ISNIE
Engineering Summer School

Part IV
Neutron Choppers
Engineering

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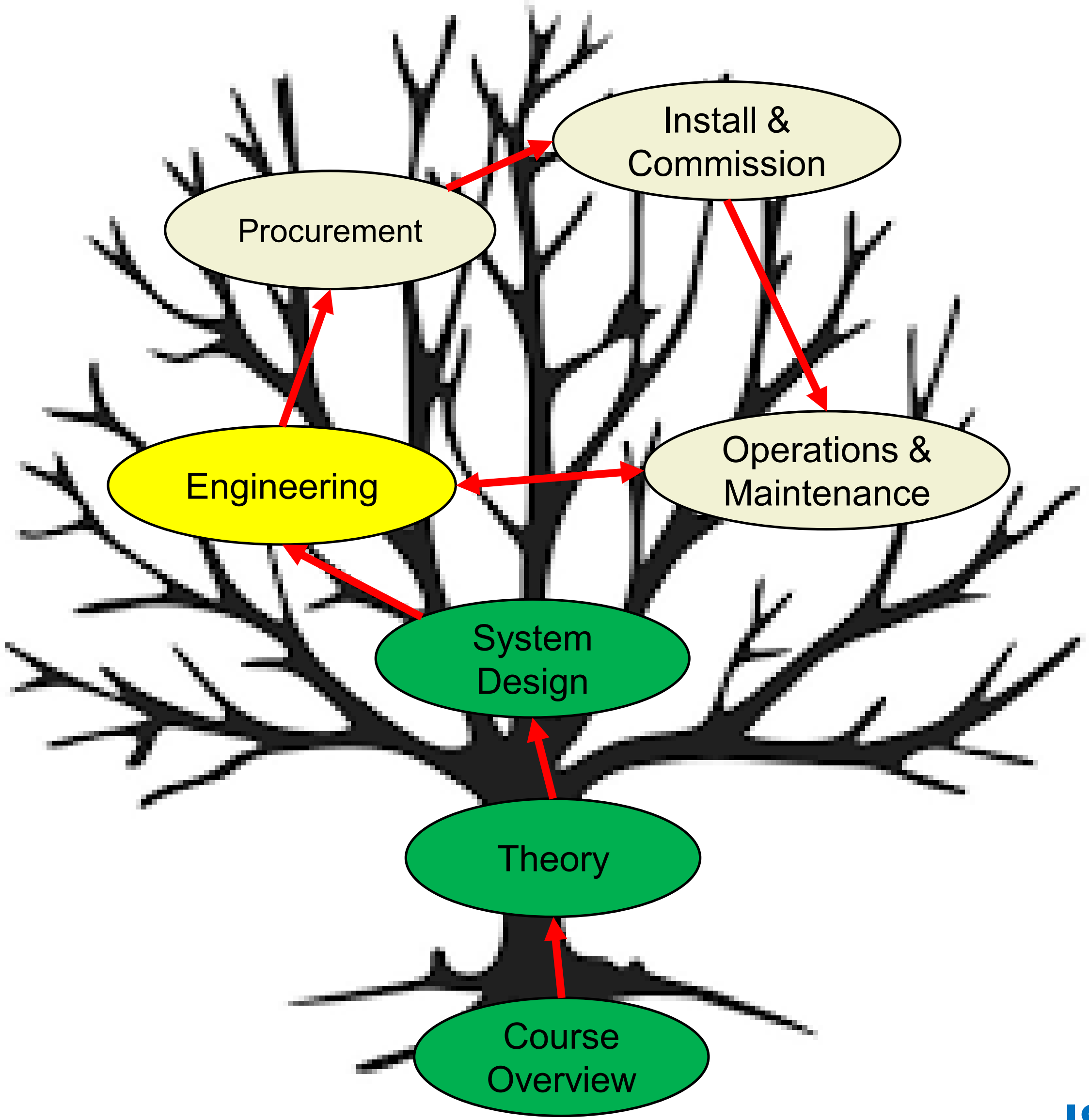
Branches

In the last two sessions Niko and Bill spoke of the Theory of Neutron Choppers and the Design of Chopper Systems.

Here I plan to discuss a number of subjects, in relation to the Engineering Design of these Choppers and relative features which need to be considered.



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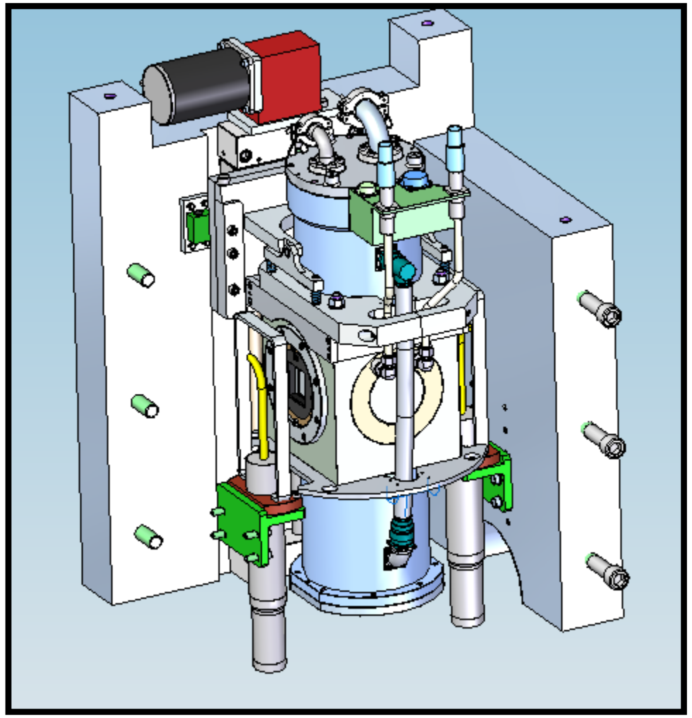
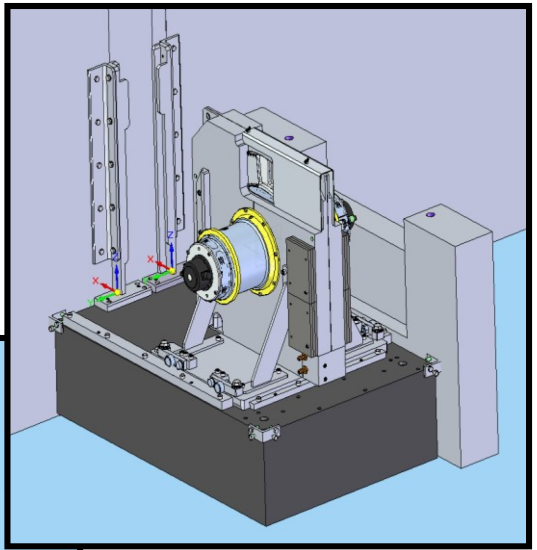
By this stage you will know **What you want your Chopper to do** and **What type of Chopper can do this**.

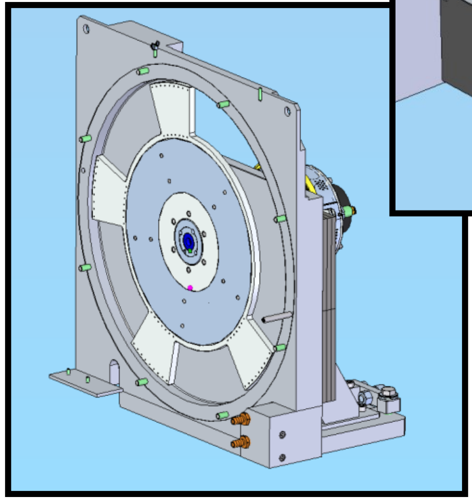
And thus, you have a Chopper System in mind to which you can apply the following subjects;



The following subjects;

1. **Design Reviews**
2. **Size – Made to Measure**
3. **Materials –**
    1. Attenuation
    2. Dynamic Assemblies
    3. Static Assemblies
4. **FEA Study**
5. **Vibration and Balance**
    1. Problem
    2. Solution
6. **Drives and Controls**
7. **Containment**
8. **Interfaces**
9. **Assembly, Testing and Maintenance**
10. **Safety**





In the next set of slides I will use two type of Choppers as examples, a T-Zero (t0) and a Double Disc Chopper (PSC).

Most of the information is applicable to other types of Choppers and Velocity Selectors

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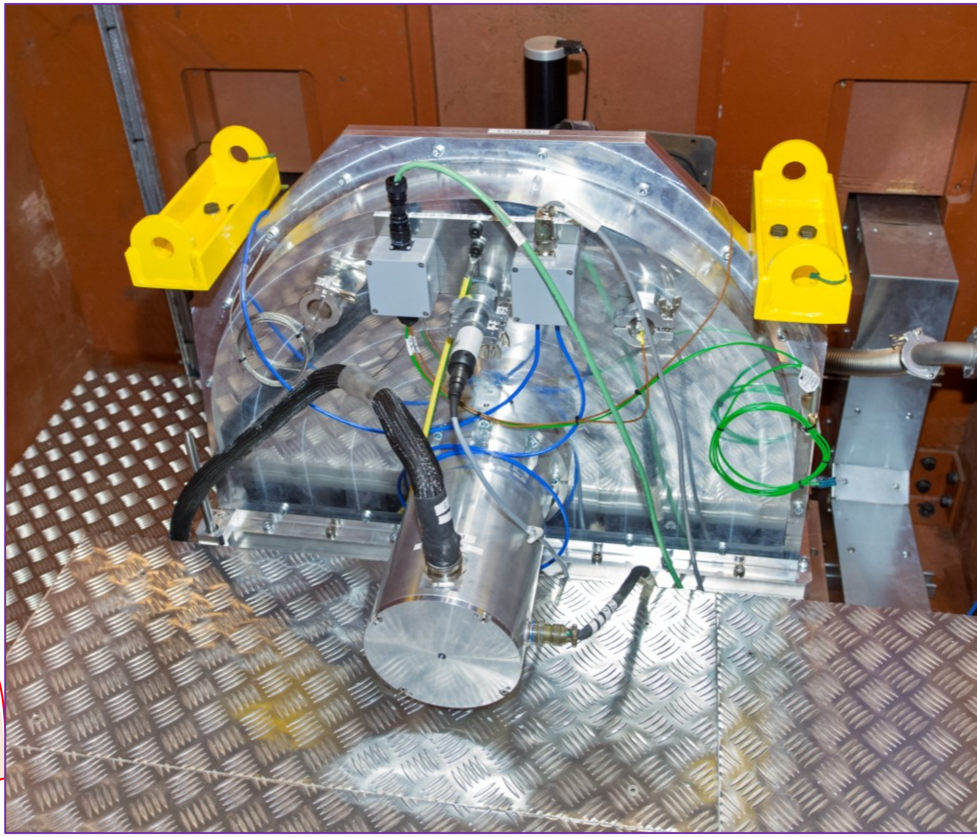
Engineering – Design Reviews

The Basic and Detailed Engineering Design procedure for a Neutron Chopper System is no different from the design of any other system, in that its success relies on Design Reviews. From the information received so far, and from that will be shown in the following slides, it can be concluded that;

The successful design of efficient, sustainable Neutron Choppers is a complex procedure involving many engineering disciplines, from composite material knowledge to ballistic analysis. As most will not be able to cover these as an individual, it is essential to include expert resources within an effective chopper design team.



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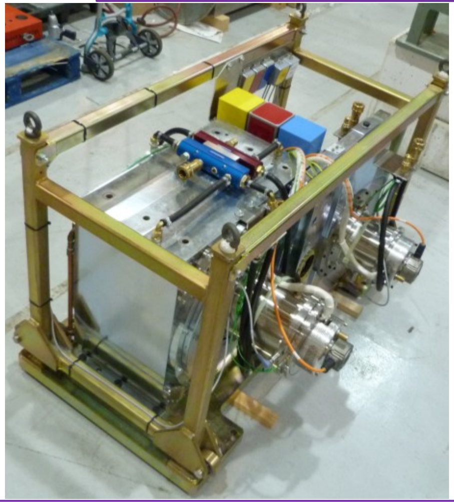
Engineering – Design Reviews

The successful design of efficient, sustainable Neutron Choppers is a complex procedure involving many engineering disciplines, from composite material knowledge to ballistic analysis. As most will not be able to cover these as an individual, it is essential to include expert resources within an effective chopper design team.

An ideal way of ensuring the design team has expert information from the all the engineering disciplines is to hold **Design Reviews.**

Reviews; Remember to invite all the Stakeholders who will be involved in the Delivery of the complete Neutron Chopper Package :-



Electrical Design – Instrument Design – Electrical Installation – Drives – Controls – Assembly – Test – Mechanical Installation – Operational Support – Vacuum – Pressure – Users – Customers – and possibly many More!

Design Reviews can be in the form of;

- Preliminary Review – 'Kick-Off', Once concept designs are in place.
- Critical Reviews – many times during the design stage to ensure all areas are covered.
- Final Review – Once the design is complete (hopefully!).
- Plus, during the design stage, Peer, Customer and Stakeholder Reviews should be held.

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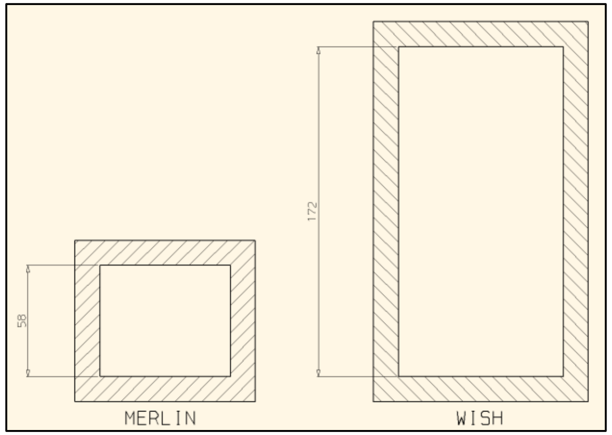
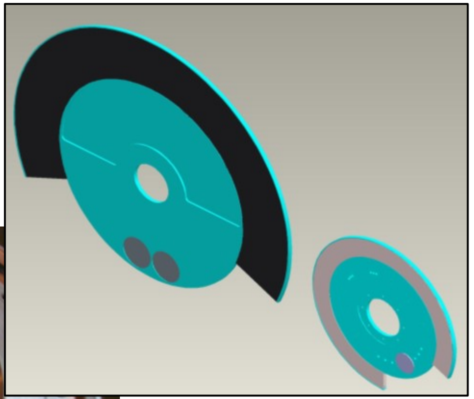
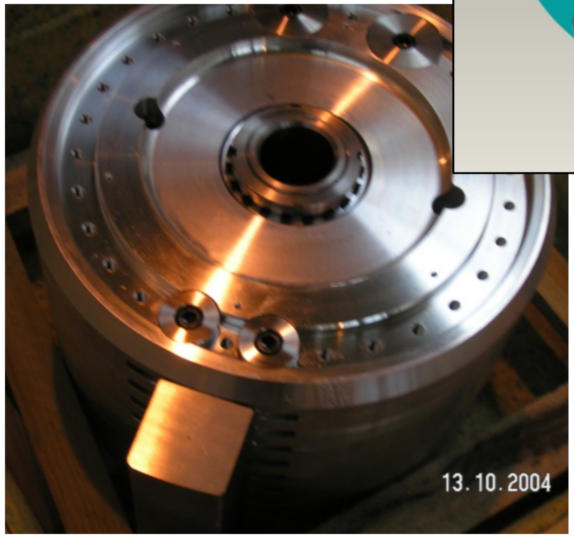
Engineering – Size; Made to Measure

Choppers are designed to suit the Beam Profile they are to cut.

- **Shortest Distance** – Ideally the Beam should be cut across the shortest distance = shortest time. If the Beam is Portrait in profile the centre of rotation will be directly above or below. If the Beam is Landscape this centre will be to either side.
- **Attenuation Area** – this should be slightly larger than the Beam Profile.
- **Diameter of Rotor** – as a guide and working from the rim, 1/3 of the radius is the attenuation area, the next 1/3 is for balancing and the inner 1/3 is for the drive.
- **Exceptions** – Large diameter rotors reduce the cutting time without increasing the speed.







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Engineering - Materials

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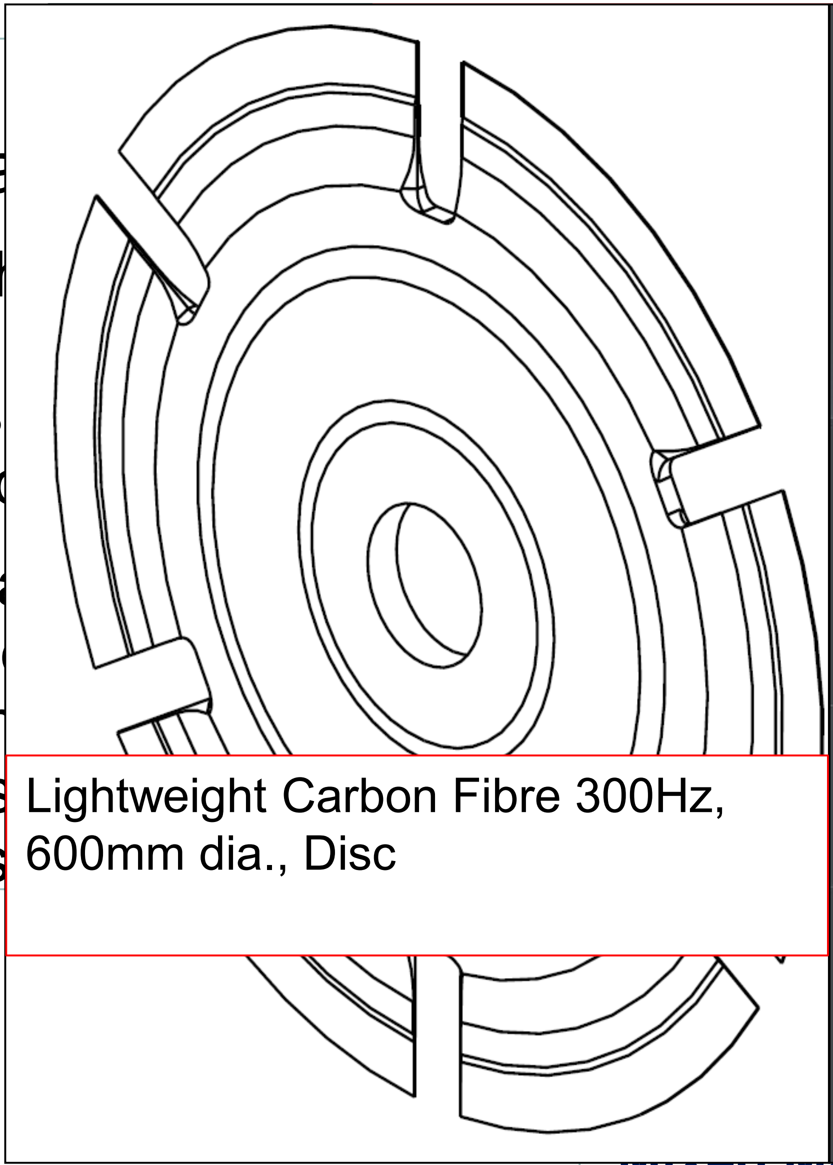

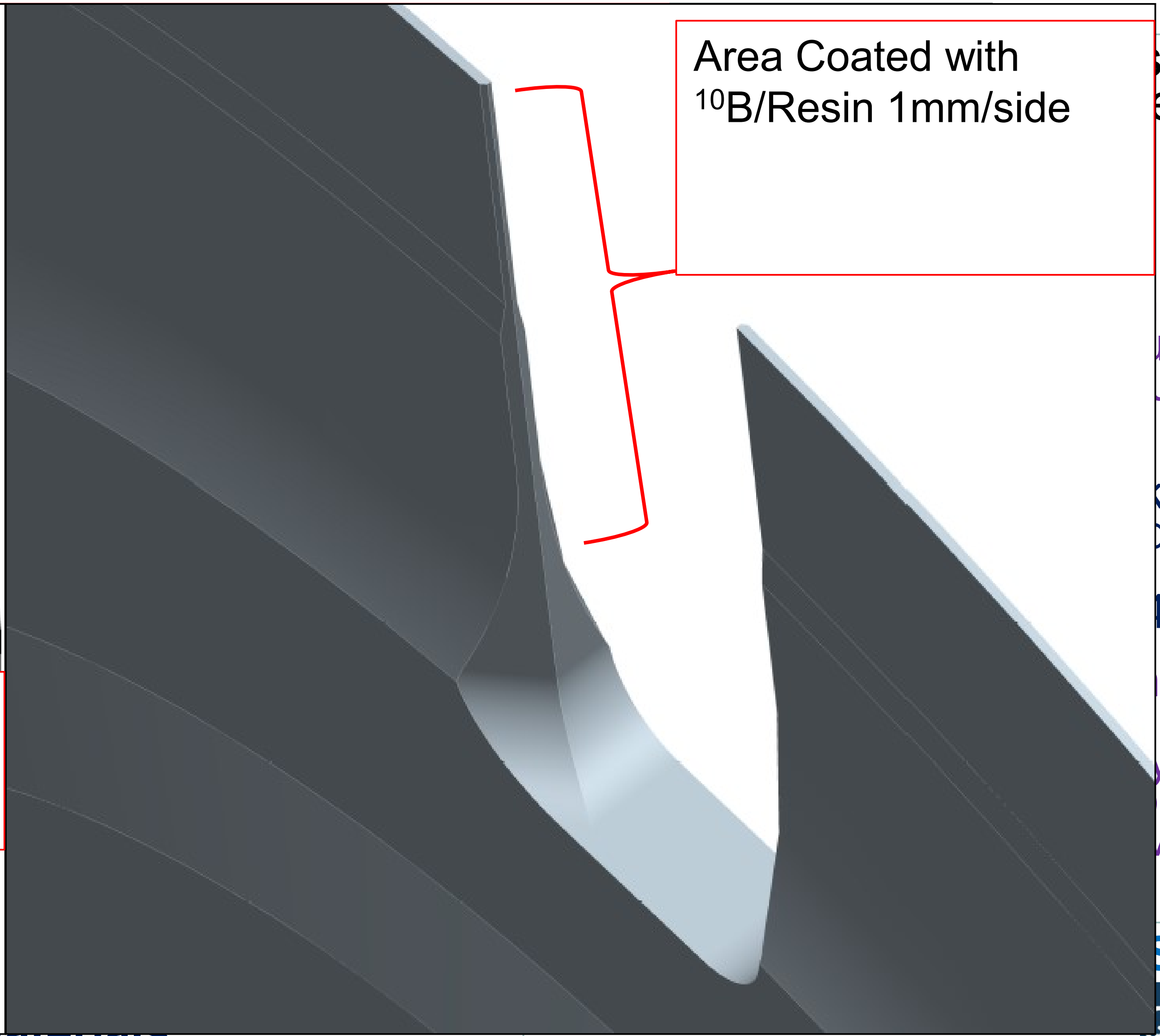

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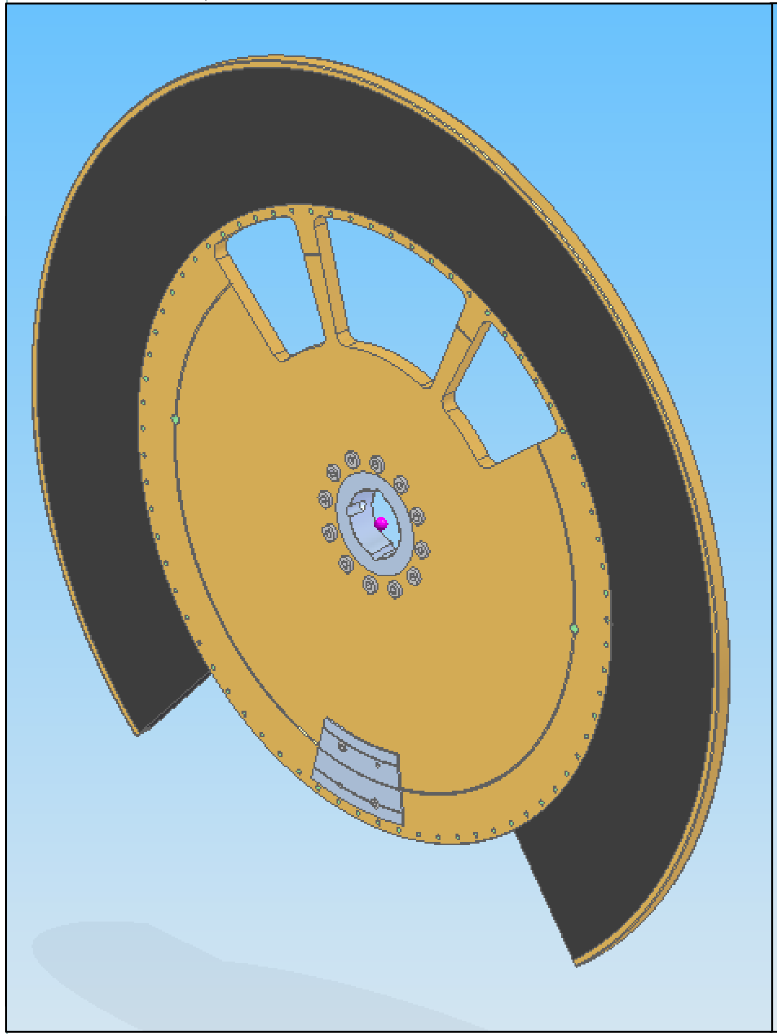
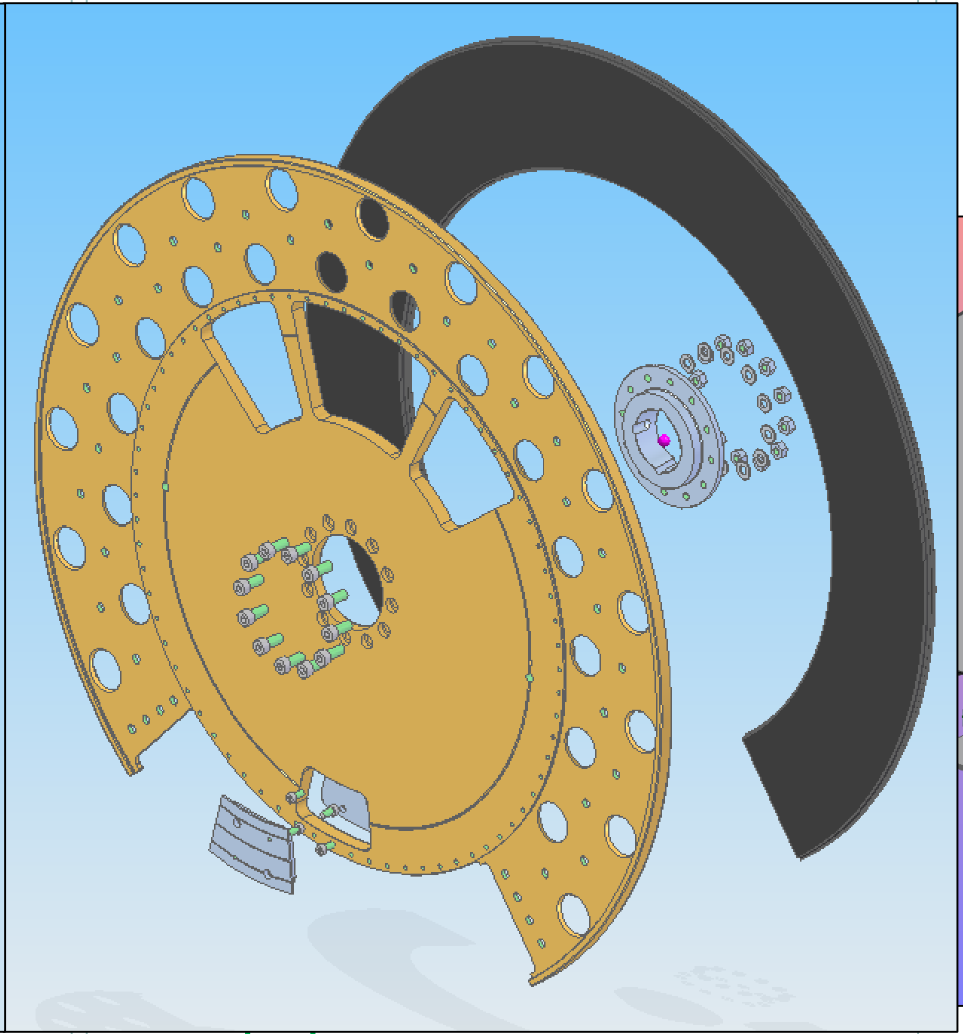
Engineering - Materials

Next, let's look at



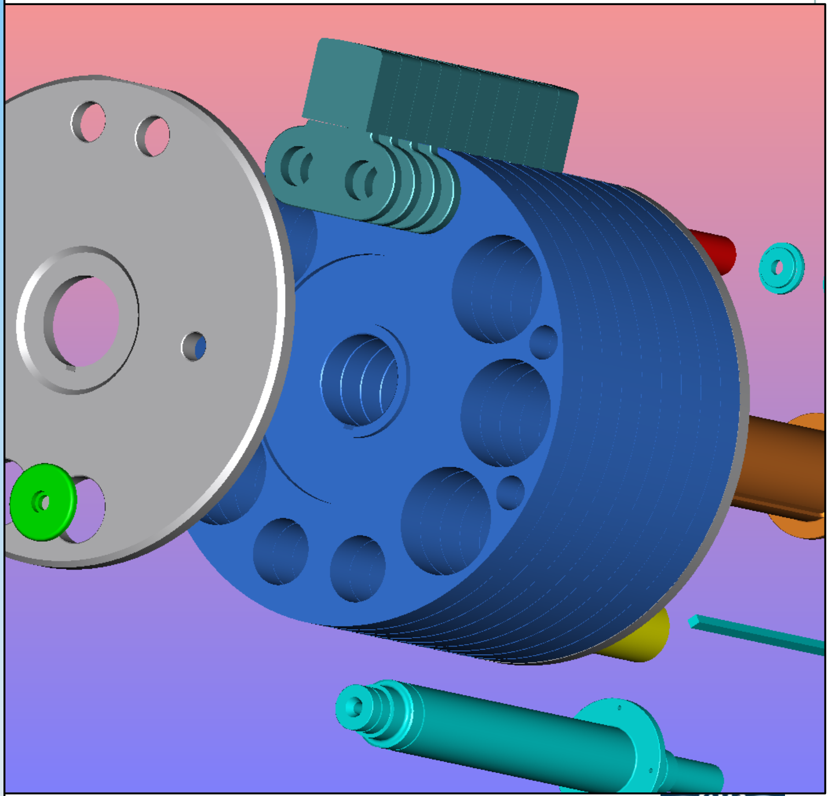
The Components of a



needed.

The Components for a Disc Chopper consists of;

Hub – Coupled to the shaft of the Drive System and supporting the Disc.



Engineering - Materials

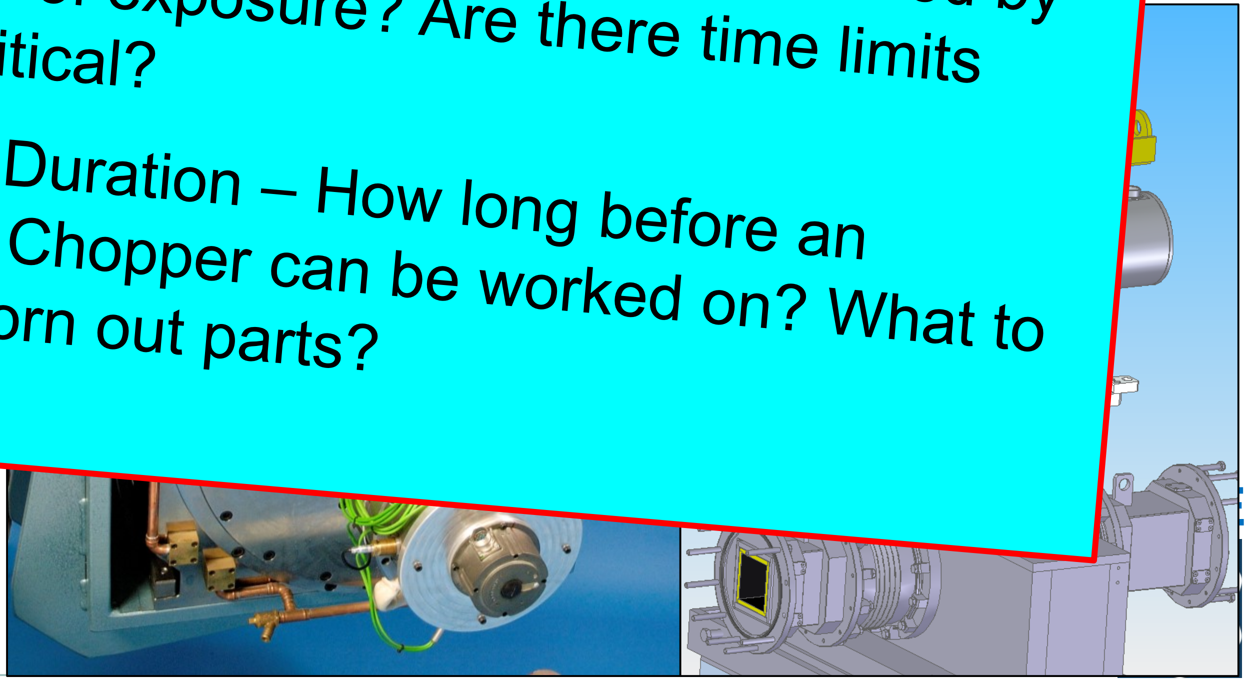
Finally, Materials for the Stat ... the Housing may need to
(Rotor Housing/Drive Mount

Robust – The Housing need to
stability when the following force
applied;

- Bearing Alignment,
- Distortion (vacuum, thermal
- Containment (internal & exte
– seismic activity),
- Drive Torque,
- Interfacing/Coupling with oth
equipment.
- Lifting and Handling

RADIATION! and of course, the effects of radiation exposure must be consideration in the selection of Materials;

- Performance – How is the material effected by the levels of exposure? Are there time limits before critical?
- Half Life Duration – How long before an extracted Chopper can be worked on? What to do with worn out parts?



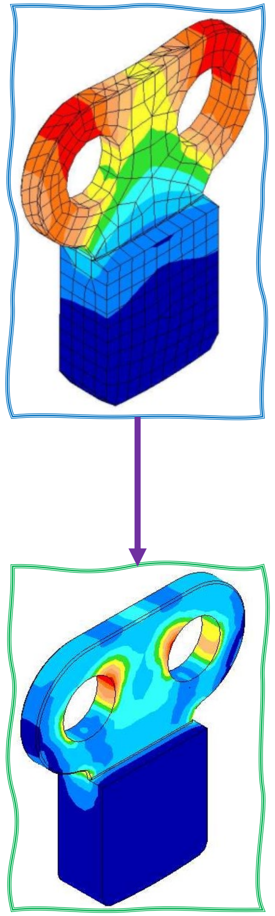
Engineering – FEA Study

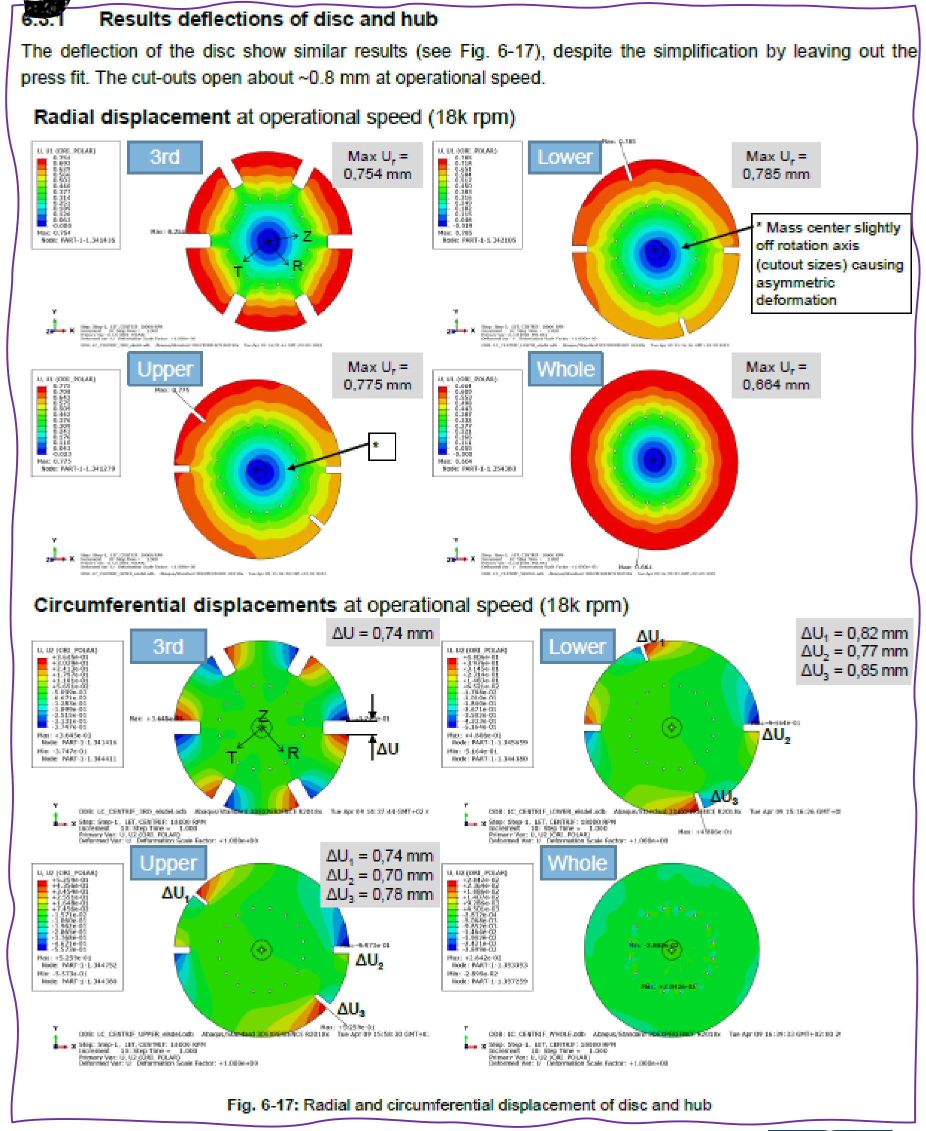
Once a basic design is in place the Dynamic Assembly and all the components should be the subject of a Finite Element Analysis Study.

The most useful FEA results are;

- Maximum Stress/Strain,
- The Deflection, both at maximum speed and during run up from zero to maximum,
- The natural Harmonics.
- Fatigue, life/longevity – number of cycle to failure.

If any of the above results do not give an acceptable factor of safety, or the Harmonics are close to any of the operational speeds, then the design need to be modified.

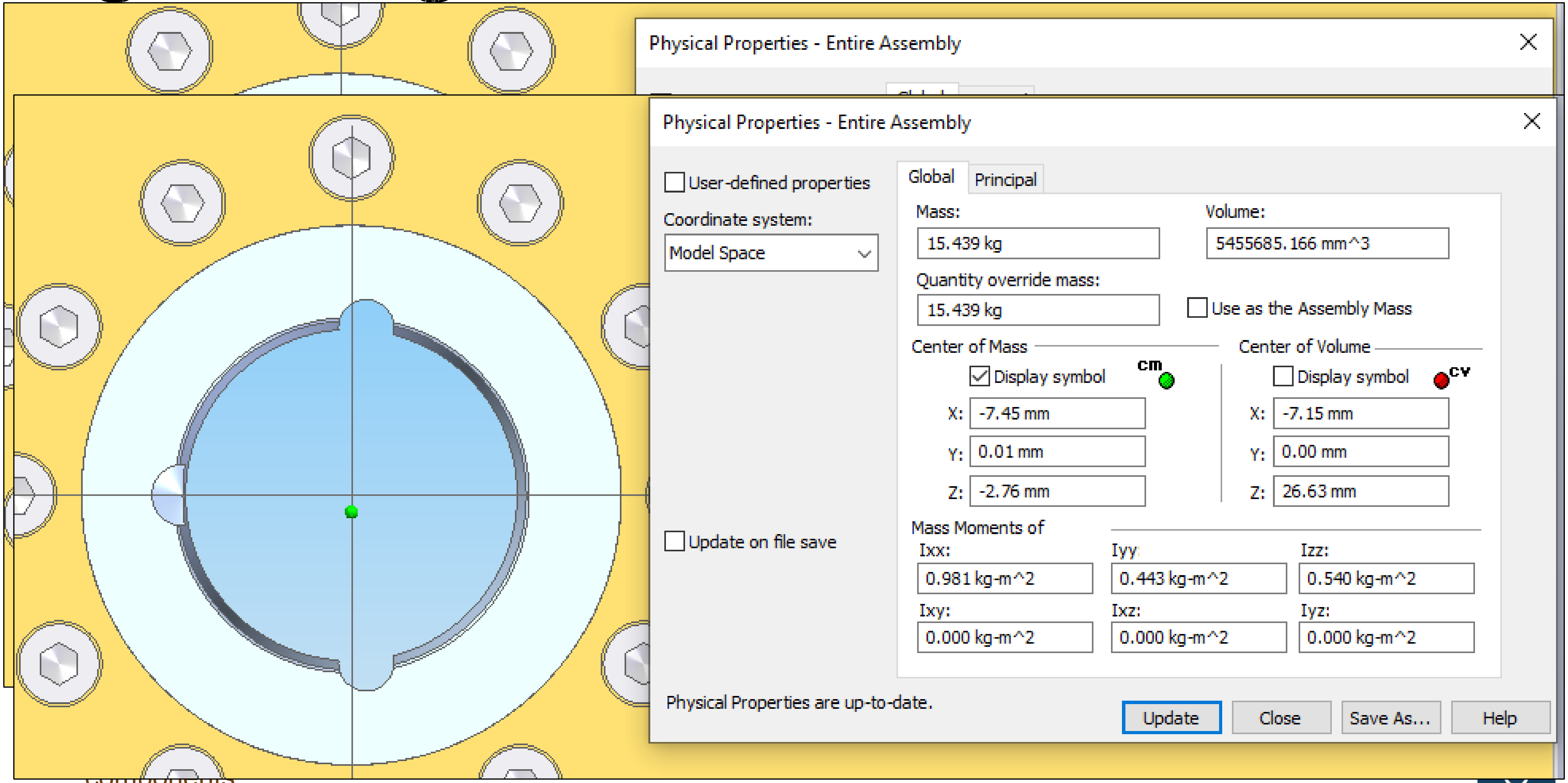



6.3.1 Results deflections of disc and hub

The deflection of the disc show similar results (see Fig. 6-17), despite the simplification by leaving out the press fit. The cut-outs open about ~0.8 mm at operational speed.

Fig. 6-17: Radial and circumferential displacement of disc and hub

Engineering – Vibration and Balance



Engineering – Vibration and Balance

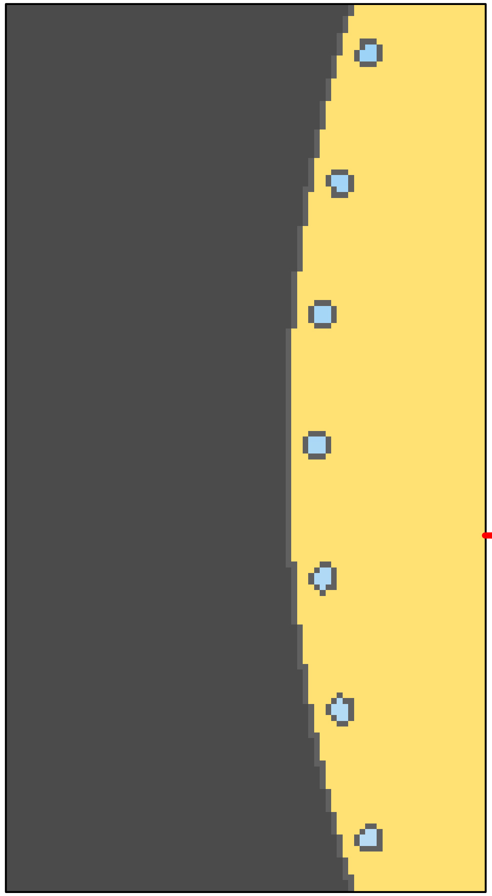
Vibration –

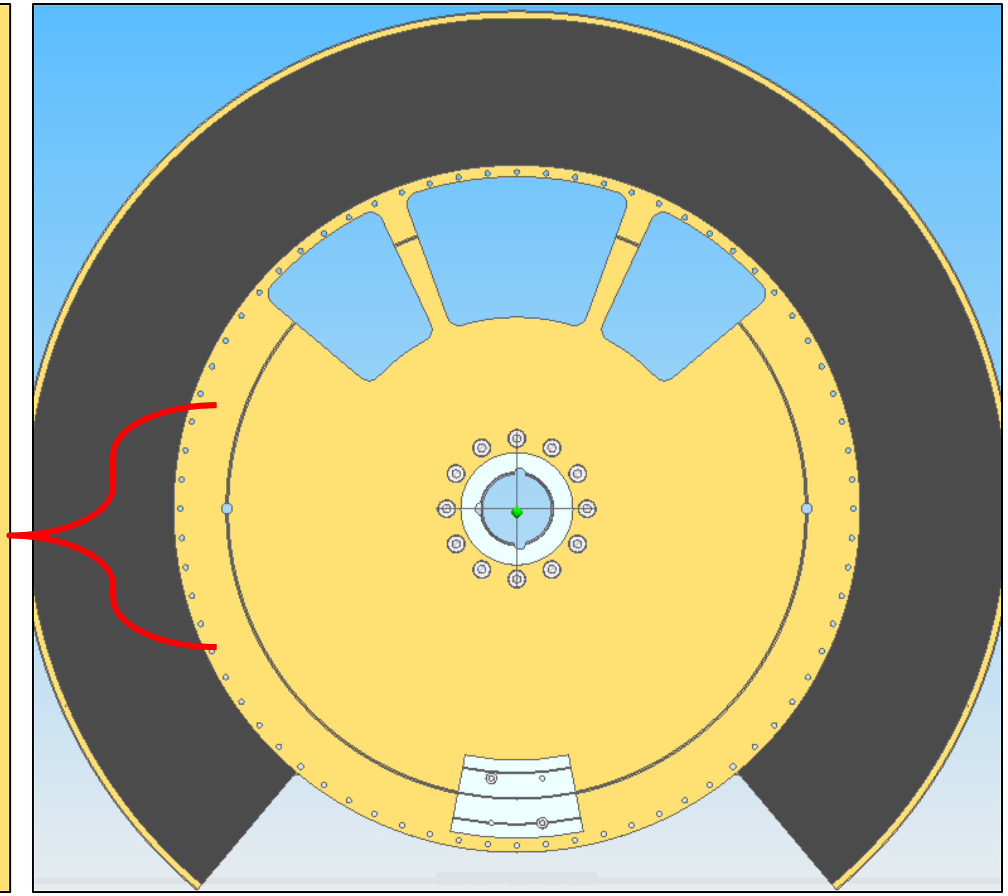
Solutions

Include within the design a ring of threaded holes to allow the addition of balancing screws,

Assemble with the axis in the vertical plane,

Perform a precision balancing procedure on a Dynamic Balancing Machine and/or the final drive Spindle.





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Engineering – Drives and Controls

Up to now we have been concerned with the mechanic design of the Dynamic Assembly but before we go any further let us consider what information is required to enable the Electrical/Controls Designer to produce and/or specify the Chopper's Drive and Controls. Listed below is some of the information that may be needed;

For the Drive;

- The Inertia of the Payload
- The Maximum rate of Acceleration and Retardation.
- The Maximum operating speed

For the Controls;

- The positional accuracy
- Synchronisation to a timing signal
- Ability to park open and/or closed, or move out of the beam for scientific commissioning of the instrument
- The interface with sensors, gauges and switches, to activate Chopper trip offs and prevent a Chopper from operating until safe to do so
- Remote control
- Level of diagnostics in order to identify and resolve faults

And in General;

- Some parts may need to operate in a vacuum and/or at elevated temperatures,
- The radiation tolerance of any electronics on the chopper itself, e.g., position feedback, rotor pulse pick-offs

Plus, a UPS

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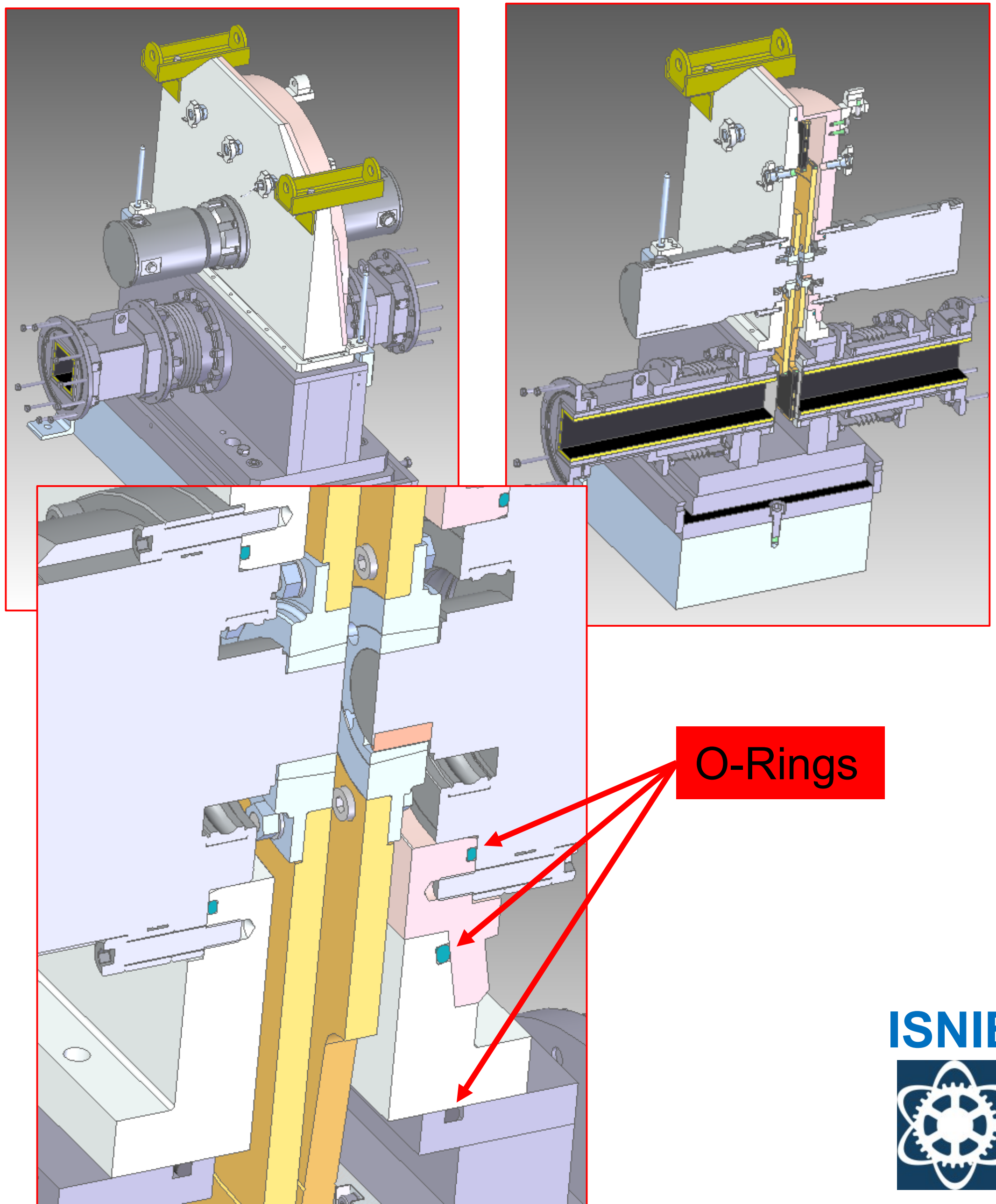
Engineering - Containment

Depending on the initial Chopper's specifications, the Rotor Housing assembly may need to do more than just cover the Dynamic assembly. These additional function may need to be incorporated into the design;

- **Vacuum Chamber** – If there is a requirement for the internal space of the Housing to be integrated with the Beam's vacuum, thus removing atmosphere and a number of windows from the Beam's path, vacuum design protocols to be observed.
- **Pressure Vessel** – Or there could be a requirement to fill the internal volume with a positive pressure of gas. In this case, and depending on the pressure levels, the housing may need to be treated as a pressure vessel.
- **Sealing** – In both the above cases, the Housing assembly will require seal, in the form of o-rings and/or gaskets at all joining faces. If any dynamic parts passes through the wall of the Housing, these will require rotary seals
- **Rotor Failure** – In the event of part of the Rotor assembly becoming detached at speed, the housing should be designed to contain the parts. If containment is not practical a method should be incorporated to reduce the velocity of the parts.



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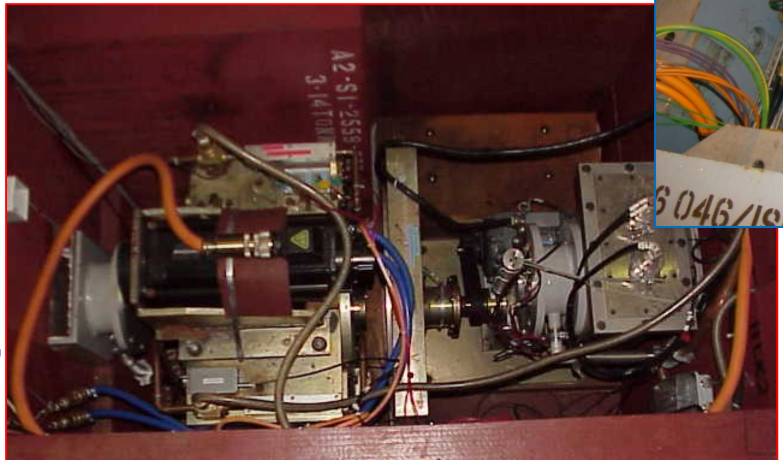
Engineering - Interfaces

When Designing the Main Body (rotor housing), consideration should be given to possible interfaces with its location and other local equipment. Such as;

- **Pit Mounting** - The fixing of the Chopper within the Instrument. In most cases the Chopper will be in a Chopper Pit and on some form of Mounting. This should be stable, solid, accurate, repeatable and accessible.
- **The Beam Guide** – the lower section of the housing could be connected directly to the guide, usual for vacuum choppers, or at least align to the guide.
- **Services** – On the electrical side there will be cables running to the chopper for Power, Control, Condition Monitoring (vibration/temperature/speed/vacuum), and on the mechanical side, Cooling pipes and Vacuum hoses.
- **Auxiliary Equipment** – beam monitors, beam shutters, Jaws, etc,.



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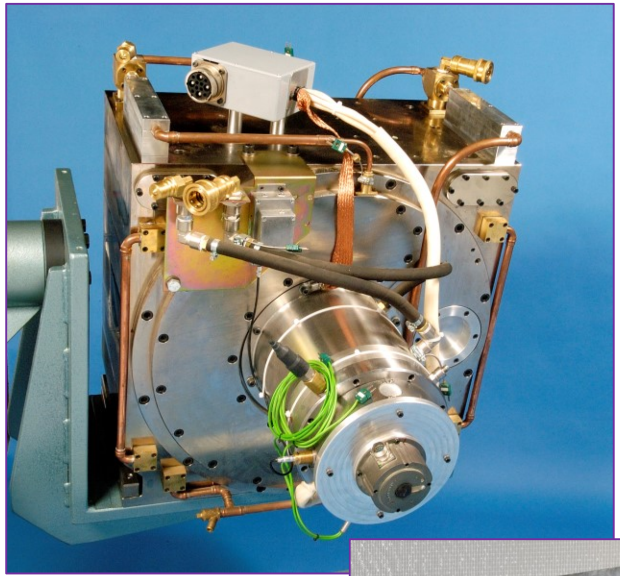
Engineering – Assembly, Testing and Maintenance

Throughout a chopper's design, consideration must be given to;

- Assembly
- Testing/Trials
- Maintenance

The Assembly;

- Special tools,
- The fitting of lifting points of large components and/or sub-assemblies,
- Stands or orientation build rigs,
- Support stands.



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Engineering – Assembly, Testing and Maintenance

Throughout a chopper's design, consideration must be given to;

- Assembly
- Testing/Trials
- Maintenance

The Testing;

- Guards, shielding and suitable location for Pressure and/or Vacuum testing,
- Suitable enclosures for full speed testing,
- Mounting rigs,
- Blanking plates,
- Observation windows,
- Service access,
- Safe Drive and Controls area.

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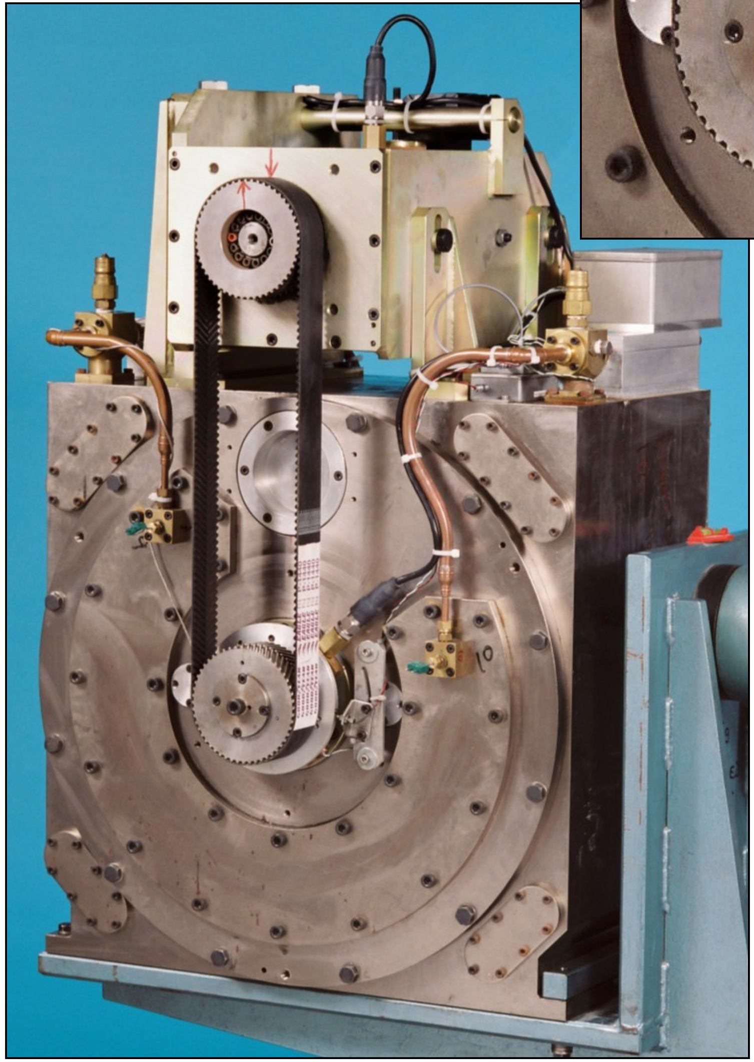
Engineering – Assembly, Testing and Maintenance

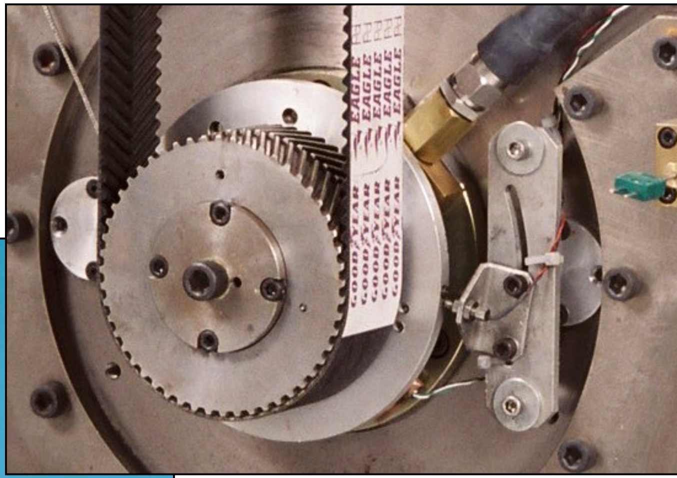
Throughout a chopper's design, consideration must be given to;

- Assembly
- Testing/Trials
- Maintenance

The Maintenance;

- Easy access to pit connections for extraction and installation,
- Access to high maintenance components with limited exposure to active areas,
- Special tools to reduce contact times.





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Engineering - Safety

Lifting and Handling

- ✓ Are there suitable Lifting Points?
- ✓ Is a Lifting Frame required, Certified and Tested?
- ✓ Are warning Labels needed?

Entanglement

- ✓ Are all Rotating features Guarded?
- ✓ Is there Secure fixings and routes

Electrocution

- ✓ Have all Electrical Safety procedure been met?
- ✓ Are there suitable Precautions in place to prevent the disconnections of Live Couplings?

Personnel Shielding

- ✓ While Testing, are the
over Thin Windows?
- ✓ Are there Procedures
prevent Access to Tes

Safety Reviews

- ✓ **Have all these Safety Issues been regularly Reviewed with all the Stakeholders?**
- ✓ **Have the details of the Reviews been Recorded?**

Trip Offs

- ✓ Are Trip Off systems in place to prevent the possibility of unsafe conditions?
- ✓ Does the activation of these Trip Off's leave the chopper in a safe status?

Exposure to Heat and Pressure

- ✓ Have all hot surface been guarded?
- ✓ Are robust covers fitted over thin vacuum windows?

Pit Access

- ✓ Are t
risk of severe injury from falling on a chopper?
- ✓ Are there special long reach tools available?

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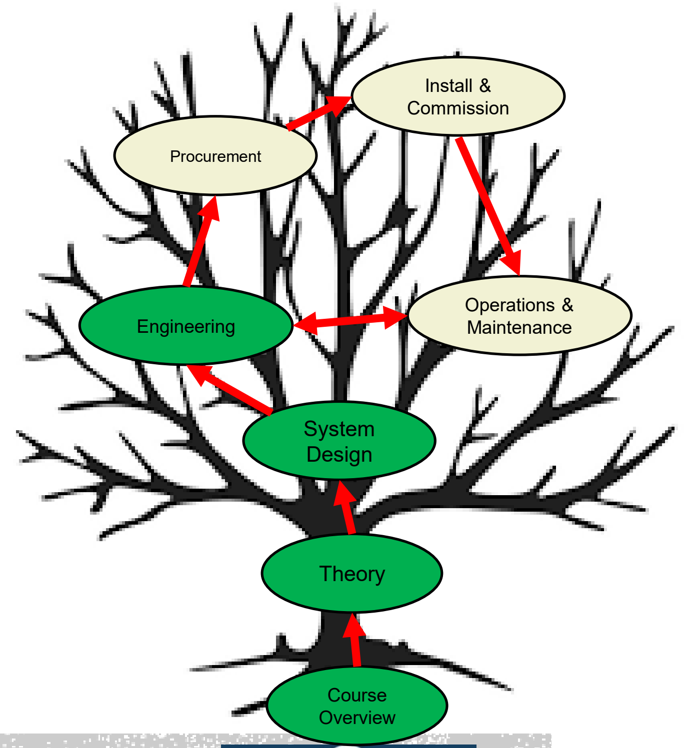
End of the line Engineering

Thanks for participating



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