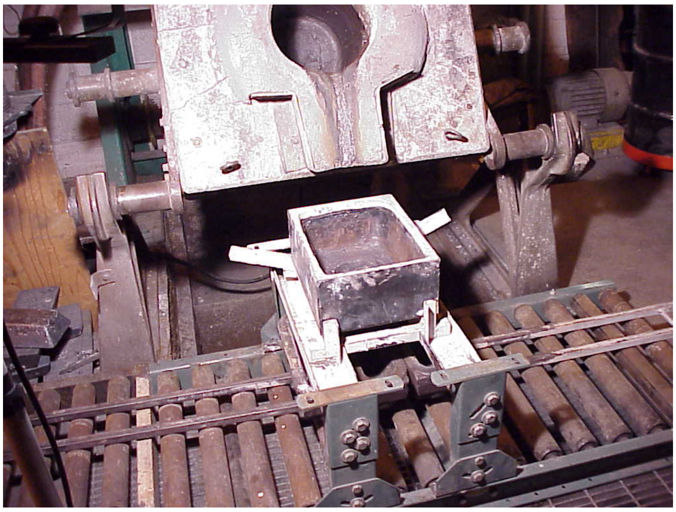
In the foundry

Me by a vertical squeeze-caster - an Ube 350T model used to cast Aluminium. I was involved in refining the conditions used with this machine, in order to get fully-sound castings at large sizes.



One of my projects, next to the 400lb induction furnace used for all ferrous melting. This was for the casting of stainless steel. I welded stuff together, like the frame on the roller table to take ingot moulds, joined two roller-tables, fabricated the frame for the tundish, . . . I also formed and fired the refractory.

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More hands-on foundry skills:

Sands - have worked with “green” sand and resin-bonded sand and mullers for each. Have used a pneumatic hammer to compact “green” sands.

Magnesium - have cast Magnesium “conventionally” and using a “freeze-gate”.

Gating and risering - I have some understanding of this topic.

Filters - Used filters to clean cast metal. Been present when filters were being developed. Have been shown, but have not tried myself, use of filters to very much simplify gating requirements.

Exothermic feeders - Same function as risers, but closed upside-down “bottle” shaped containers at the highest point of the cast component, giving prolonged liquid-metal feeding.

Other associated hands-on skills:

Machining - using machine tools. Lathes, milling-machines, drills, saws

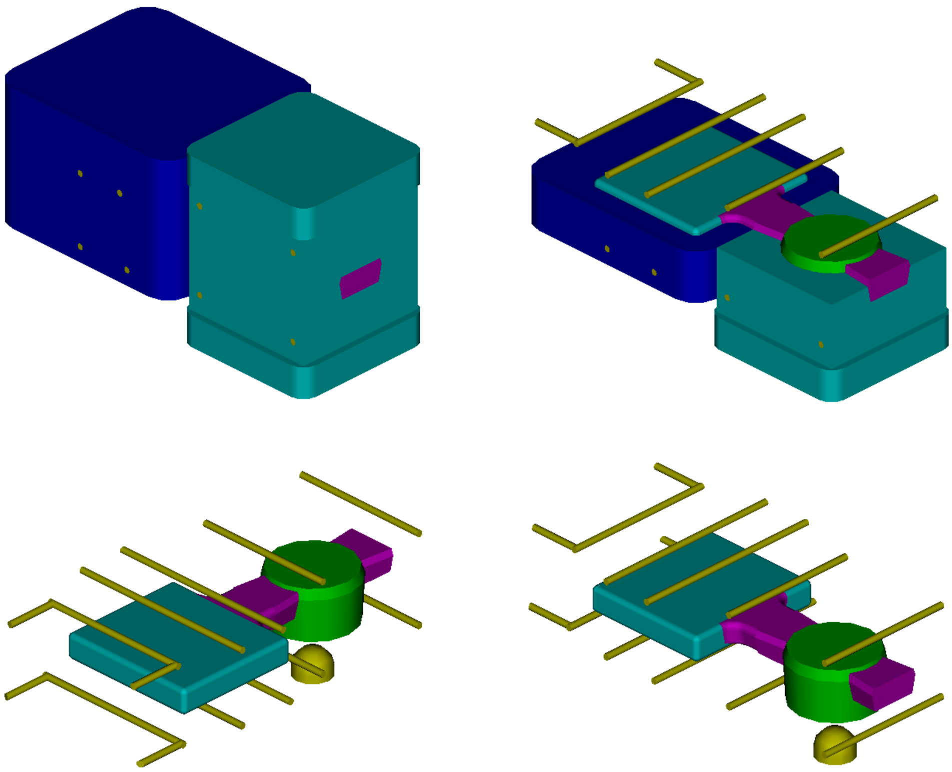
Oxy-acetylene cutting and welding - can oxy-acetylene cut quite cleanly for fabrication or rough-cut fast. Can oxy-acetylene weld to a reasonable standard

Welding - SMA (“stick”), MIG, oxy-acet. Learning TIG at present.

Mechanics - can maintain machinery and diagnose problems

Design and drawing - AutoCAD

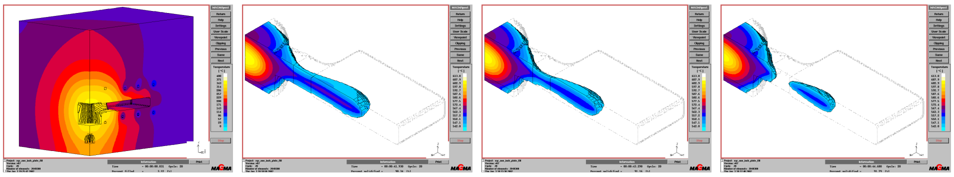
One of my skills is using “AutoCAD” in 3-D mode. This is otherwise known as solid-modeling. Here is an example.



These are for a one-inch-thick plate casting in the vertical squeeze-caster previously shown. Components individually present are the “cover” and “eject” dies with cooling/heating fluid galleries, the shotblock and the casting. The plunger is in there but doesn’t show on any rendered view. These are as dimensionally as accurate as an engineering drawing.
I also use “AutoCAD” in a much more rough-and-ready way, knocking-up visualisations of ideas. That tends to quickly allow people to see what you mean and start helping you get there.

The “Magma” casting simulator

The company “Magmasoft” makes the “Magma” casting simulator.
Here is an example of the type of work I have done with the “Magma” casting simulator : initial die temperature profile and time series of casting solidification.



(can be viewed to 12X magnification)

It shows that this one-inch plate (a challenging test as low surface-area/volume) will have some unsoundnesses in a region on the centre-line near the ingate. I simulated putting heated oil through the shotblock and city-water through the die, to cause a temperature gradient. We actually did this with the squeeze-caster and found the simulated outcome and actual result were spot-on identical. I sectioned castings and found unconnected fine porosity, as expected, in the region expected.

Typically this is how a simulation is set-up:

Drawing the components - A CAD package such as AutoCAD is used to make the solid elements - the dies, casting, cooling fluids in the galleries... (the drawings for the “one-inch plate” were seen earlier). The shapes are output as files - one file for one component.

Importing the solid forms into Magma - the Magma pre-processor imports the shapes defined CAD component/shape files (see image later).

Added detail to the shapes/components - the limited drawing capabilities of the pre-processor are used to make additions like an imaginary nozzle out of which the cast metal will flow, imaginary “thermocouples” to monitor temperature, imaginary particle-generators which add imaginary infinitesimal particles to the inflowing metal during the pour, so that flow can be seen in an animation of particle flow, and so on.

Components - assigning them materials/physical properties - In most cases a material can be selected from a list and will have associated with it standard physical properties of density, heat capacity, thermal conductivity and so on. Thus for the die one would chose steel, for a core one would chose sand, the cast metal might be Aluminium. Cooling lines are often defined by imaginary materials with infinite heat capacities and so on, so that the physical effects of fluid flow down heating/cooling channels are simulated without having to define flow. The components do need to be assigned initial temperatures.

Surface heat transfer properties - Surface heat transfer coefficients are assigned between different components which have common boundaries.

Casting variables are defined - The pour rate; either a volume/time or a total time to fill the mould, is defined. The time to die opening and casting ejection is often defined, so that repeat cycles can be simulated.

There is then the process of “enmeshing” the model. This is protruding through to the surface the underlying nature of the simulator as a computer-numerical solution. A few rules-of-thumb gets you through this. The finer the enmeshment (“mesh”) the more accurate the solution, but the longer it will take to run. Concentrate a finer meshing in the areas which are of special interest. Most of the time the “auto-enmesh” will be just fine and will also be the starting point from which to concentrate a finer mesh on features of interest. An image is shown of the “mesh” later in this section.

The solution is then run - which commonly takes several hours of computer time. A common approach is to run the solution several times, throwing away the results of the initial runs, then “grab” the results on say the eighth run. This allows conditions to equilibriate to what they will on a long run. This matches just like how a caster is really operated, with a “start-up” until it attains steady conditions.

The final stage in this cycle of the work is to inspect the simulated outcome. This is done in the Magma post-processor.

What can be seen in the post-processor:

The progress of filling of the die - which regions filled first

Flow during filling - whether smooth or turbulent, direct or circulatory or stagnant, seen throughout the casting cavity

Volume regions of porosity / unsoundness - where volume regions have been isolated from feeder metal

Surface regions where the metal will have shrunk away from the die - the metal in contact with the die or mould was still liquid when feeding was cut-off

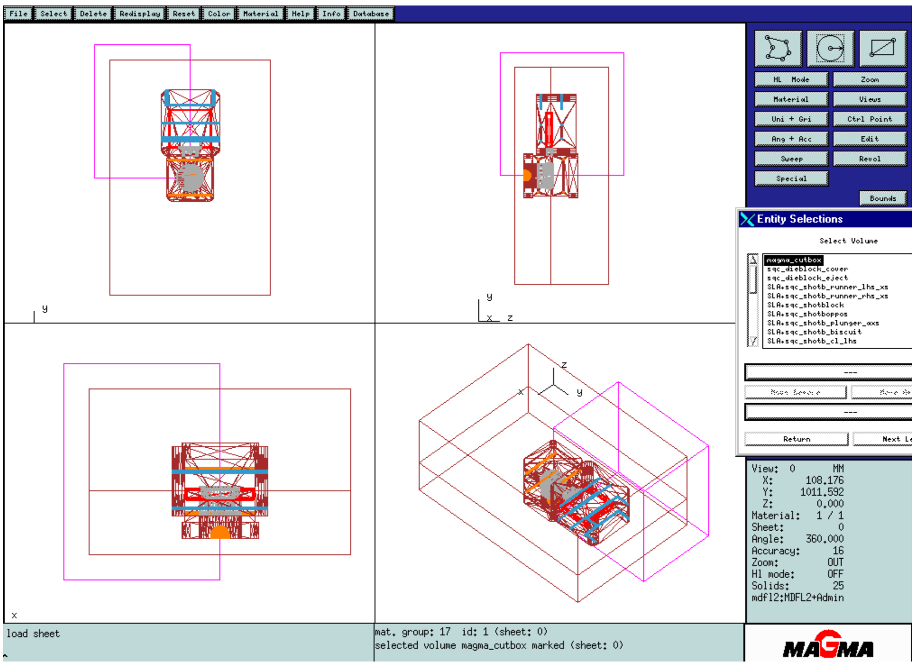
Regions of the die which have become unacceptably hot - which would imply die-life and "soldering" problems

Stresses in the die - where high stresses combined with high temperatures may lead to plastic yielding and "fire-checking"

The simulations, shown as 3-D renderings usually with cut-planes, have the variable under consideration, often temperature, overlayed as a colour contour across the surfaces.
These are very engaging and "real" to people who actually do casting so it is often possible to get experienced foundry people to sketch what they would do to try and correct a casting in this situation.
The difference is you are not spending $100000 a throw on dies as you experiment, just a few hours of one person's work and a few hours of computer time. Generally, this allows more complex cast components to be manufactured. Trail-and-error trying to get a good casting would have been infeasibly expensive. In the model, the simulation is cheap and you can kind-of see what is causing the casting to be not right, in the flow advancement, flow animations or temperature profiles. You can often see whether you are "well OK" or only very closely making it to a good result.

Now for some images:

The pre-processor on loading the solid component shapes and drawing-in additional features.



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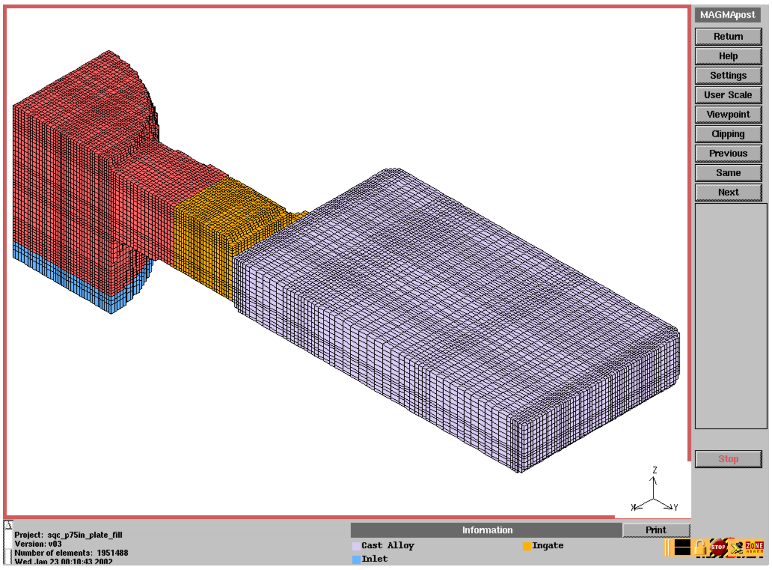
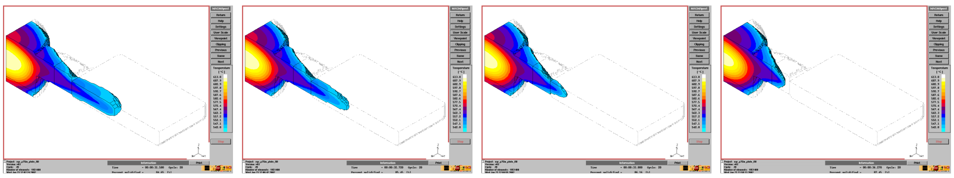
The discretisation-enmeshment ("mesh") of the 0.75inch big-ingate casting.



A fully-sound 3/4 inch thick casting (predicted). This outcome is obtained because the casting is less thick (0.75inch) than the ingate is high (0.9inch) and there is oil-heating of the ingate area / water-cooling of the die.



(can be viewed to 12X magnification)