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'SPACE PUZZLE MOLDING'™ - THE FACTS

Or

WHAT EVERY DESIGNER SHOULD KNOW ABOUT SPM

POSITIONING THE "BRIDGING TECHNOLOGY" OF SPM

SPM, the acronym for the patented, and intriguingly named, Space Puzzle Molding™ process operated by the Bavarian based company **protoform**™ (yes, the lower case 'p' is correct) has a track record second-to-none for producing early-to-market, production quality, injection moldings for product evaluation, design confirmation and product launch in volumes from one to a hundred or so initially, with the capability to move up to several thousand items to support market demands before or during the manufacture of production tooling. This, however, has been mainly in Germany and weighted somewhat



Lamp-set fittings supplied for the Porsche Cayenne 2

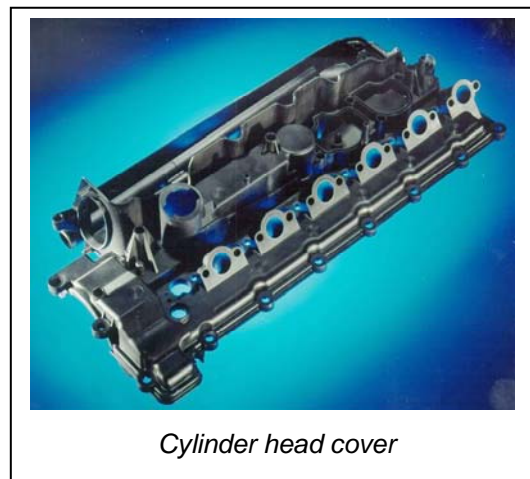
towards the automotive sector, serving all the major names in that industry like Porsche, Mercedes and BMW, as well as clients like Kodak, Leica and Bosch in other market areas. A small number of UK clients have also benefited from the SPM process but to the vast majority of designers and engineers in the UK, SPM undoubtedly remains the 'Puzzle' that the name implies.

To solve this puzzle and to participate in introducing the process more widely, the author, a veteran of the Rapid Prototyping / Rapid Tooling / Rapid Product Development (RPD) industry with 25 year's experience of manufacturing in the plastics industry, was able to visit **protoform™** recently and study the process from start to finish. This article sets out to share the facts on SPM with both the reader and the media.

Managing Director, Dipl. -Ing. Peter Hofmann, son of the inventor of SPM, together with Project Leader (English Language Markets) Sean Halstead BSc, were the hosts, and all aspects of the process were discussed in depth. The author's conclusion was that the SPM process is an absolute '**must**' for serious product development and evaluation in the UK.

There is nothing to compare it with in the market place since it is neither RP nor temporary Rapid Tooling in the conventional sense. Rather, SPM forms a rapid, shortcutting and economically viable bridge from the virtual reality of a CAD design straight into significant quantities of production-quality moldings in production-intent materials.

Appropriately used, SPM can eliminate the need, and considerable expense, of RP/RT exercises such as SL/LS/FD/SLS and others, which are essentially "**Enabling Technologies**" assisting in early design stages by giving shapes but in substitute materials mostly unsuitable for 'flight-critical', mechanical, impact, or environmental testing, where certificated approvals have to be obtained before the product can be marketed.



The term "**Bridging Technology**" on the other hand, is eminently suited to the technique as SPM soars rapidly above other technologies from CAD to first-offs, putting **real finished product** into the designer's hands at the earliest possible point in the rapid product development (RPD) program.

'SPACE PUZZLE MOLDING™' USES PRODUCTION QUALITY TOOLING

The first thing to realise about the SPM process is that it adheres exactly to the CAD data of the design. Before cutting metal, which is mainly aluminium and only occasionally tool steel, **protoform™**'s expertise is shared with the client and the design is analysed for potential problems. This is an important exercise, as, often, small adjustments to details can simplify not only the SPM tooling but also the projected production tool later.

It is also noteworthy that, in some cases, conceptual elements of the tooling design and other useful information can be transferred to the makers of the full production tooling should they wish to visit with their client and view the Space Puzzle tool itself, thus saving both thinking time and money for the client.

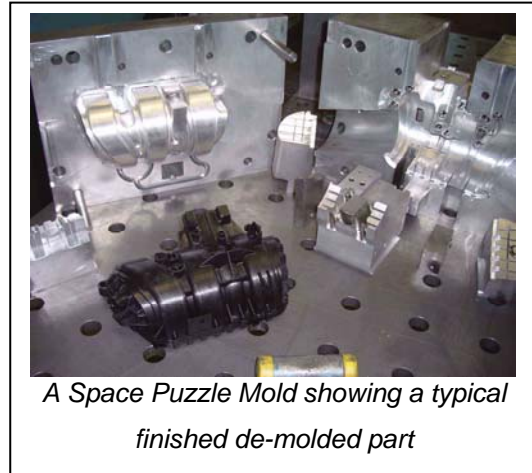
The collective experience at **protoform™** with some 8000 individual plastic product exercises now completed (250 to 300 individual moulds per annum means that an SPM tool is completed on average every working day of the year) is an invaluable bank of knowledge freely available to clients and their design teams.



With the initial assessment completed, experienced SPM mold designers then proceed to import the CAD data from disc or via ISDN in any of the popular languages such as IGES VDA STEP etc, (**protoform™** has a multiplicity of state-of-the-art CAD/CAM workstations using IDEAS, Unigraphics and other sophisticated solid modelling software) and create the elements of the tool.

SPACE PUZZLE MOLDING™ IS NOT A COMPROMISE

There is no compromise in the SPM process. Cores, undercuts, inserts, outserts are all to production specification. The difference is in the skill with which the mold designer arranges for all the parts of the sophisticated metal 'Puzzle' to be stripped and re-assembled manually, usually with the assistance of simple, product-dedicated, hand tools. The tooling



A Space Puzzle Mold showing a typical finished de-molded part

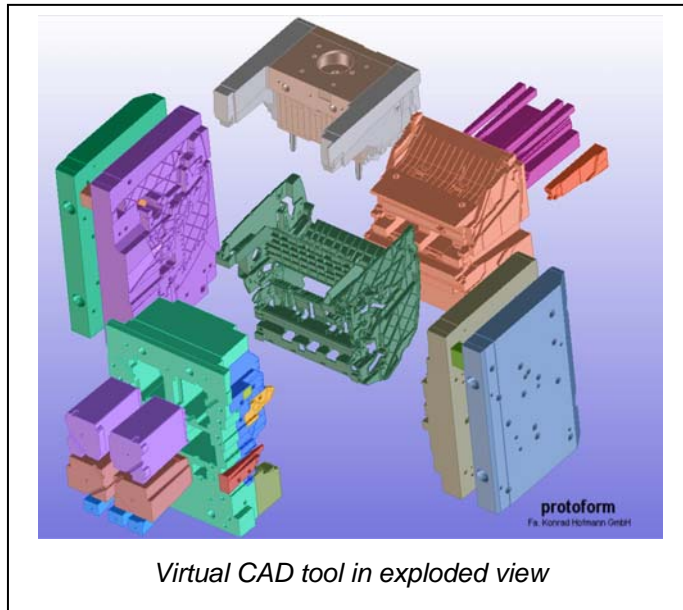
as designed is not bulky with the considerable mass of metal associated with a fully automated production tool. The patented system employs a unique surrounding frame or bolster dedicated to each injection machine to provide the strength required to withstand injection pressures which can typically be 1000 bar and more. This bolster is not a permanent part of the tool but accepts many tools of similar overall dimensions and its provision is not part of the tooling cost resulting in a further major saving.

The Space Puzzle Mold itself, therefore, is often only 20% up in volume, or less in some cases, from the envelope of the product, making handling and de-molding a tabletop operation.

Neither is there a problem with complexity. The illustration of a heavily detailed chassis for a paper-handling device required a mold with 6 different ejection planes and over 80 individual inserts!



The Award Winning molding



This particular exercise was remarkable for two reasons:

- Against stiff international competition it won the prestigious Golden Euromold Award for SPM
- It also broke production records in that over 3000, series-identical, items were produced for a client whose automated tooling, for a variety of reasons, ran late and marketing required product to meet early demands.

THE SCOPE OF SPM TOOLING

It is clearly evident that SPM can handle most projects within the scope of **protoform**TM's in-house injection machine capacity. This is stated as an envelope of approximately 200 x 400 x 800mm, 3gm to 2200gm shot weight with clamping forces from 300 to 6500kN. Examples in the retained samples of completed projects in **protoform**TM's available archives illustrate that the maximum single dimension has been exceeded in exceptional cases for some long components so there is, in fact, a degree of flexibility in the envelope.

Co-injection and gas-assisted injection techniques are also employed if required. The injection machines in the production department are industry

standard and require no special treatment to handle SPM tooling once the patented bolster system is installed. Materials range through most available, including PC, ABS, PEEK and PP, PA, PBT, and PPS, and reinforced grades are used where specified.

If the assembly and de-molding from the tool is to be slick and totally repeatable without loss of accuracy then the high-speed cutting, the machining, and the spark-erosion of tool elements and inserts must be to the best quality obtainable using the best of modern machines.



One of several Rapid Machining centers at protoform®

The handling methods in combination with skilful design mean that hot runners, cooling systems and hydraulic or pneumatic ejectors are not required.

Manufacturing emphasis is therefore on the precision of the cavity and the smooth action of the sequentially sliding components of the



The 5 axis Machining center at protoform®

final 3D 'Space Puzzle'. In some cases the action is reminiscent of the party game Jenga, played with sliding wooden blocks.

Fast cutting CNC processing centres supplemented by a Röders 5 Axis machining centre form the heart of tool production and a unique, common-

datum, palleting system facilitates multiple operations on one program, machining inserts, cavities, and multiples of spark electrodes simultaneously.

HOW THE TOOL WORKS IN PRODUCTION

When a finished tool is ready, an injection molding machine of the appropriate capacity, with its permanently attached, unique, Space Puzzle bolster is set up for a production run. These patented devices are the frames to be repeatedly loaded with the Space Puzzle assembly each time a product is injected.

The highly skilled operator assembles the tool and loads it in position using a custom-designed device combining the properties of a robotic arm and a



Typical production arrangement showing robot arm and assembly/demold platform

miniature lifting-crane facilitating a simple line-up operation. The procedure is swift and accurate whereupon the clamping force is applied and a specified material injected.

In a surprisingly short cycle for a manual operation the Space Puzzle tool, now carrying the product, is transferred using the robot arm to the de-mold and re-assembly surface close to the throat of the machine. The stripping of high precision inserts and their replacement in the empty tool is a truly fascinating sequence to watch as the operator makes it seem easy in spite of the apparent complexity of the product.

Once samples have been taken and approved by the client production can commence up to the level required. Various materials can be evaluated. Changes to the gating to alter mold-flow can be made and, if the design calculations for shrinkage, dimensional characteristics, or cosmetic effects such as sink marks, need adjustment, this can be accommodated by 'tweaking' the tool body, or one or more of its inserts.

At this point **protoform™** becomes a vital part of the development team as the product moves smoothly and rapidly over the 'bridge' from CAD..... through prototype evaluation and approval..... and onwards to short-series (kleinserien) production of commercially acceptable moldings.

Cosmetically it is possible to apply all the popular finishes to the tool surfaces such as the full range of standard textures and the more advanced procedures of in-mold decoration (IMD). **protoform™** also can have mouldings lacquered on behalf of clients if specified, and, in appropriate cases, can offer an assembly service for sets of moldings such as complex keypad applications.

In all cases the performance of the tooling is monitored and documented for quality (**protoform™**, with around 100 staff and 1400m² premises, operates to Quality Assurance standard VDA 6.4 and is registered for ISO 9001/9002). If an insert or part of the tool needs engineering attention due to high volume use it is easily dressed or replaced at a relatively small cost.

USING 'SPACE PUZZLE' BRIDGING TECHNOLOGY

Addressing the two vital issues of cost and timescale, **protoform™** state that the cost of the tooling works out around 50% of a fully automated production tool, it is, however the fastest way to obtain production parts in production-intent material. The moldings so-produced are indistinguishable in service from high volume produced items made later.



MD Peter Hofmann with a typical SPM® production molding

On timescales, MD, Peter Hofmann states:

“We have our own internal records detailing some pretty fast turn-arounds. On one occasion 28 individual moulds for various components forming a keyboard assembly were created and up and running in 30 working days.”

Normally however a large mold of medium complexity can be completed in 3 to 5 weeks. A premium channel is held in reserve for emergencies and extra-urgent requirements, but the client’s own planners usually find SPM delivery times perfectly acceptable and not an issue.

One frequent point of discussion with new users is the ***‘hindsight factor’*** where stories are sometimes related by clients about previous exercises where full production tooling had been commissioned before discovering SPM’s unique ***‘bridging technology’***. Products either failed to come up to specification, resulting in considerable repeated tooling and expense, or were spectacularly late with the resultant launch date and early revenue problems. With the advantage of hindsight, the benefits that SPM could have offered under such circumstances become even clearer.

“We wish we had known about SPM earlier, it would have saved us a lot of trouble”, is a heartfelt comment heard often at the first meeting with a new client.

Based on such experiences buyers, engineering designers, and marketing departments alike tend to refer to Space Puzzle Molding™ as:

“A soft landing for hard tooling”, enabling full parameter evaluation, test, performance, and final design adjustment before major financial commitment.

Additionally, in the case of products such as Medical and Scientific, where the projected market volume is always going to be low, Space Puzzle Molding™ maybe the only production tooling ever required.

Basically, Space Puzzle Molding™ from **protoform**™ makes good, sound, technical, commercial, financial and RPD sense.

SPM uniquely goes where others cannot.



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