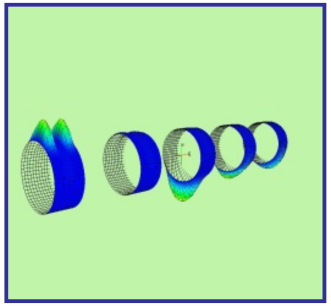

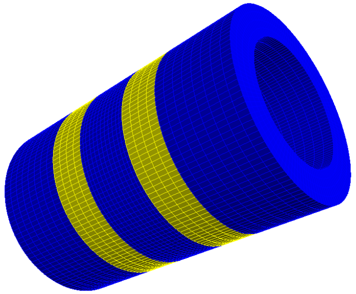

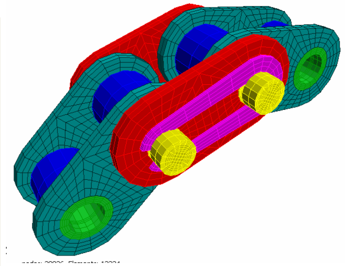

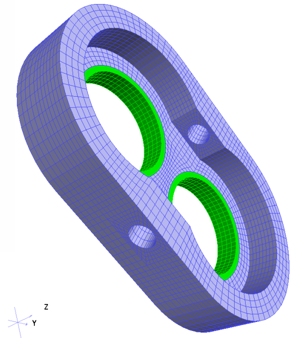

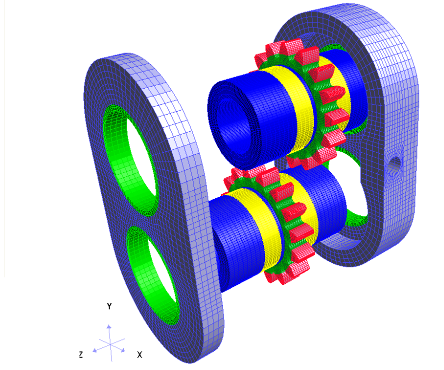

Future Trends Part - 1
A New CAD & CAE Process @ AIES Ltd

Dr Ian McLuckie

April 2016

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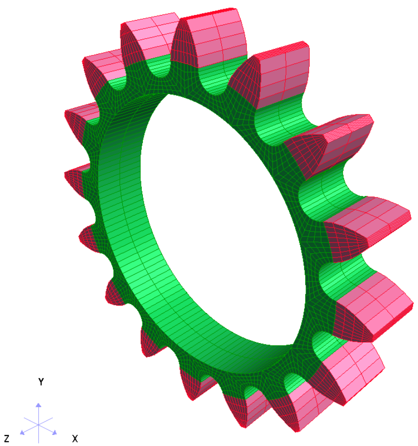
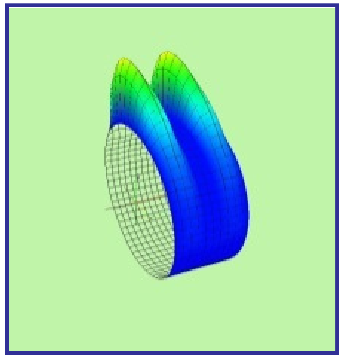
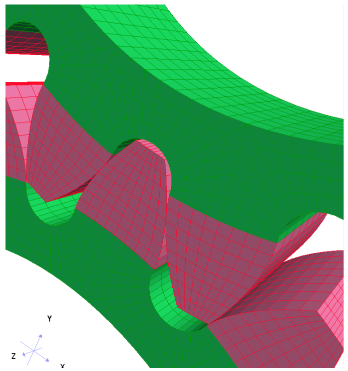
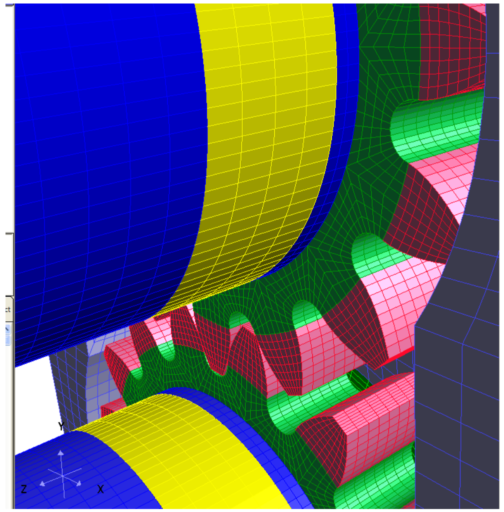








Future Trends - CAD & CAE

There is a lot of discussion about how we need bigger and faster computers to deal with the needs of the very large detailed CAE models we are using. GPUs have been investigated, HPC and water cooled machines. But where is the need coming from and why?

Firstly, people want to carry out analysis with a lot more detail, so a beam and shell model is not adequate or accurate enough these days.

Secondly, lots of these bigger models are tetrahedral which is a 5x - 8x increase over the size of hexahedra models. Mainly because tetrahedrals are easier to mesh than hex's, with hex you have to partition the CAD model and this is time consuming. With both meshes you get only one instance, and time is everything isn't it?

Thirdly, people want to do multi-physics so they want CFD, Thermal and FEA to model the real world; combining combustion, heat transfer and stress analysis or electromagnetics , thermal and stress for example.

Fourthly, people want to carry out optimisation and find the best design solution that gives best life, lowest weight and lowest cost.

These above 4 goals are admirable however some of the approaches used to achieve them are not.

With todays shortage of engineering talent, we have a shortage of engineers and technologists who can understand the physics of an IC engine, Gas Turbine, Electrical machine and an Epicyclic transmission, when they finish university.

How do we help companies remain competitive and control their IPR, smart designs, new concepts and patents? How do they do this and say, produce a range of machines of their new concept? I will discuss our approach to system integration and knowledge based systems, which addresses this important issue.

Future Trends - CAD & CAE

Engineers have to take control of their design process and become less driven by cost. There are lots of business models and the longer term view is always more successful. In todays market companies need to reinvent themselves, constantly self evaluate and maybe reinvent: What tools do they need? What people they need? What type of company do we want to be?

As it stands today, the way to improve our computing efforts is a plan in two parts: a) we need to constantly review hardware , b) reduce the size of models but not their accuracy.

How can we do this? Well we can use hex models rather than tets and use new thought processes on how we perform solid modelling with the emphasis on CAE (design) rather than on CAM (manufacture).

We also need to respond to all company's needs for a safe repository for its designs, IPR and R & D..

When we stand back and look at these issues in a new way a whole new way of thinking opens up. Thinking with design and analysis in mind to create a new approach that deals with, design, meshing, optimisation, design control (PLM) and that is far more intuitive for engineers to operate.

Let us for example think about building a solid model in whole new way.

What for?

We have established methods which now revolve around surface modelling along with a set of issues when it comes to meshing and fixing thin slivers in models.

Let us say we will build solids by connecting shapes together (like we did with LEGO as kids) to build solid models with what we call finite objects. The basic shapes or finite objects have solid and hex fused, therefore as you build the solid you also build the hex mesh.

When you are connecting the finite objects together you have a goal in mind, a final shape, like a gear, ball bearing or a shaft in mind, just the same as conventional solid modelling.

New solid modelling and hex meshing

Advanced Integrated Engineering Solutions Ltd

Similar to most solid modelling methods you can carry out certain operations, like extrude, revolve, shear, helix to form parametric shapes.

However whilst you are doing this you are also getting the mesh for free, solid modelling and meshing are now integrated in one process.

Wow, I hear you say. Too good to be true? No it is not.

Not only do you get the solid model and mesh but you also get the geometric parameters or attributes as well.

So, as you build your model you generate a list of dimensions you can use to size, scale and carry out robust design space studies.

So you get solid, parameters and mesh from one process.

The mesh can be biased at kt features and for CFD we can generate boundary layer elements as well.

The builder or definer does not have to do anything special other than follow the building process and use some imagination.

When the object is built it is saved to a library for reuse in the building of other more complicated assemblies.

The library is used to build assemblies by connecting solids together by interface objects (like joints or connections), our tribology interface objects (fluid film) or contact used for bolted joints and interference fits for example.

We can also represent our tribology interface objects as stiffness or as rotor dynamic stiffness and damping coefficients (8 oil film coefficients).

As connections are made in the building process the computational model is also being built, represented by the solid hex mesh, interface objects and boundary conditions (loads and restraints).

New solid modelling and hex meshing

This data is output to CAE solvers for computations.

Each object has an outline.

Why?

This is used for condensation, contact surfaces, boundary element mesh and results retrieval to minimize the size of the results file.

In order to carry out multi-physics you need some form of process map or what we call a CAE tree which governs the order in which you do the physical calculations. For example the following may be a tree used for an IC engine

1. Combustion
2. Cycle simulation
3. Colling and heat transfer
4. Thermal elasticity
5. Tribology
6. Dynamics
7. Stress analysis
8. Fatigue and durability

Once calculations have been completed depending on the physics you are simulating then you can build results like

1. 2D plots
2. 3D plots
3. Animated 3D
4. 2D performance or trend plots
5. Power point report of your design

New solid modelling and hex meshing

The solvers in the CAE tree can be your own spreadsheets, Fortran programs, C, C++, or OEM program codes that you can now make more productive.

Figure 1 illustrates a typical finite object. Figure 2 is chain pin object. Figure 3 shows a chain plate object. Figures 4 are examples of gear pump and chain and timing belt. Figure 5 is the CAE tree and Figure6 illustrates 2D, 3D Iso and 3D bearing plots.

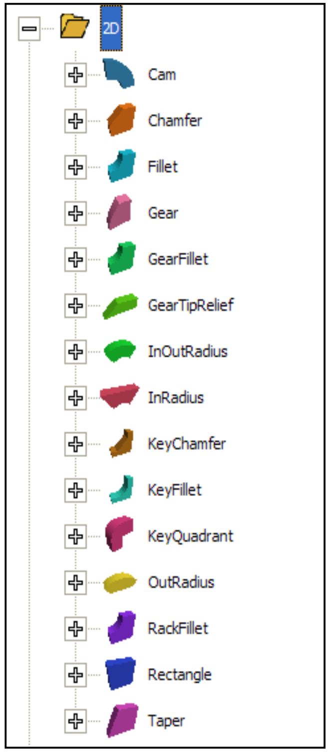


Figure 1

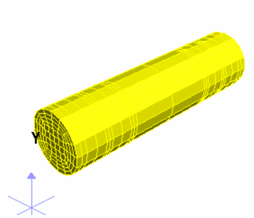


Figure 2

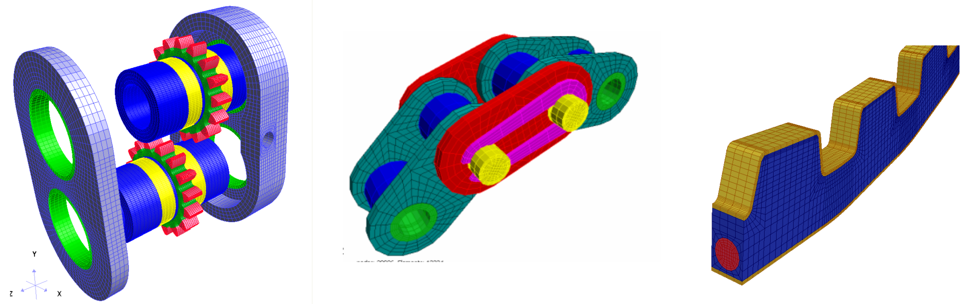


Figure 4

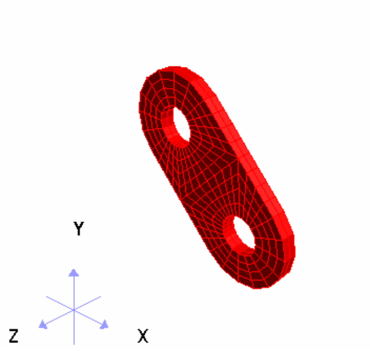


Figure 3

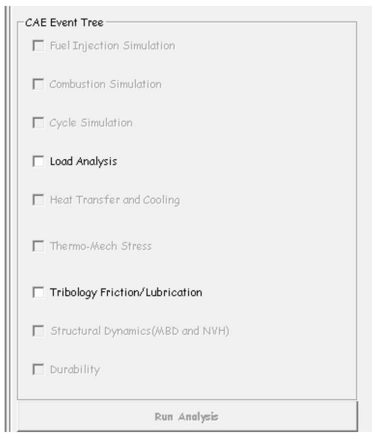


Figure 5

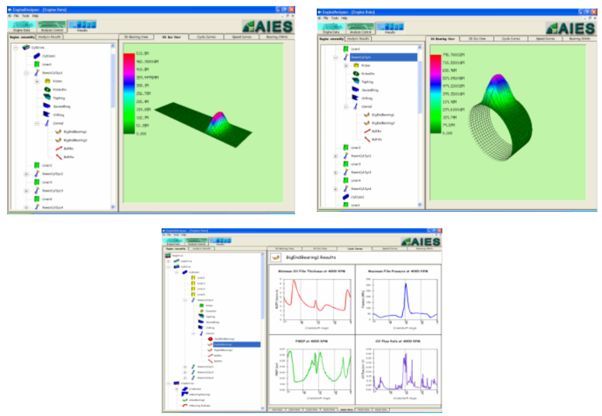
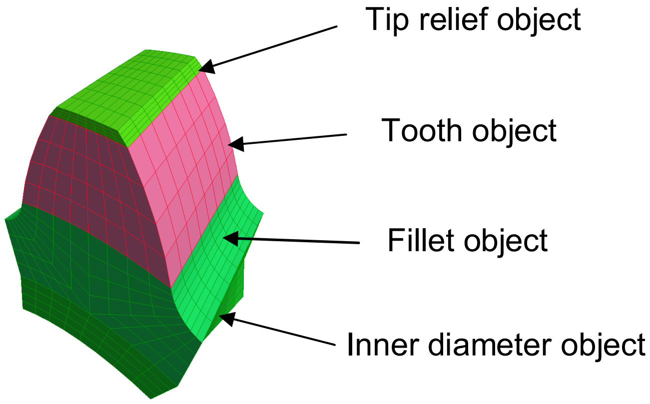
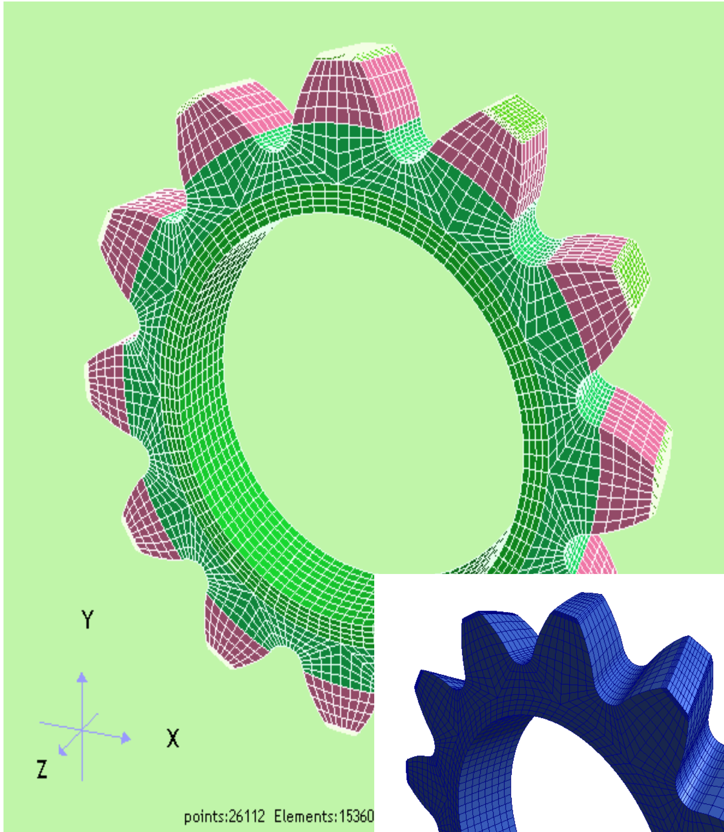
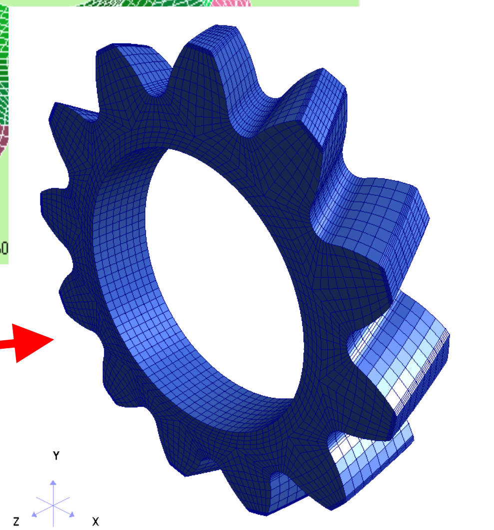


Figure 6

Basic building block – Finite objects





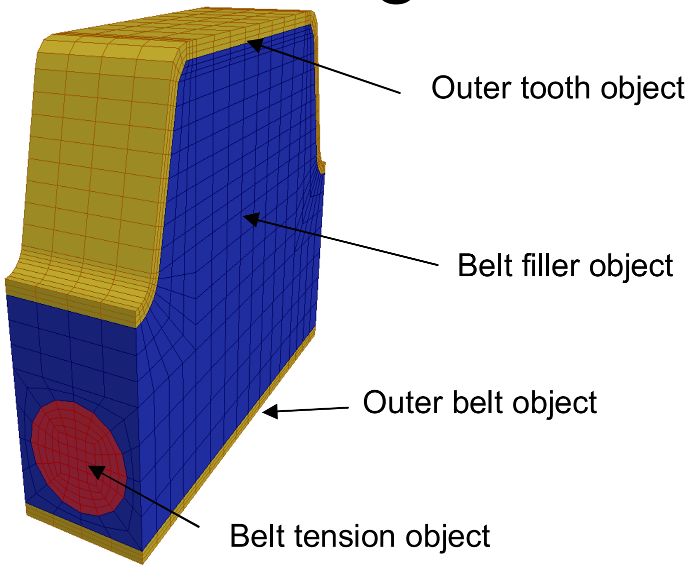


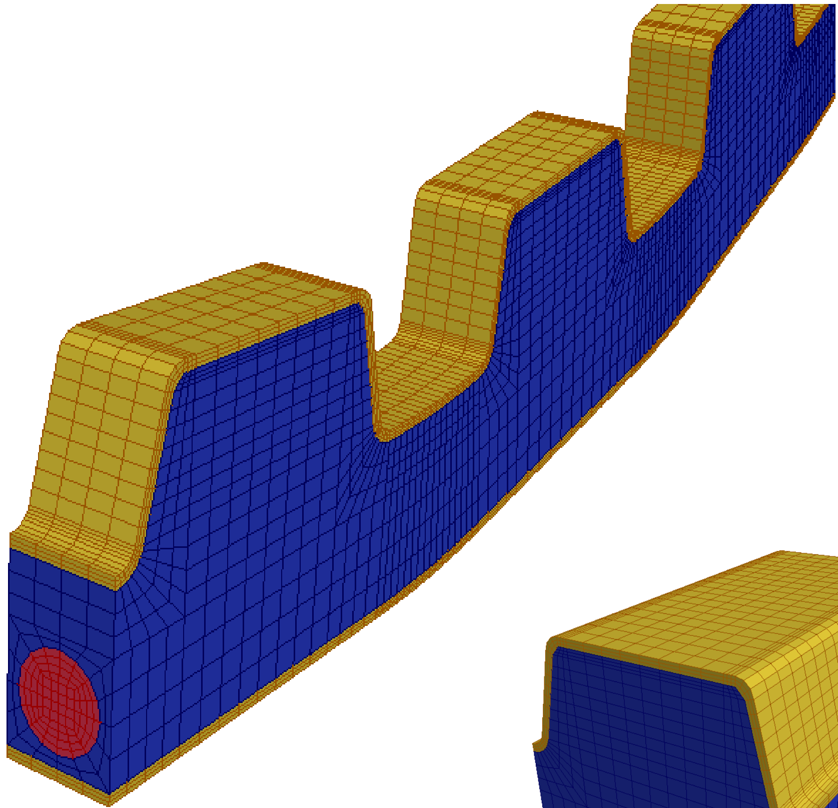
Building tooth and gear objects

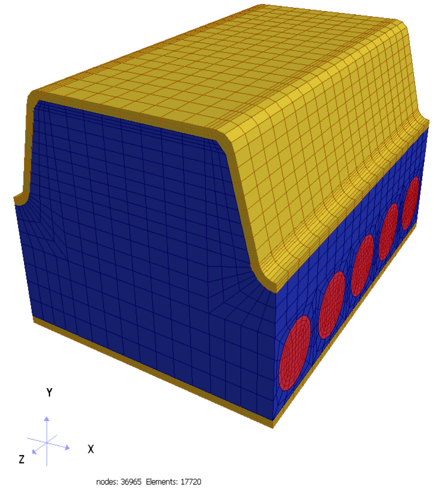
Gear tooth assembled from
- Tip relief object
- Tooth object
- Fillet object
- Inner bore object

To form tooth object
Transformed easily to a helical gear
Gear assembly formed by connecting tooth objects together

Basic building block – Finite objects





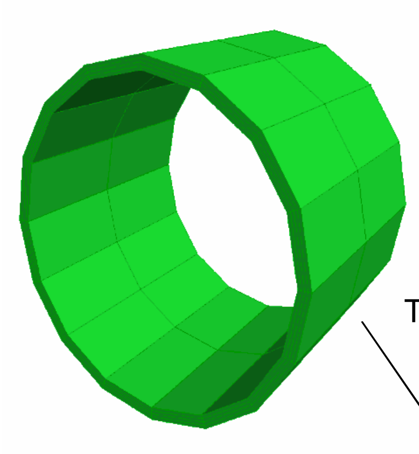


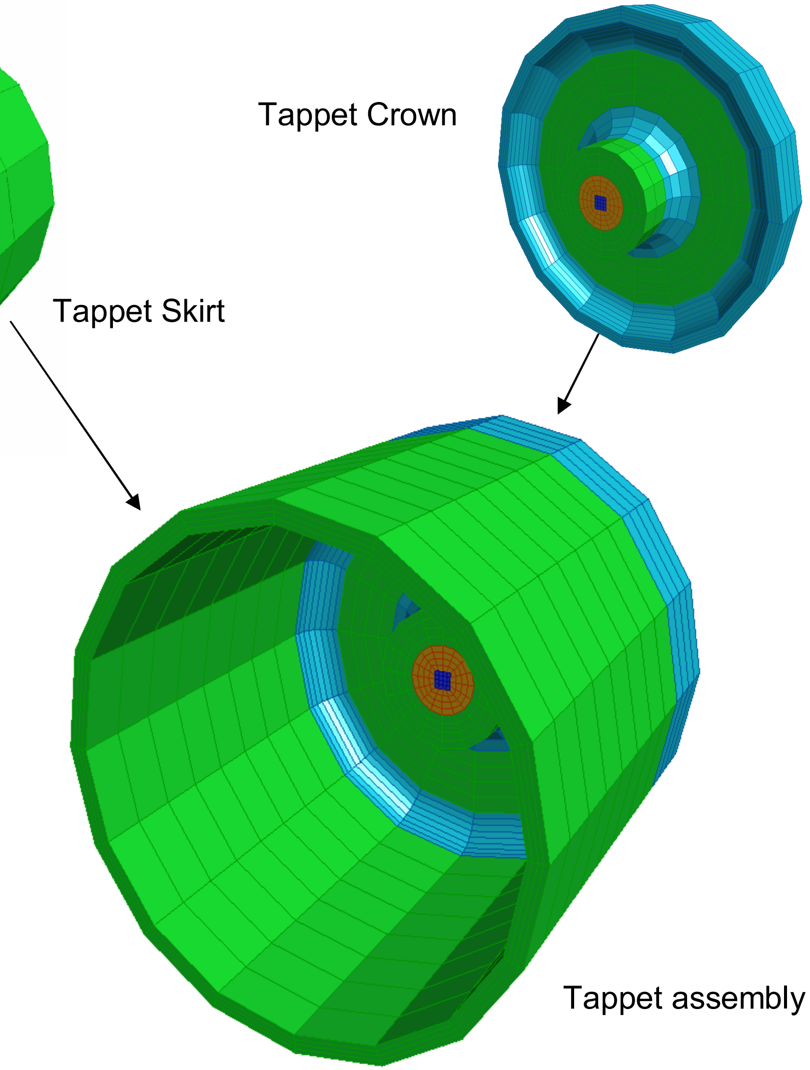
Building tooth and belt objects

Belt tooth assembled from
- Outer tooth object
- Outer belt object
- Belt tension object
- Belt filler object

Belt assembly formed by connecting tooth objects lengthwise and sideways

Basic building block – Finite objects



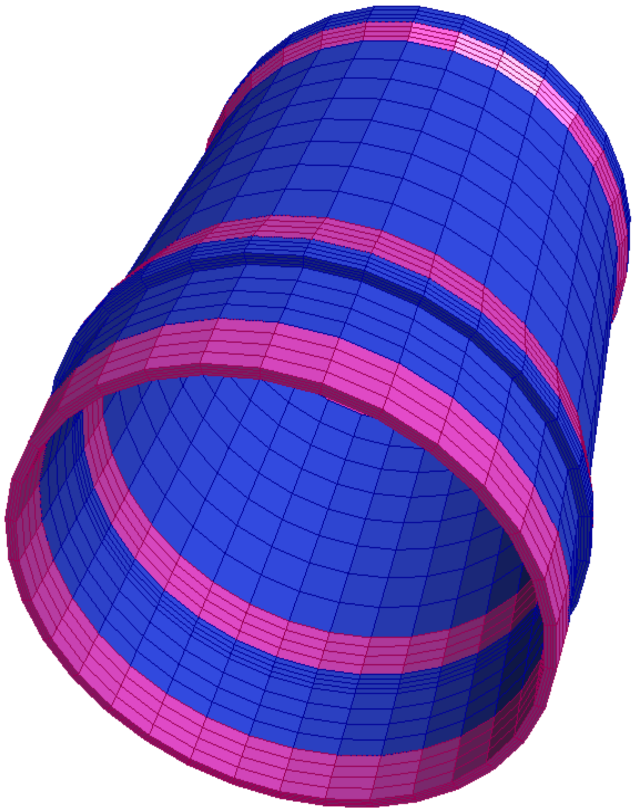


Building crown, skirt and tappet objects

Tappet Principal Attributes generated automatically whilst building the tappet

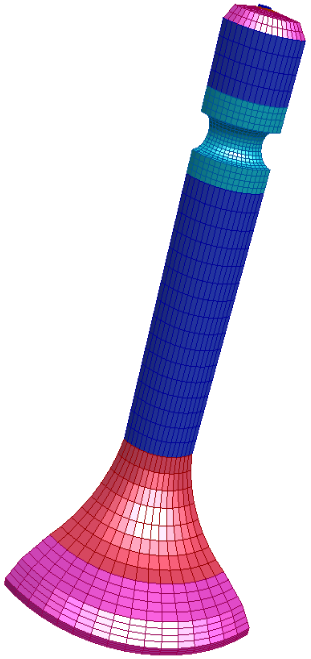
- Outer diameter
- Overall length
- Crown thickness
- Up stand length
- Up stand diameter
- Up stand fillet radius
- Crown internal fillet radius

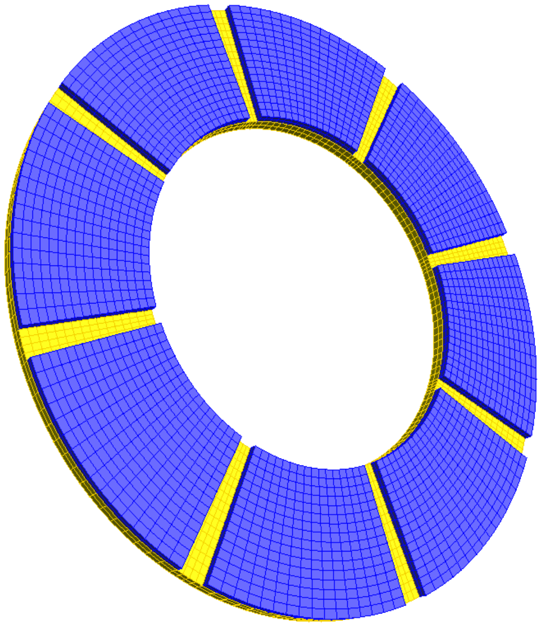
Basic building block – Finite Objects



Liner with 18 principal attributes

1/4 of poppet valve





Thrust bearing with separate
substrate and backing materials

Object Assemblies–Tribology & Contact

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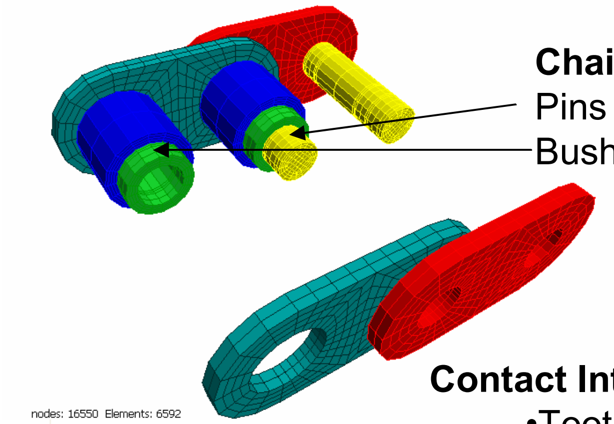
Tribological Interface objects

- Journals – bearings
- Pins – bushes
- Bushes – rollers
- Tooth – tooth
- Etc.

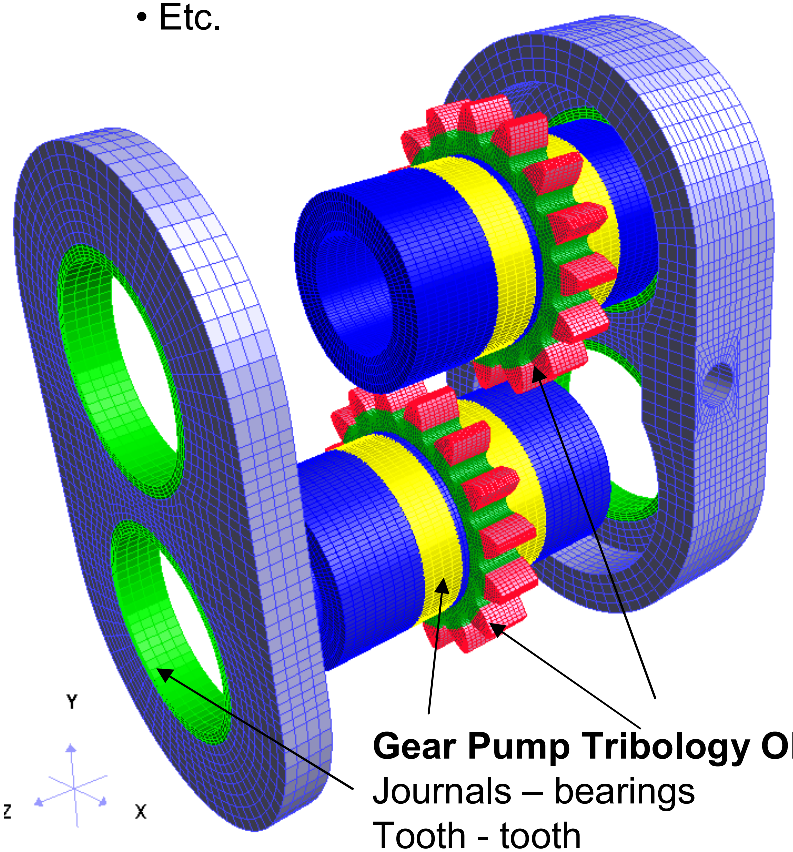


Chain Tribology Objects

Pins – bushes
Bushes - rollers

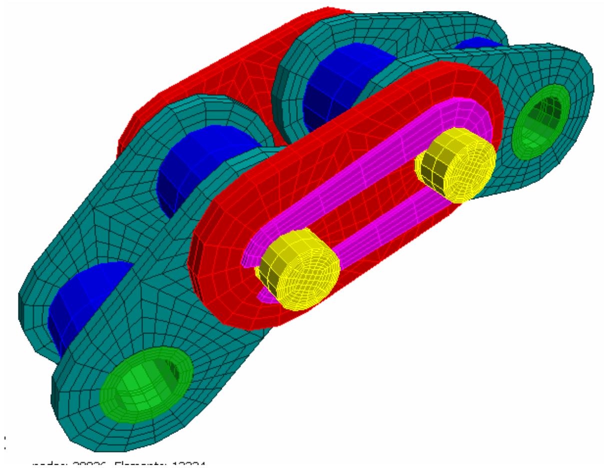
Contact Interface Objects

- Tooth – tooth
- Pin – sideplate
- Circlip – pin & sideplate
- Sprocket tooth - roller



Gear Pump Tribology Objects

Journals – bearings
Tooth - tooth



Conclusions

I hope I have given you some food for thought. Something you may have thought hypothetical is now achievable and becoming a reality.

Thank you for your kind attention

Dr Ian McLuckie

April 2016

If you have any questions or want to know more please contact us on Tel. +44 (0) 1858 414854 Mob. +44 (0) 7801 575725 or on info@aiesl.co.uk and sales@aiesl.co.uk or to me on ian.mcluckie@aiesl.co.uk