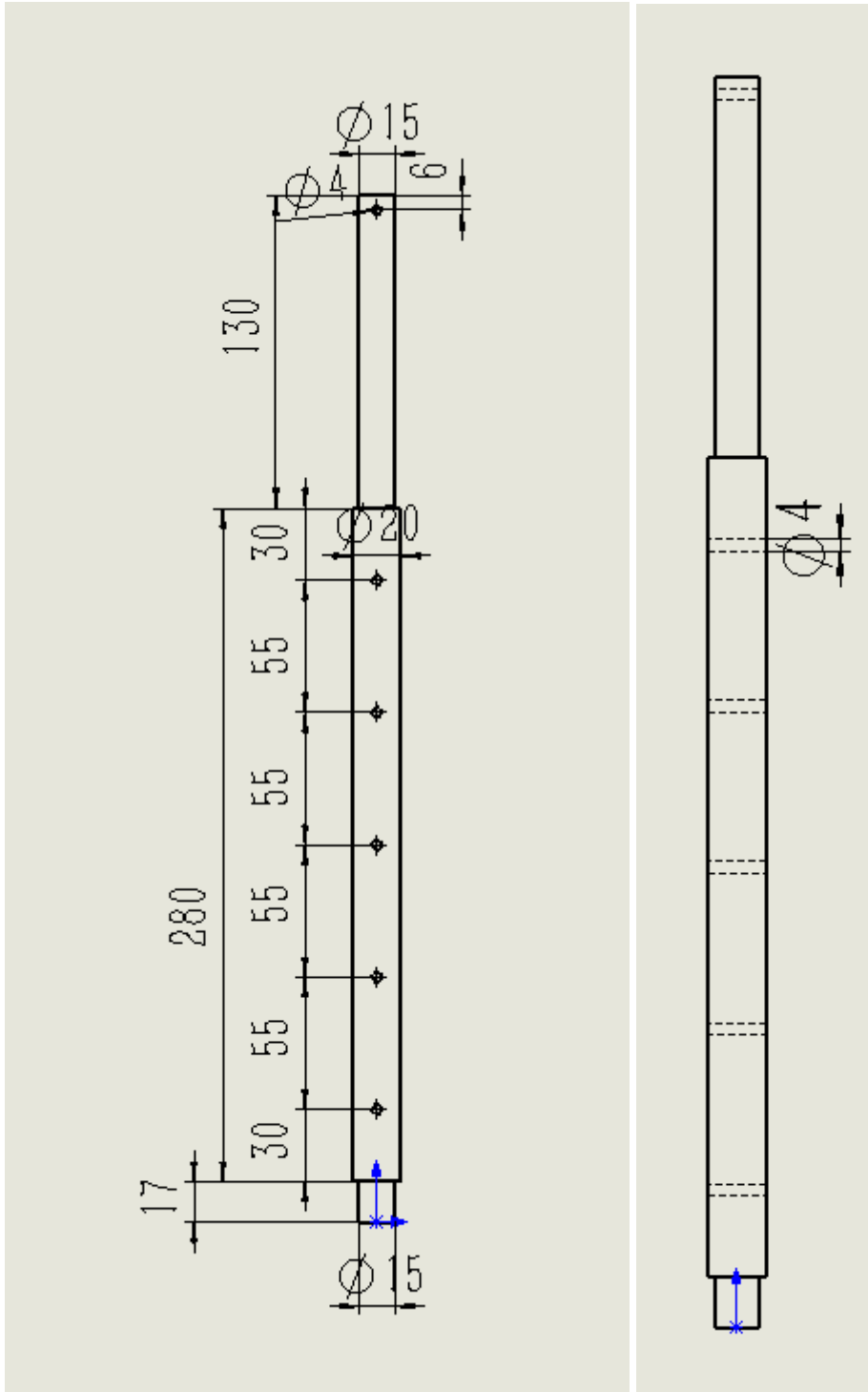


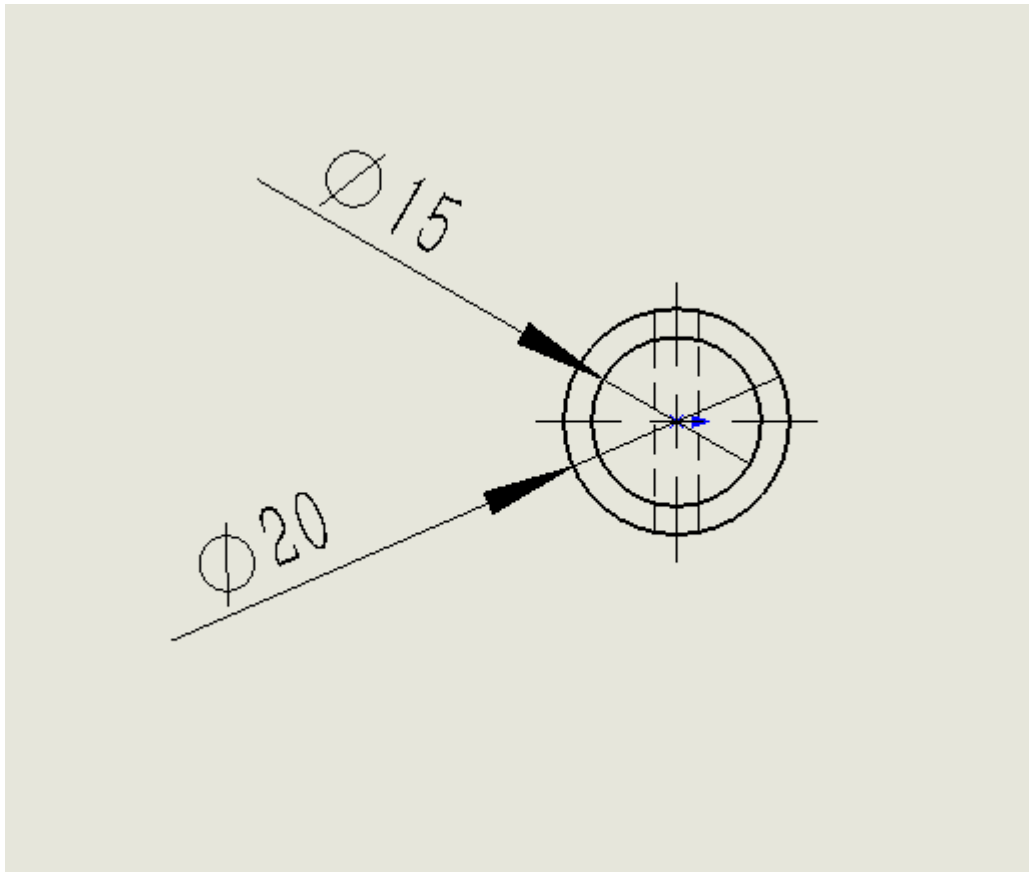
Mesh Drum



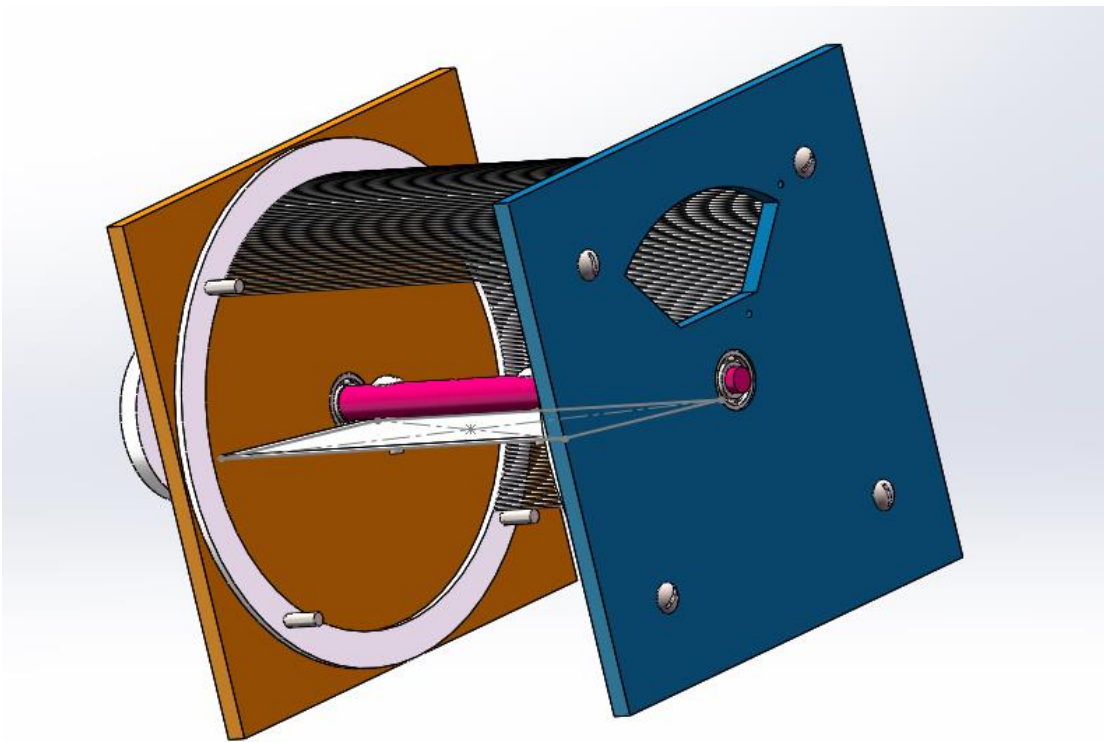
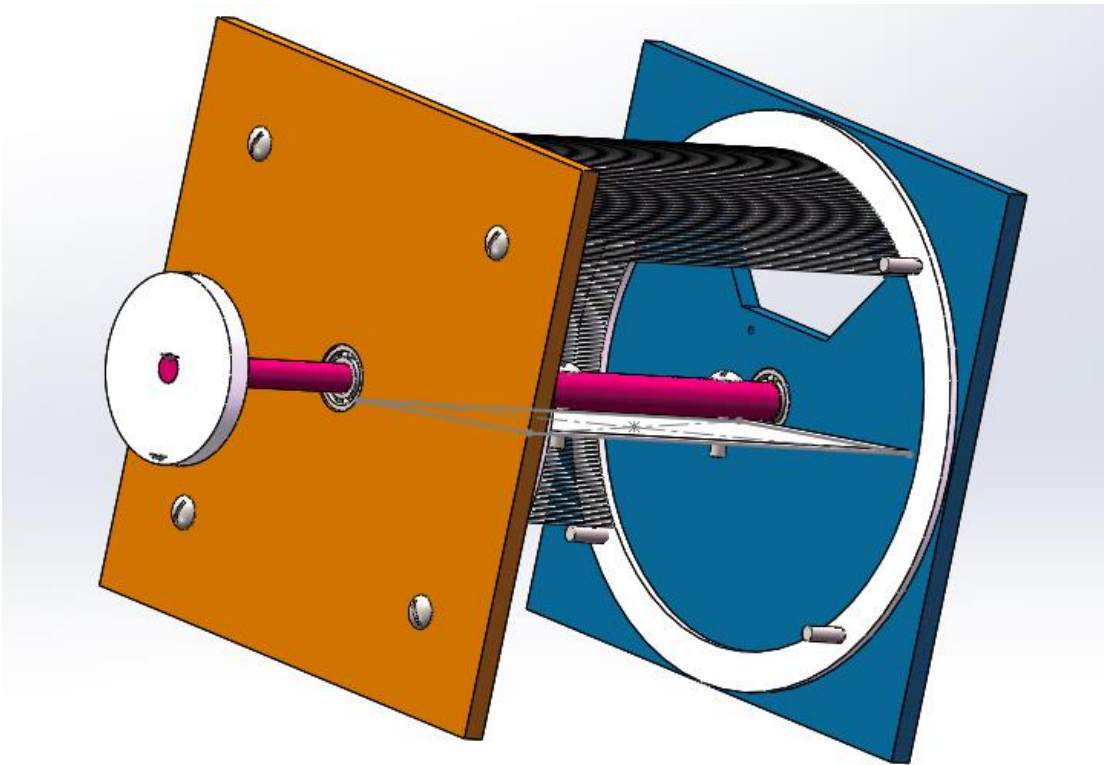


Shaft



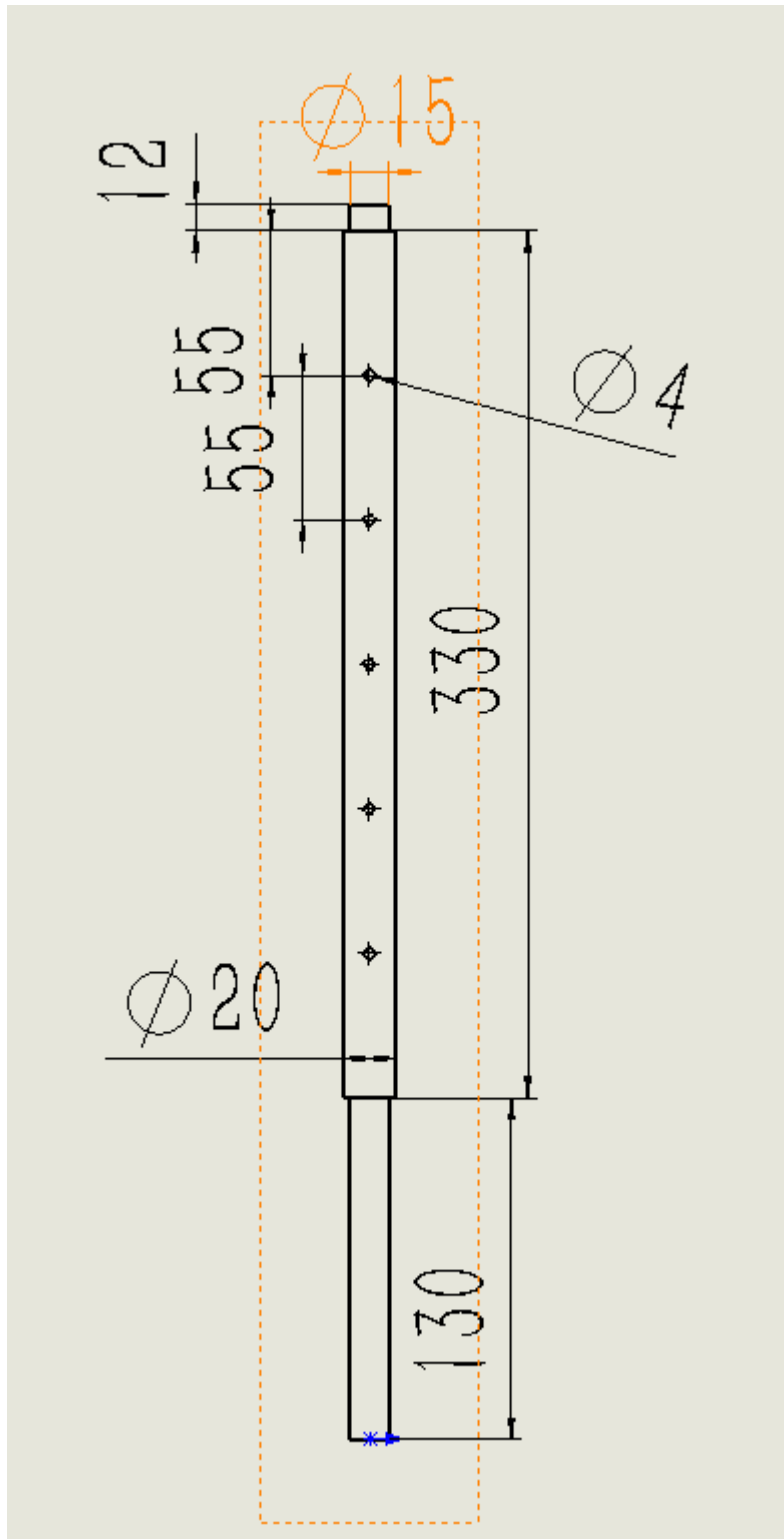


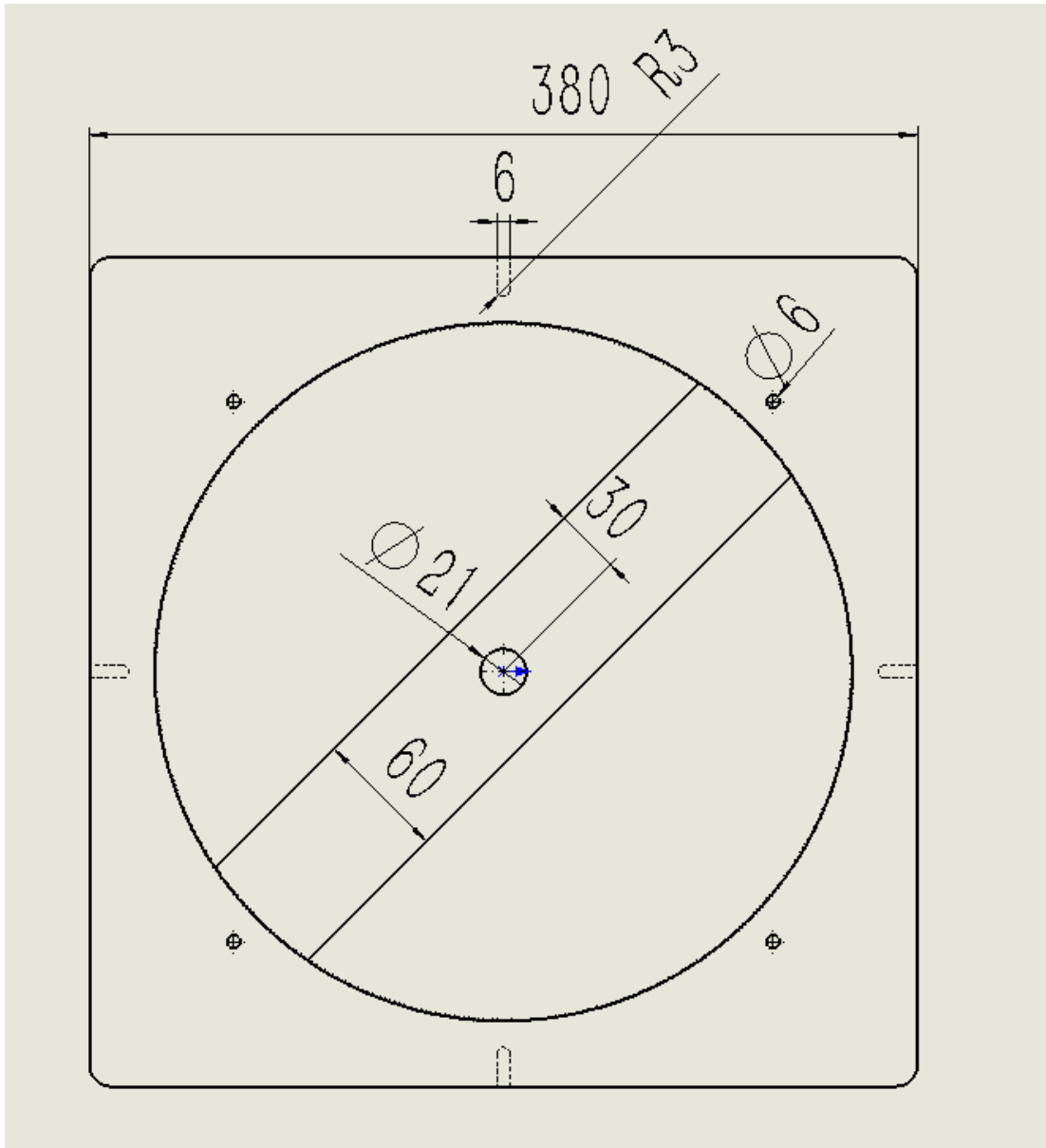
Overview

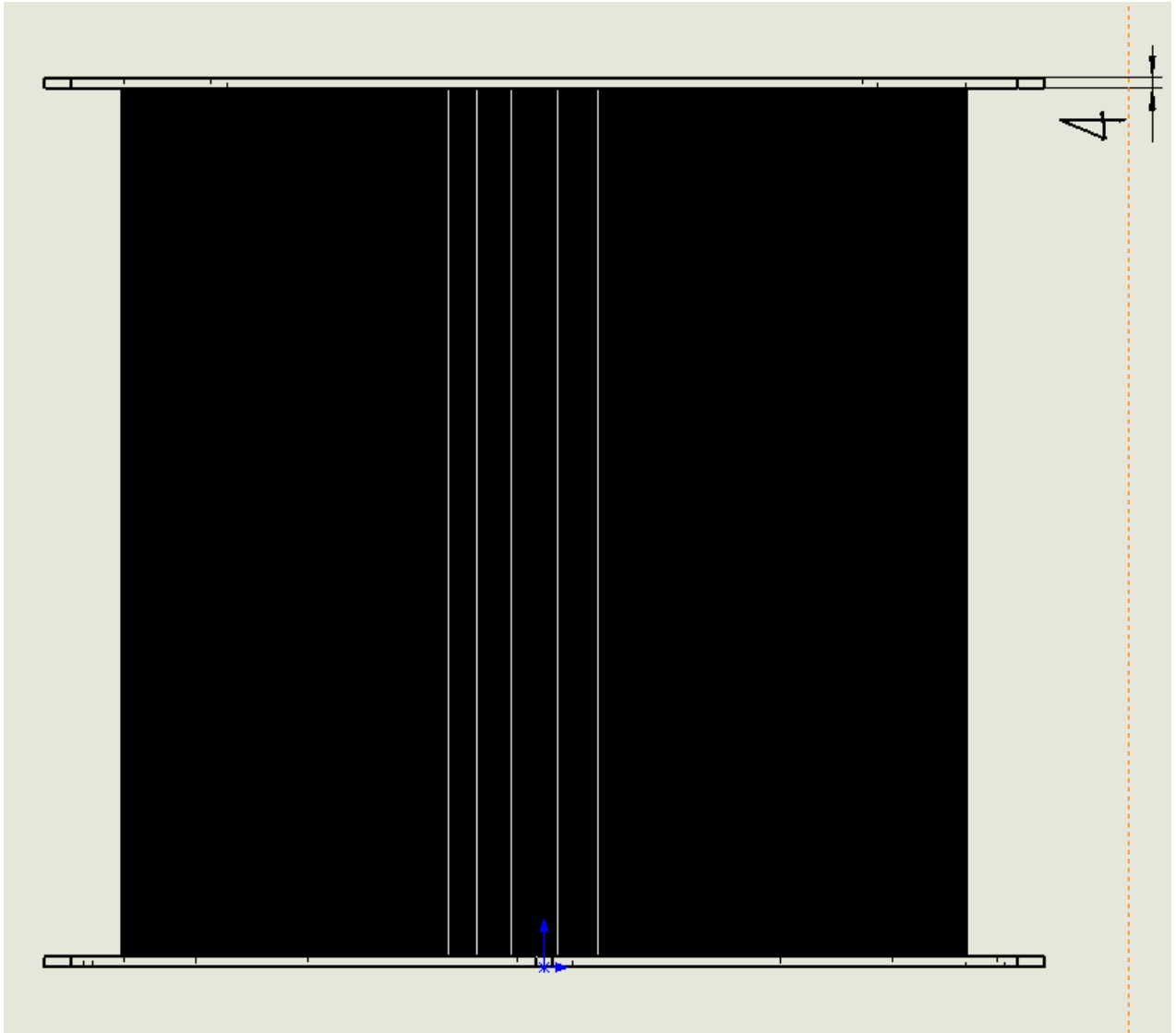


Mark 3

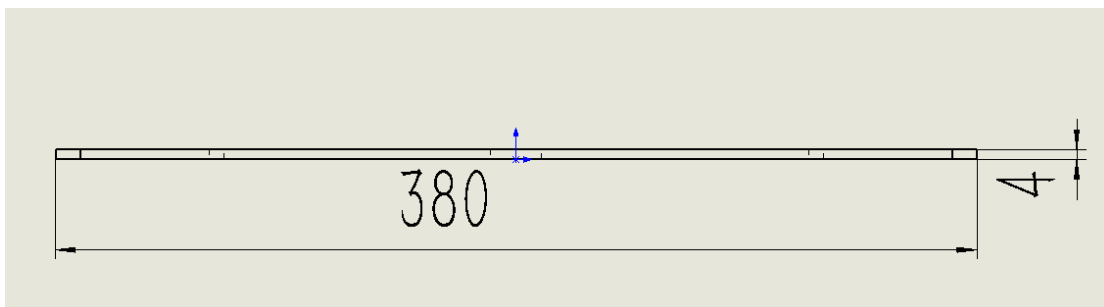
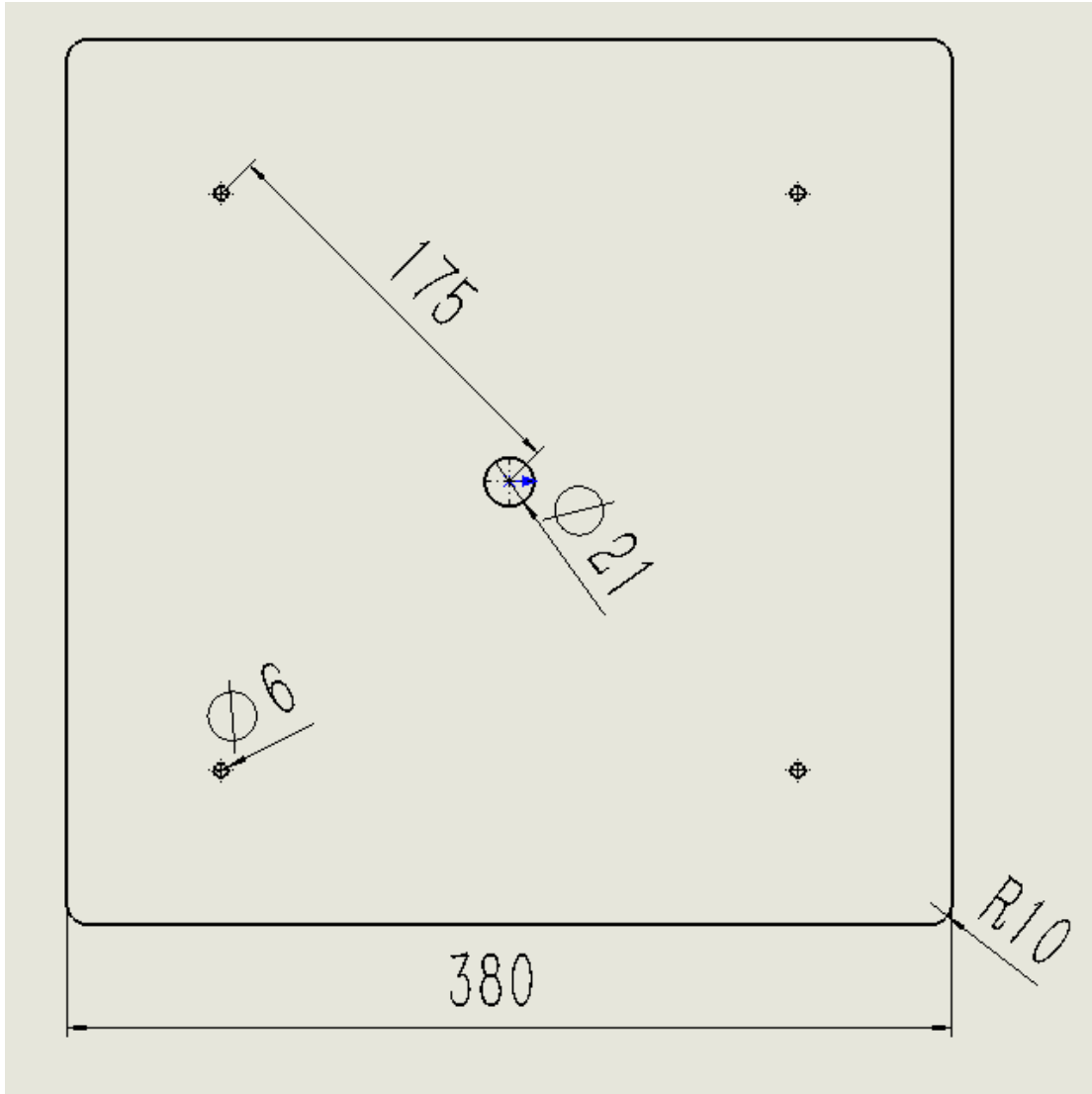
Shaft







Acrylic Sheet



B. Materials providers

Mark 2

Company Name: Anping County Chen Yi Wire and Mesh Products Ltd. (安平县晨屹丝网制品有限公司)

Address: Anping County North Fu Min Road No. 5 (安平县富民北路 5 号)

(Retrieved from <http://apchenyi.atobo.com/WebSite/apchenyi-c13.html>)

Contact Number: (+86) 15028802051

(Retrieved from <http://apchenyi.atobo.com/WebSite/apchenyi-c13.html>)

Order from:

https://item.taobao.com/item.htm?id=576985544381&price=100&sourceType=item&sourceType=item&suid=1511d400-abaa-47db-8fa1-c374f118fc88&ut_sk=1.W%2BujUSOqWwDAFJzg8LgpQwh_21646297_1583120481822.Copy.1&un=7b0f08b992ab53973dd3af49e2902fce&share crt v=1&spm=a2159r.13376460.0.0&sp tk=wqJtaDITMTVEWW9COMKi&cpp=1&shareurl=true&short_name=h.V3B8DEz&sm=8dd7f9&app=firefox

Mark 3

Mesh Drum

Company Name: Anping County Ya Hao Wire and Mesh Products Ltd. (安平县雅浩丝网制品有限公司)

Address: Hebei Province Hengshui City Anping County Mazhuang Town Town South 300 (河北省衡水市安平县马庄村村南 300 米处) (Retrieved from <https://pagmac3.m.coovee.com/>)

Contact Number: (+86) 14730575155

Customer Service Number: (+86) 15030872466

Order from:

https://item.taobao.com/item.htm?id=587002854768&price=5&sourceType=item&sourceType=item&suid=013a512e-8bfc-4dcc-867c-ccfacef9ffac&ut_sk=1.W%2BujUSOqWwDAFJzg8LgpQwh_21646297_1583120481822.Copy.1&un=7b0f08b992ab53973dd3af49e2902fce&share crt v=1&spm=a2159r.13376460.0.0&sp tk=4oKkZkpNWDE1RGI1TVDigqQ=&cpp=1&shareurl=true&short_name=h.V393z93&sm=da2cc3&app=firefox

Flanges (on which the bearings are mounted)

Company Name: Jiangsu Province Jia Jun Stainless Steel Ltd. (江苏佳俊不锈钢有限公司)

Address: Jiangsu Province Xinghua City Dainan Town Shibao Industrial Park (江苏省兴化市戴南镇史堡工业园区)

Contact Number: (+86) 13705264730

(+86) 15052839509

Order from:

https://item.taobao.com/item.htm?id=540910722767&price=10&sourceType=item&sourceType=item&suid=50802107-b2ae-470f-8ae2-158072b0971b&ut_sk=1.W%2BUjUSOqWwDAFJzg8LgpQwh_21646297_1583120481822.Copy.1&un=7b0f08b992ab53973dd3af49e2902fce&share crt v=1&spm=a2159r.13376460.0.0&sp tk=4oKsQUd6WDE1RGJYaVHigqw=&cpp=1&shareurl=true&short_name=h.VWA7FbN&sm=e2f217&app=firefox&price=10&sourceType=item&sourceType=item&suid=50802107-b2ae-470f-8ae2-158072b0971b&ut_sk=1.W%2BUjUSOqWwDAFJzg8LgpQwh_21646297_1583120481822.Copy.1&un=7b0f08b992ab53973dd3af49e2902fce&share crt v=1&spm=a2159r.13376460.0.0&sp tk=4oKsQUd6WDE1RGJYaVHigqw=&cpp=1&shareurl=true&short_name=h.VWA7FbN&sm=e2f217&app=firefox

Mark 4

Mesh Drum

Company Name: Anping County Chen Yi Wire and Mesh Products Ltd. (安平县晨屹丝网制品有限公司)

Address: Anping County North Fu Min Road No. 5 (安平县富民北路 5 号)

(Retrieved from <http://apchenyi.atobo.com/WebSite/apchenyi-c13.html>)

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<https://world.taobao.com/item/576985544381.htm?spm=a21wu.11804641-tw.0.0.5e9e8d7fKacw0b>

Project team:



Figure 4: Thresher development team L-R Dr Stefanija Klaric, Dr Sean Bellairs, Felix Sutherland, Dr Penny Wurm, Yafei Gary Ge. Absent from the photo was Zhenyang Frederick Hou.