PDM 2013: Optimising The Design To Manufacture Process

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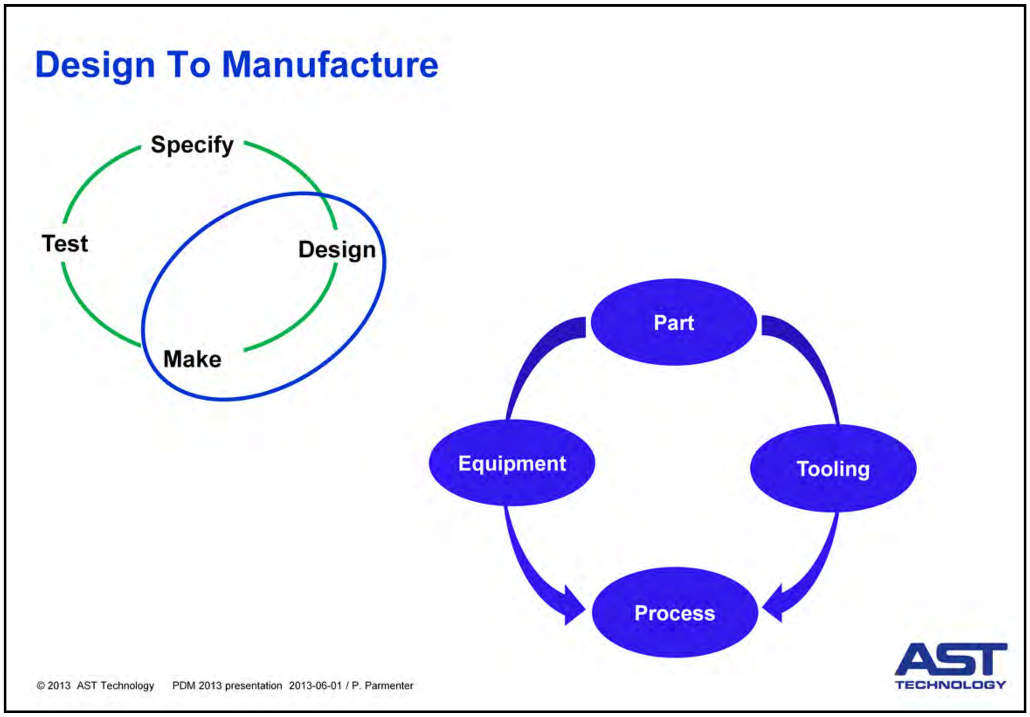


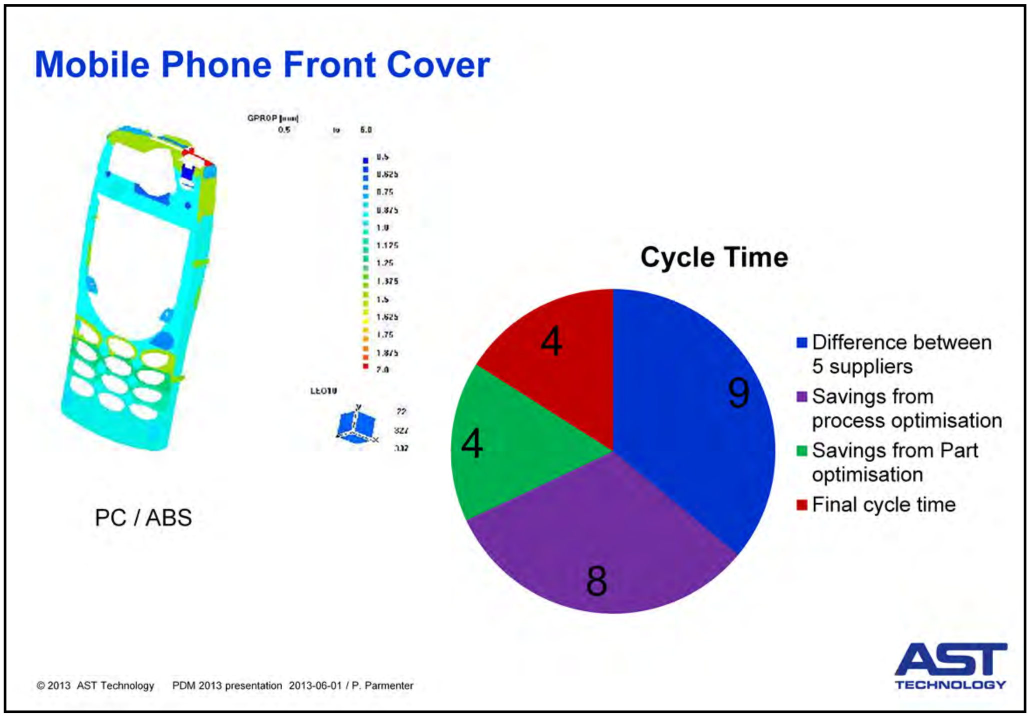
To Achieve an optimum manufacturing capability for an injection moulded component requires consideration of four key elements:

- Part specification.
- Tooling.
- Manufacturing Equipment.
- The Process set up.

Only by ensuring all four elements are correctly specified and verified can world class manufacture be achieved.

The models for product development do not cover the requirements of manufacture sufficiently and more importantly do not enable engineers to learn about the importance of the up front specification to the latter manufacturing process.

Rarely are the implications understood.

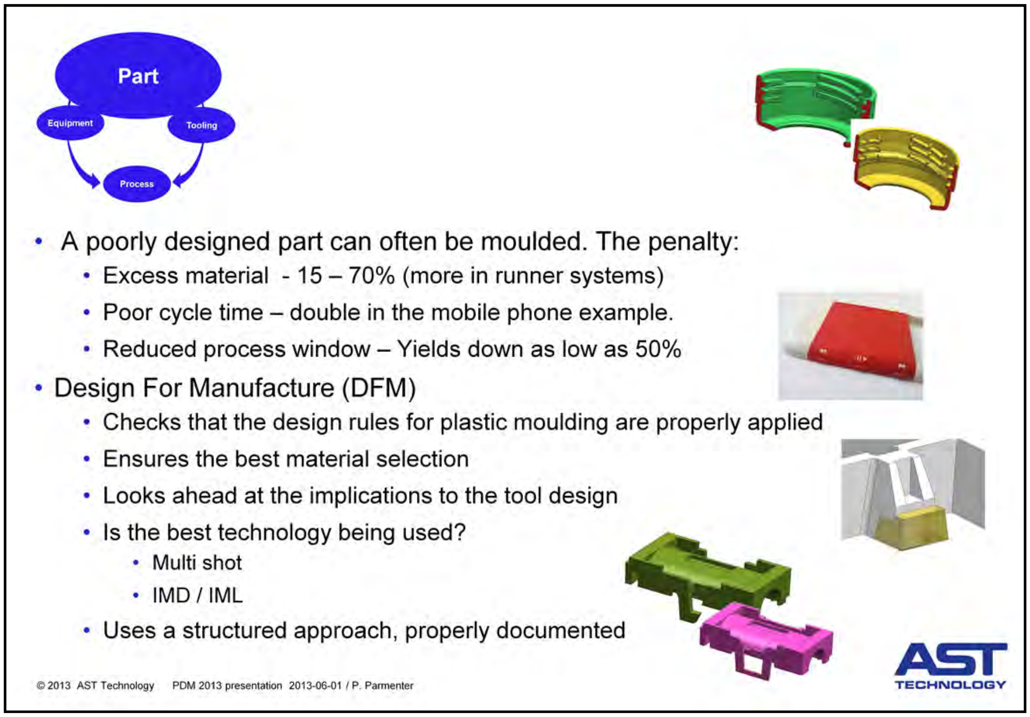


The component image shows the variation in wall thickness. Particularly the red section up at the top by the power switch aperture.

There were 5 suppliers, each one having their own choice of equipment and essentially their own specified tooling.

Even with the best supplier, there was the opportunity to optimise the process with the best equipment and a good quality tool to halve the cycle time.

Finally the constraint is the part design. Small changes in the part design then halved the cycle time again. How many designers realising that they are doubling the cycle time by breaking the rules.



A proper DFM review will check the following points:

- Wall thickness analysis.
- Splitting of the tool – where will the cosmetic witnesses appear? Could the tool split be changed to reduce tool cost, give longer tool life, give more robust performance?
- Gating – where and what type. What are the requirements of part size and material type?
- Ejection – How will the part be removed once the tool is open. What risk is there to damaging the part during the ejection process? Cosmetic implications of ejection.
- Venting – Where are the end of flow points, what venting will be required to ensure good part quality (no weld line / burn mark issues)?
- Cooling – what areas of the component will need special attention to cooling in the tool design?
- Weak steel situations – does the part design create a need for thin sections in the mould tool steel. Can the design be modified to avoid these yet achieve the same function and aesthetics?

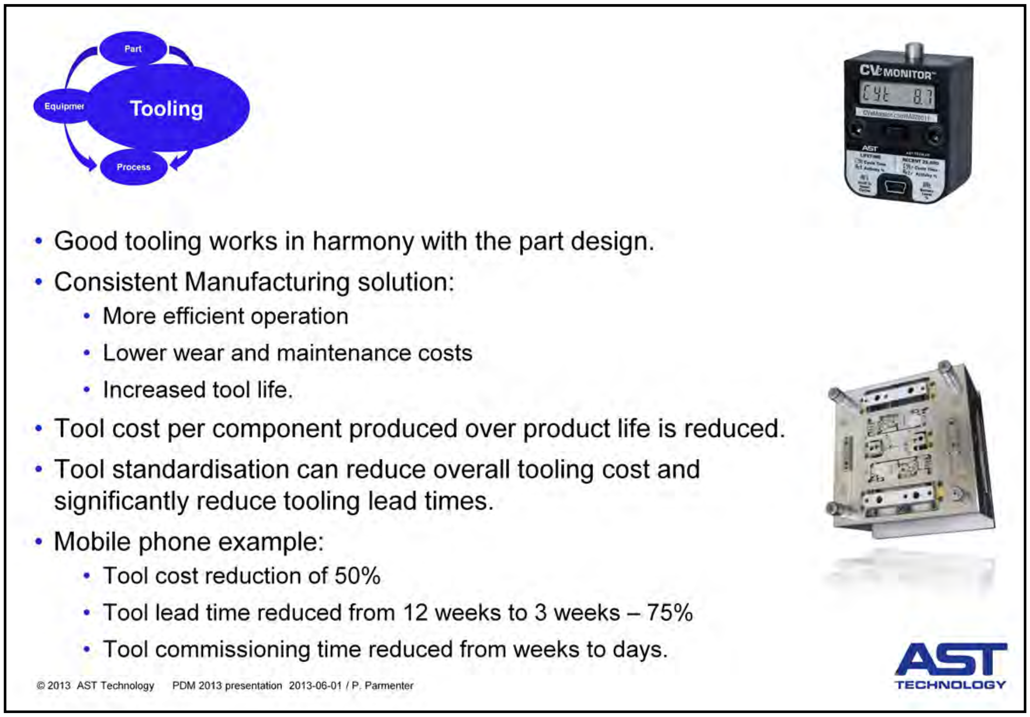
As well as supporting the development of the part design, much information is being gathered which feeds into the tool specification.

There is also the opportunity to generate information for the equipment specification. First of course the injection moulding machine:

- Clamp tonnage.
- Barrel & screw type / size.

Other areas include:

- Hot runner controllers.
- Robot / part handling requirements – including any special end of arm effectors.
- Heating / cooling equipment / capability.
- Material handling / drying.



The mould tool provides a consistent manufacturing solution (in combination with the equipment).

- Consistent geometry of the cavity (good alignment across any split lines and of moving sections).
- Consistent temperature – across the cavity itself but also over time.
- Consistent venting – through natural tooling split lines and through designed in end of flow vents.
- Consistent mechanical operation.

The tool specification is to ensure this. A well specified tool can halve cycle time, reduce tool wear and reduce mould maintenance costs, extending tool life and reducing the overall tooling cost per component produced over a products life time.

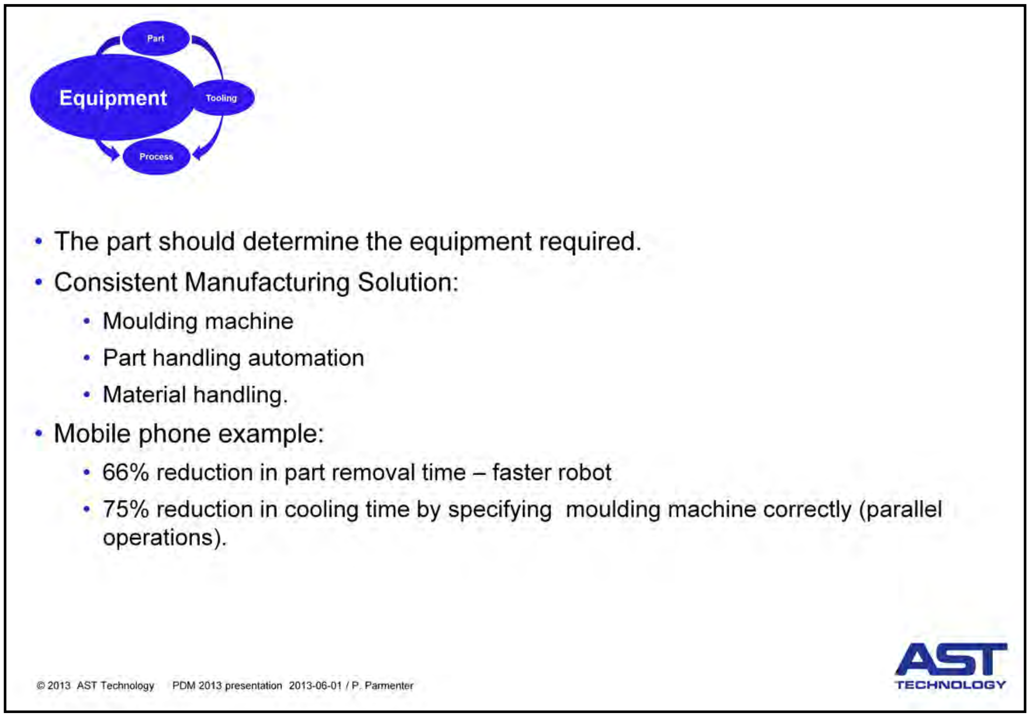
- The tooling specification can also simplify introduction to production by ensuring that the tools are compatible with the moulding environment.
- Tooling standardisation enables good practises to be captured, ensuring their re-use. Two big benefits of standardisation.

Tool cost reduction:

- Use of standardised tool components cheaper than custom made parts.
- Optimised tool manufacturing solution based on known and frequently repeated processes.

Tool lead time reduction:

- Standardised stock components and starter components.
- Tool manufacture based on verified process capability.



The equipment used to support and operate an injection mould tool provides a consistent manufacturing environment in which the mould tool can operate so together they can provide a consistent manufacturing solution.

The equipment needs to be specified based on the part design and tooling requirements. Often we see problems due to mould tools running on the wrong specification equipment. Just because a tool fits between the tie bars and platens does not make the specification correct. Other issues to consider:

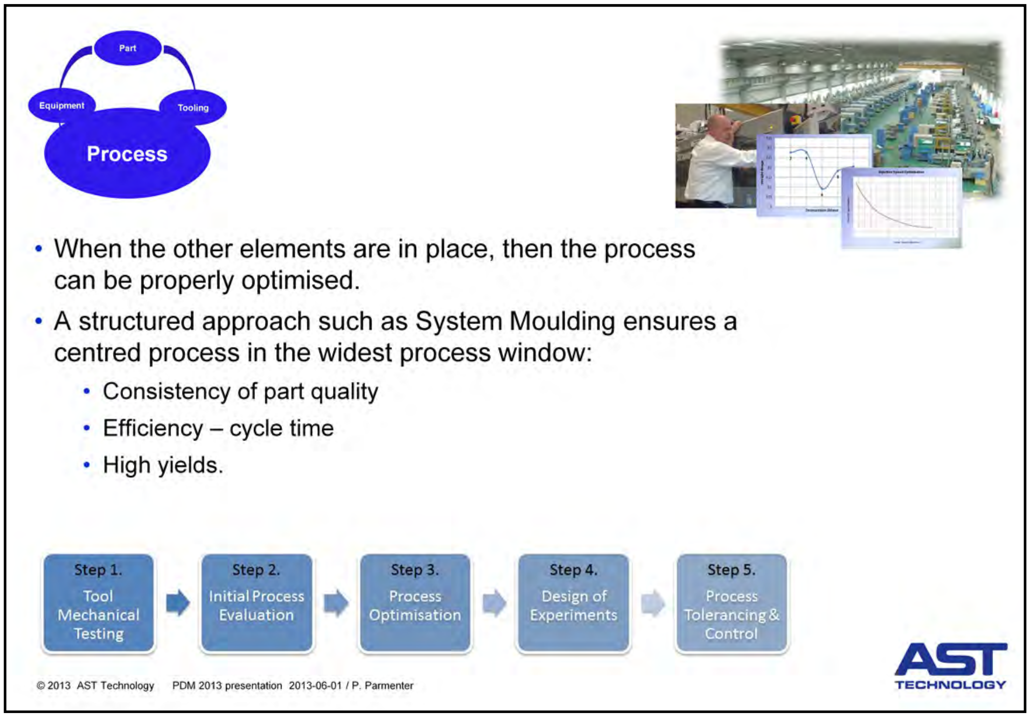
- Is the barrel correctly sized with the correct screw profile.
- Cooling hoses –are they of a suitable size to allow sufficient coolant flow to achieve stable temperature control?
- Material feed – clean, dry, any additives such as colourants.
- Hot runner controllers.

Part handling is an area which needs careful consideration:

- Can the part drop freely or will this risk damaging the cosmetics and / or dimensions.
- How fast does the robot have to be to support the moulding cycle time.
- If a robot, does a special end effector need to be made?
- Can other tasks be performed by the robot (optical inspection presentation, traying) and will these have any impact on overall system performance (cycle time)?

Mobile Phone example

- Take out time reduced from 1.5 seconds to 0.5 seconds.
- Cooling time reduced from 2.0 seconds to 0.5 seconds by having a higher specification moulding machine that could retract the screw and plasticise the material while demoulding.



Process optimisation builds upon the other elements.

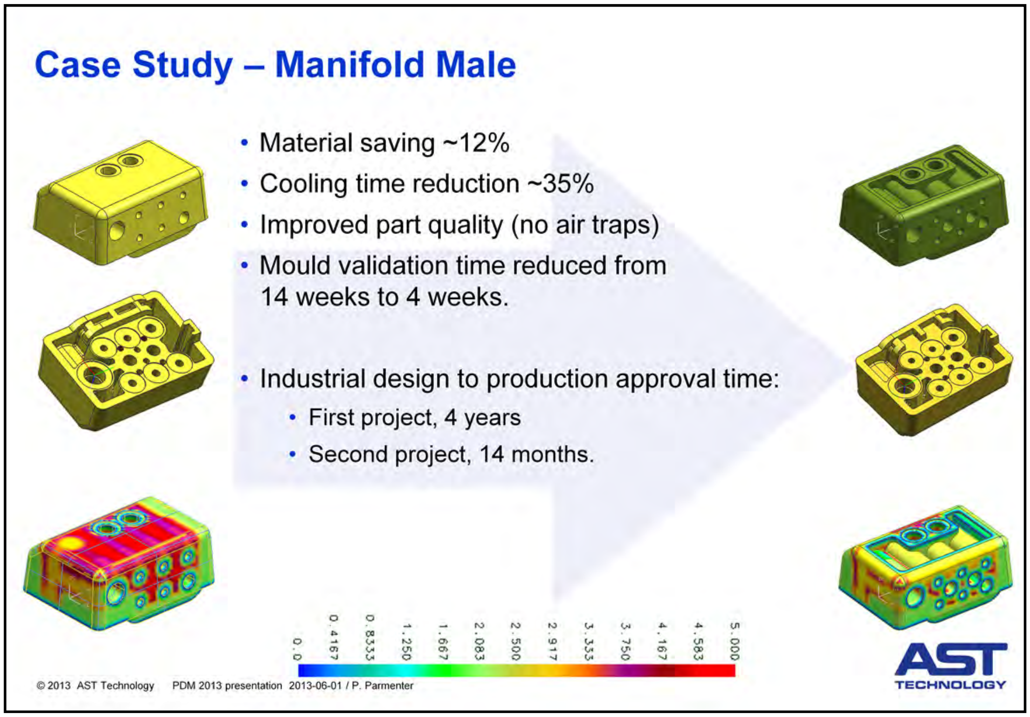
Reductions in cycle times are easiest to quote because they are easy to measure. We typically see between 10% and 50% reduction.

A properly centred process in a defined process window is the most tolerant manufacturing solution. Small variations in any input criteria are less likely to influence the output. Giving more consistent part quality and higher yields.

Another key aspect is an optimised and tolerant process is that restarting is quicker.

The process optimisation brings all of the elements together. The best process cannot be achieved without a part design aligned to the moulding process, a mould tool properly specified and well manufactured and running on the correct equipment. All four correct and world class manufacturing is possible.

It’s usually at the process optimisation stage that deficiencies in the other areas are found. The process can only be optimised within the constraints of the part design, tooling and equipment. The final process is only as good as the weakest of these elements.



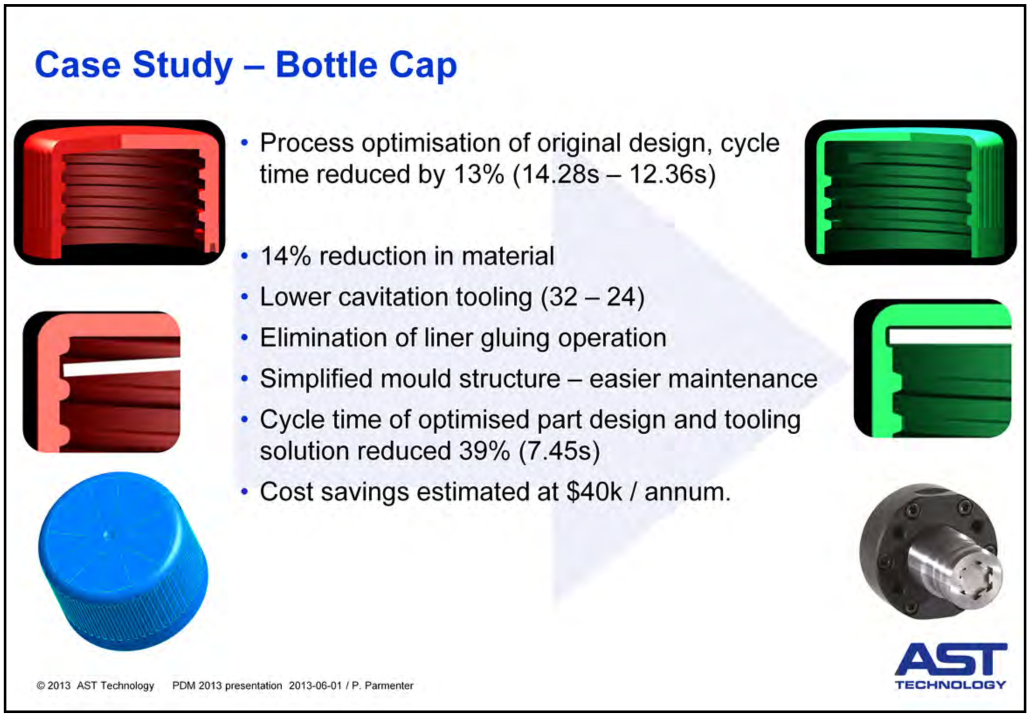
This is a project that we supported a customer on.

The part on the left, shows the original design and the mould tool was already made. They could not mould the part without air entrapment and were unable to achieve a reliable production component. Porosity was a big concern as this was part of an fluid feed system.

By redesigning the component to better align with the injection moulding process, not only was there savings on material cost and cycle time but more importantly a production capable part could be produced. How do you measure the cost of a product development project that is stalled because a key component can not be manufactured?

For the follow on project, we were invited to support during the product design and then through to tool validation. Services provided:

- DFM.
- Moldflow simulation.
- Tool specification.
- Tool design review.
- Moulding process optimisation and tool validation.



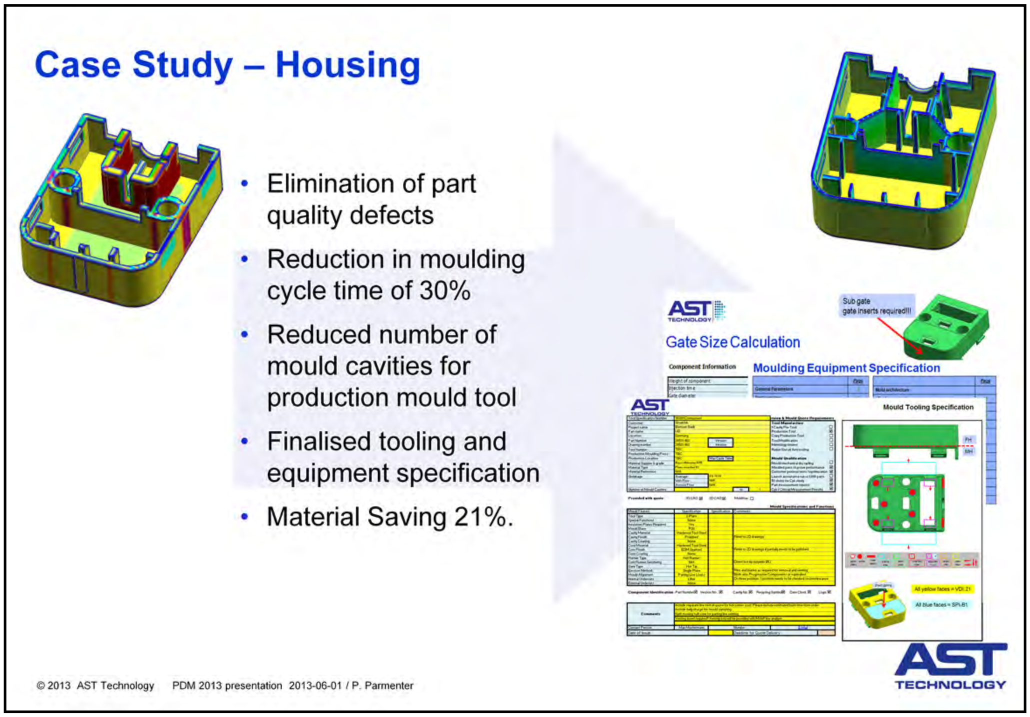
Component details:

- Polypropylene material.
- Original tool: Unscrewing thread design.
- Approximately Ø33mm x 18mm deep.
- General wall thickness 1.2mm for top and side surfaces of component.
- Small gate detail on inside of component.
- Sealing via liner added inside cap after moulding.
- Run in several different colours.
- Annual volume 30 Million caps.

Achieved:

- 14% reduction in material.
- Reduced wall section - 20%.
- Dovetail coring.
- Improved thread profiles.
- Liner retention inherent.

AST Provided DFM and moldflow analysis. We proposed and engineered a solution based on our sister companies collapsible DT Cores. Faster cycle times allowed for less cavities to make the same annual requirement.



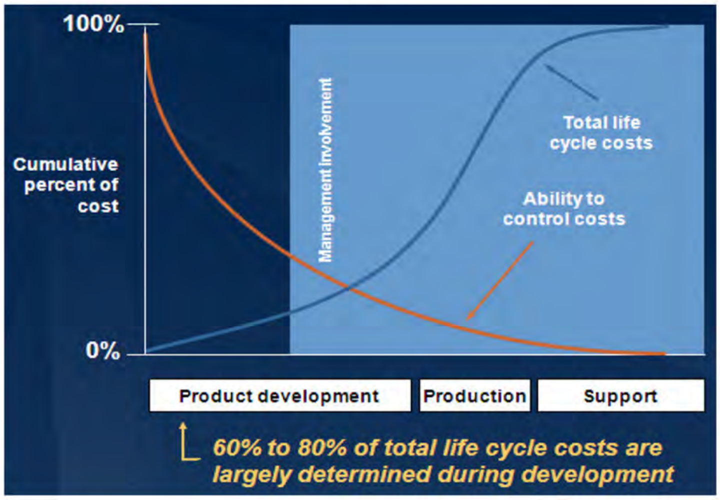
This project was for the moulding of a glass filled nylon housing. Poor component design was causing significant visual issues on the moulded part. Support was provided to help improve the part design when it was to be re-tooled.

A more efficient solution was created (reduced material and cycle time, increased yield). More importantly the tool could be put into production much more easily because of the wider processing window achieved.

For this customer, we:

- Completed a DFM review.
- Generated an equipment requirement specification.
- Generated a tooling requirement specification.
- Completed a tool design review.
- Supported validation of the mould tool with initial trials and a process validation.

Benefits of a Balanced Approach



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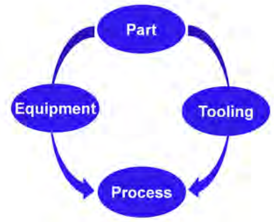
This is not a unique graph. This model applies to optimising injection mouldings. The part design is created in the product development phase and from the part design comes the tooling and equipment requirement. The best chance to influence the manufacturing solution is from the beginning. The real benefits or costs are seen in the latter phase as the product goes into production and then on as the product matures.

Summary



- Part design to manufacture model
- It starts at the part design
- Benefits
  - Reduced time to implement production
  - Lower cost
  - Increased capacity
  - Higher yields
  - Improved cosmetic quality.
- Who wants to pay between 2 and 4 times too much for their components?
- Who wants to be unable to ship a product due to a plastic moulding?

When developing products with plastic mouldings, it is important to understand the transition from design to manufacture.

With the injection moulding process all four elements of the model have to be considered and in the appropriate order.

The part design is the starting point and drives the requirements and capability of the manufacturing solution.

How well the injection process can be optimised depends on the preceding 3 elements shown in the model.

Understanding and applying this model can be the difference between a manufacturable part and a non manufacturable part at the extreme.

Usually the part can be made but if any steps are poorly considered then the penalty is on part quality, cost and capacity with higher cycle times, inefficient material usage and poor yields.

Thank you

AST Technology is a member of the PCIC Group of Companies.

With teams in Germany and the UK, we support customers around the world in all aspects of plastic component part design through to the effective and efficient ramp up into volume production.

If you would like to learn more about AST Technology and how we can help your company, please visit our stand D015 at the PDM show or e-mail: philip.parmenter@ast-tech.de.

