

Lucy's Simulate Iron Castings with Mavis

Author K Pashley of W Lucy & Co

During the last few years a number of computer simulation packages for use as design aids in the foundry industry have become available. One such package is the Mavis gravity casting simulation system developed at the Department of Materials Engineering, University College Swansea, to be a rapid and user-friendly package running on a standard IBM compatible PC. The Mavis system was only released onto the market in January 1992. This paper describes the experiences of W Lucy & Co which was one of the first UK foundries to purchase the software. The system has been shown to provide significant benefits in terms of improved design of castings and sizeable financial savings in terms of reduced materials and scrap costs. The package has also been used as a tool to help gain design concessions and modifications from the casting purchaser by highlighting likely problems before castings are produced, or by helping to explain current problems and suggesting remedial design modifications.

Use of the software

The program allows the operator to construct a 3 dimensional model of a component using a 2 dimensional engineering drawing. This obviously requires good knowledge of engineering drawings but it has been found that a competent operator can readily model complex shapes (such as the thermostat housing shown in (fig 2). Within the first month the operator was able to model casting shapes quickly and consistently. The most difficult part of the operation when the operator was familiar with 3D modelling was the choice of optimum casting orientation within the 3D computer grid.

Once the component has been modelled in 3D its orientation can be changed to present the optimum configuration within the limits of the moulding process to obtain a sound casting. This enables the feeder



Fig. 1 Typical parts modelled with the MAVIS system

head to be designed into the most advantageous position to give maximum effect and yield. At the same time, either for components requiring feeding or ones that should not, the ingate/runner system can be designed to give directional freezing to or from critical areas.

The conventional method of drawing a layout of the pattern plate to supply to the patternmaker can now be carried out with much more confidence since once the pattern equipment is manufactured it is very often impossible to move the location of the pattern on the plate. The software has also highlighted situations where the design of the component would not produce sound (porosity free) castings and indicates the effects of possible design alterations to improve the situation.

The Lucy foundry in Oxford is a Disamatic foundry producing castings in both flake and nodular iron. In the first six months that MAVIS has been operating in the methods department a number of new and problem



Fig. 2 Solid Model of a thermostat housing

jobs have been modelled with good results and a few examples are given below.

Case study 1

A bearing cover plate in BS 1452 Grade 250 flake graphite iron weighing 2.1 kg with three impressions per pattern plate was a new part and the obvious problem was the position of a heavier boss section towards the middle of a thin plate section (fig 3). The orientation of this boss together with the ingate effect i.e. the relatively higher heat input into the mould near the gate) were the main considerations when trying to achieve directional solidification towards the feeder with minimum shrinkage in the boss. Being grey cast iron it was decided to run computer simulations using a shrinkage contraction on freezing of 1%.

Simulation of the part with the boss in different orientations showed that the minimum amount of potential shrinkage occurred with the boss orientated at the bottom of the mould with the hot metal (ingates) introduced towards the top of the component. With this preliminary design in mind the customer was consulted to establish their exact requirements concerning quality, fettling, jiggging and machining.

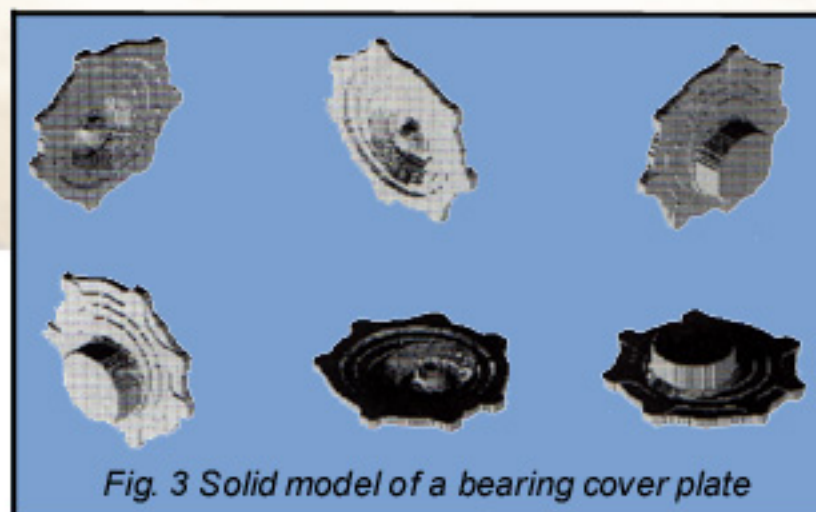


Fig. 3 Solid model of a bearing cover plate

This allowed the design of the runner system to incorporate a small conner type feeder on the casting that would not interfere with machining or jigging. The MAVIS simulation was then employed to give the size of the feeder needed and most importantly the relative dimensions of the fillet/overlap to obtain the maximum yield from the feeder (fig 4). This design resulted in the pattern plate sampling correctly first time and allowed the part to be produced with no fettling. Without the benefit of Mavis this component would most likely have been designed with ingates and hence fettling in the critical jigged location.

Details of the component are as follows:-

Casting weight 2.1 kg,
three per mould = 6.3kg
Feeder weight 0.15kg at 7%
of casting weight,
three per mould = 0.45kg

Runner system 0.79kg
at 12.5% of the casting weight

Pouring bush 2.9kg at
46% of the casting weight

Total box weight 10.44kg
less pouring bush = 7.54kg

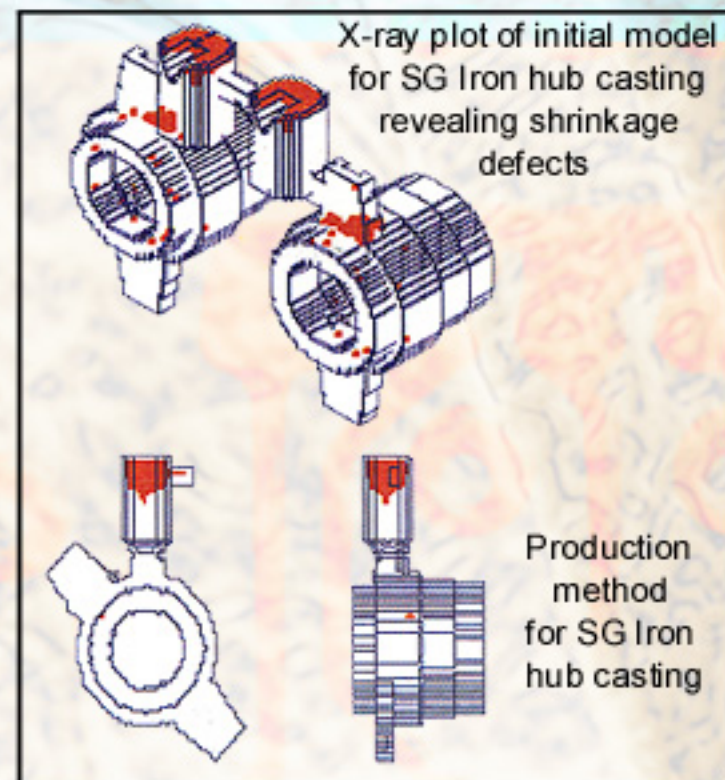
Yield with pouring bush empty 83%
Yield with pouring bush full 60.3%

Case study 2

A hub bearing casting in BS 2789 grade 420/12 ductile iron weighing 1.62kg with four impressions per pattern plate was a new plate with two legs off a central pipe and again the initial problem was orientation of the casting to obtain maximum feeding efficiency and yield while producing a sound casting. Being a ductile iron casting it was decided to run the computer simulations using 3% shrinkage.

After trying various orientations on the computer the best design was considered to be with the legs at 45 degrees to the vertical and the casting fed and run through the small

boss. It was shown from the simulation that a neck could be designed and a feeder head fitted that would result in maximum soundness of the component again with maximum yield and minimum fettling (fig 5). With this information from the computer simulations a right-first-time methoding was achieved incorporating an unusual orientation of the casting and with minimum fettling. Details of the casting are as follows.



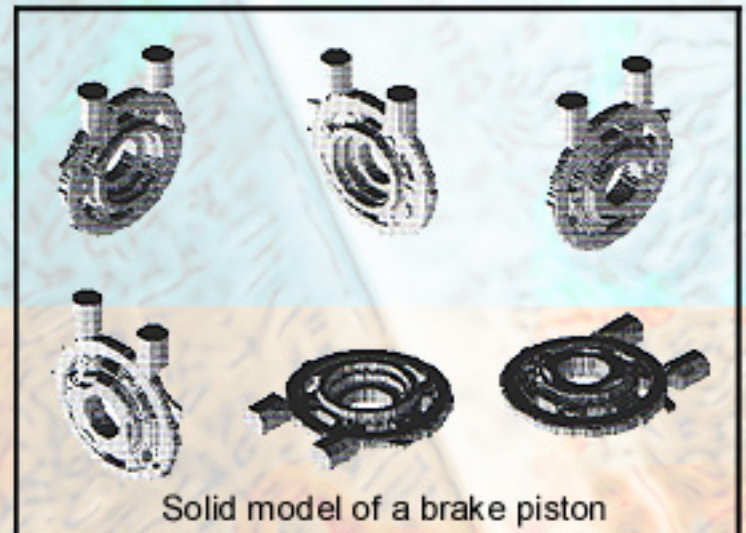
Casting weight 1.62kg, 4 per mould = 6.48kg
 Feeder weight 0.34kg @ 21% of casting weight, 4 per mould = 1.36kg
 Runner system 1.18kg @ 18% of the casting weight
 Pouring bush 2.94kg @ 45% of the casting weight

Total box weight 11.96kg
 Yield with pouring bush empty 72%
 Yield with pouring bush full 54%

Case study 3

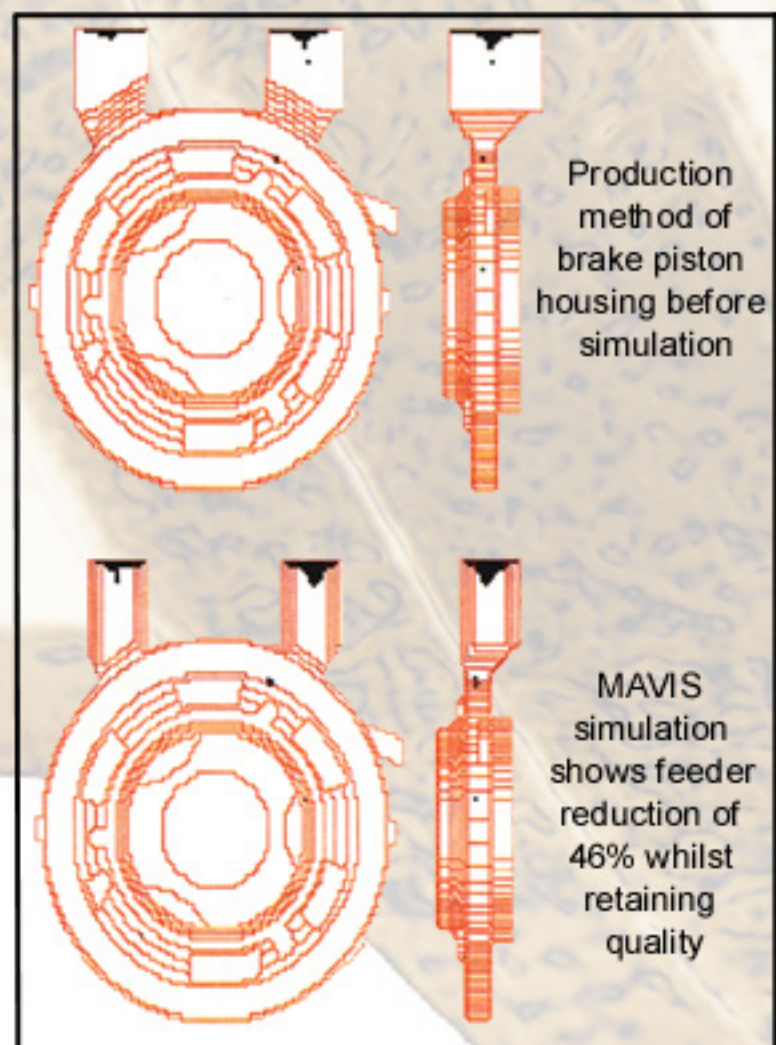
A 19kg brake position in BS 1452 grade 250 flake graphite iron with one impression in the pattern plate is a medium volume long established part which had previously suffered from low yield and a medium to high scrap rate (fig 6). The casting was modelled to determine the optimum feeder size. At this

point it was shown that whilst the feeders were in excess of those theoretically required the casting feeder neck was too small to allow directional freezing towards the feed metal.



It was also shown that by introducing hot metal (ingating) at the base of the feeders they could be made to operate more efficiently and hence require less feed metal (fig 7).

The pattern plate was re-methoded using the guidelines shown by Mavis. The results of these modifications are shown below.



Casting weight 19kg
 Old feeder head 7.5kg,
 new feeder head 3.5kg
 Old runner system 4kg,
 new runner system 3.7kg
 Old yield 62%, new yield 72.5%
 Scrap reduction 2%

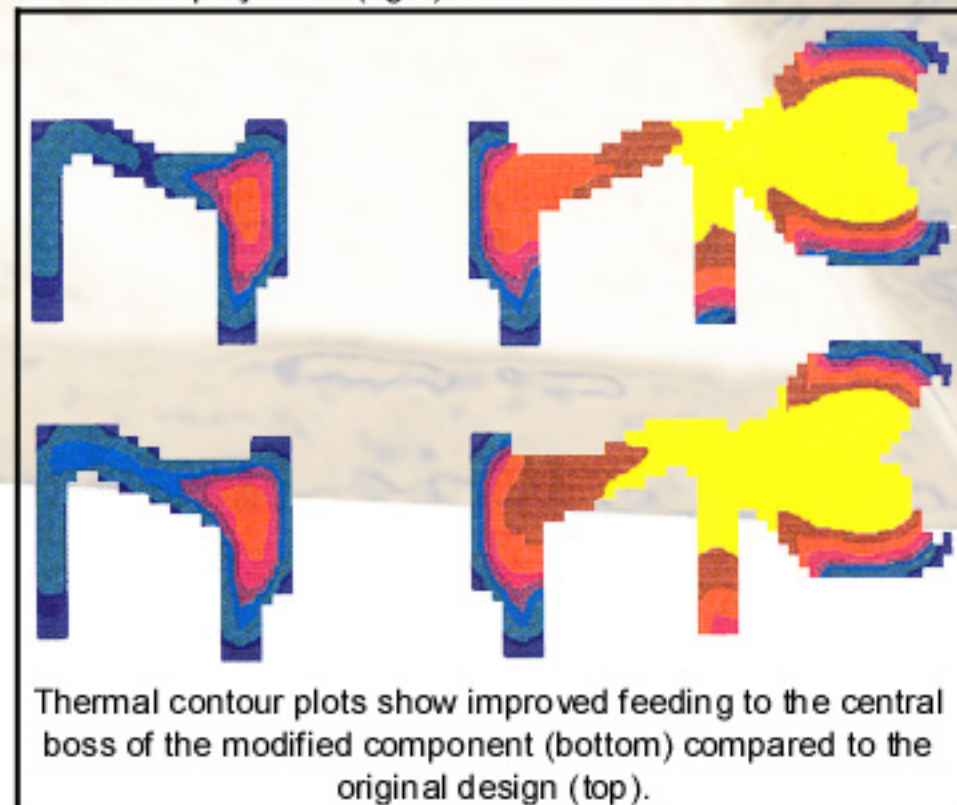
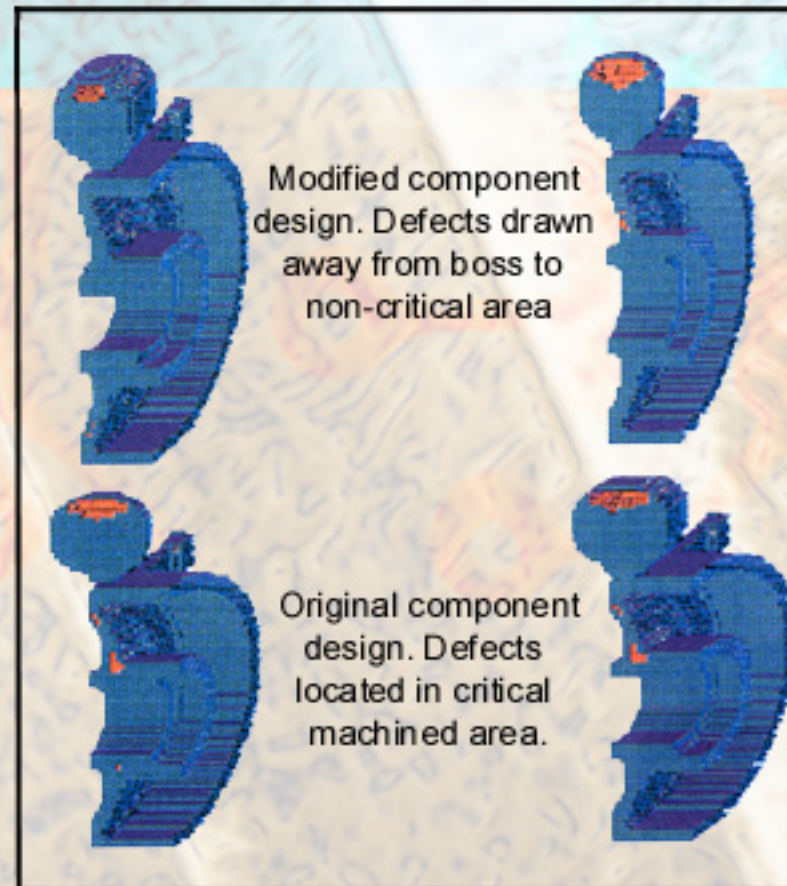
This has resulted in savings on metal melted and scrap on this part alone of £12,000 / year.

Case study 4

A 3.09kg piston housing in BS 2789 grade 420/12 ductile iron with four impressions on each pattern plate again was an existing part which had suffered considerable reject rates from the customer due to porosity revealed when the casting was machined on the outside of the centre boss.

Modelling on Mavis showed that it was not possible to manufacture this part on the Disamatic without porosity in the affected area because all effective feed paths have solidified while there is still a significant amount of liquid metal present in the central boss. Lucy Castings managed to demonstrate to the customer that in order to keep feed paths open and allow directional solidification from the central boss to the feeder, the back wall of the casting needed to be thickened up by 4mm (fig 8).

At the same time it was demonstrated that the feeder head volume could be reduced by 25%. With this information the customer agreed to the modification being carried out even though this would mean extra machining costs. However, the improved casting quality (fig 9) reduced the machining reject rate from an initial 20% down to 1%. Details of the casting are as follows.



Old casting weight 2.7kg,
 four per mould = 10.8kg
 New casting weight 3.09kg,
 four per mould = 12.36kg

Old feeder weight 0.75kg
 four per mould = 3kg

New feeder weight 0.56kg,
 four per mould = 2.24kg

Old runner and cup 2.46kg
 New runner and cup 2.46kg
 Old machining scrap rate 20%
 New machining scrap rate 1%

This example clearly shows that although extra units costs were incurred the design changes resulted in better economics of production.

The case studies demonstrate that in the first six months that Mavis has been installed at Lucy Castings methoding department very good results have been obtained which easily translate into an economic pay-back period for the initial cost of the software.

Use of the system initially entails the determination of the best computer parameter settings to use (shrinkage, relative mould conductivity, ingate effect etc.) which will most closely imitate actual production conditions. After running simulations design changes can be made on-screen to different castings always remembering that computers only simulate solidification and practical considerations of moulding plant limitations and general foundry rules still apply.

If design modification work is necessary this can first be simulated on the system to check the likely results thus saving expensive machine and pattern shop time which would have otherwise been required to assess the benefits of proposed changes. The benefits of Mavis are that right-first-time design is achieved with significantly greater regularity than before, and if changes are required these can be modelled with much less cost than conventional modification and sampling techniques. Yield and runner systems can be optimized and as experience grows it gives the operator a much clearer insight into what is happening as castings solidify in specific moulding media.

The ability to simulate solidification on computer has enabled Lucy Castings to consistently design economic methoding systems producing sound, right-first-time castings. Now operators are familiar with the Mavis software a success rate of 95% or more is being achieved.