

means to accommodate eleventh-hour engineering changes. There is a strong trend toward shop floor programming in Europe, especially in the auto industry, mainly driven by pressures to reduce cost and time.

### Metrology, Quality awareness and inspection

An essential part of world-class tool making.

### Project management

An essential part of world-class tool making.

### Robotics

Robotic loading and unloading of machines is the next level of automation that many mould shops are rising to. System 3R, best known for its pioneering integrated tooling systems for EDM, saw more mould shops purchase its Workman robotic systems for mills and EDMs last year than in the three previous years combined. Automation allows increased productivity level to be inherent to the process and not the operator.

Automation is a strong theme in the machining of dies for stamping or forming sheet metal in Europe. There is a clear trend to high speed machines with automatic pallet changers and automatic head changers (but no automatic tool changer). The pre-eminence of mould and die cavity work as a major application for electrical discharge machines is well understood. In fact, "die sinkers" is still a very common name for ram EDMs. Wire EDM-ing is also widely used in die and mould work. Few mould and die shops do not have at least one EDM in the shop. EDM technology has advanced rapidly in the last few years. These changes are altering the strategic value of EDM for mould and die work.

One important change is that both ram and wire machines are considerably faster than they were only a few years ago. "Burn" times have been reduced, although they are still measured in hours. The days of setting up one job and letting it run in the unattended mode overnight are disappearing. In order to achieve extended unattended operation, some means of automating work piece and/or electrode changing must be provided. This is a major incentive for installing automated robotic handling systems on EDM units in mould and die shops. A faster burning EDM with robotic automation will consume electrodes quickly. Meeting this demand creates a bottleneck in electrode fabrication. In the United States, high speed machining of graphite has become an increasingly popular solution. The most significant time savings lie in reducing or eliminating benchwork and polishing. Typically, the time reduction is in the neighbourhood of 50 to 75 percent.

Eliminating most hand work means that the as-machined, CAD-defined geometry will not be lost. High speed machining allows a shop to produce electrodes that are virtually identical to the customer's actual geometry. If more than one electrode must be produced, each "copy" will be exactly alike when benchwork can be reduced or eliminated. Having electrodes that are virtually the same means that virtually identical cavities can be produced at the EDM. This is a major plus for multi-cavity moulds for producing interchangeable injected plastic parts. Highly consistent, as-machined results also mean that EDM time can be reduced. A near-perfect match between electrodes creates optimum conditions for efficient EDMing. Another advantage of high speed

machining appears when producing electrodes with thin walls or ribs, especially in graphite, a very brittle material. With high speed machining, stepovers as fine as 0.001 or 0.002 inch put very little pressure between the cutter and the graphite, whereas conventional machining would almost always cause the rib or wall to break off before being completed. Being able to machine thin walls and ribs allows one-piece electrodes with all ribs in place to be produced. One-piece electrodes eliminate the multiple setups and eliminate the location errors that may have occurred and accumulated between setups. This saves time and improves quality.

Meeting the technical challenges of efficient, high precision, highly automated mould/die machining is within reach. The equipment to do it is available. Proof from the field that this technology works is abundant. Restructuring a shop to exploit this technology is a manageable affair. Many believe however, that achieving a balanced workload is the top priority—a consideration even more important than having the latest equipment dedicated to high end die/mould work. A shop usually has no control of workload. No matter how competitive a shop is technically, it is ultimately dependent on having sufficient volume to return the investment.

### **International Trends in Skills Development**

International trends in skills development follow the technology trends. Tool and Die making has shifted from an occupation requiring primarily artisan skills to one which requires extremely sophisticated skills in areas such as IT and design, inter alia.

Most artisan tool and die makers learn their trade through four or five years of education and training in formal apprenticeships or postsecondary programs. Apprenticeship programs include a mix of classroom instruction and job experience and often require 10,400 hours, or about five years to complete. According to most employers these apprenticeship programs are the best way to learn all aspects of tool and die making. Tool and die maker trainees learn to operate milling machines, lathes, grinders, wire electrical discharge machines, and other machine tools. They also learn to use hand-tools for fitting and assembling gauges, and other mechanical and metal-forming equipment. In addition, they study metalworking processes, such as heat treating and plating. Classroom training usually consists of mechanical drawing, tool designing, tool programming, blueprint reading, and mathematics courses, including algebra, geometry, trigonometry, and basic statistics. Tool and die makers increasingly must have good computer skills to work with CAD technology, CNC machine tools, and computerized measuring machines.

Because tools and dies must meet strict specifications—precision to one ten-thousandth of an inch is common—the work of tool and die makers requires skill with precision measuring devices and a high degree of patience and attention to detail. Good eyesight is essential. Persons entering this occupation also should be mechanically inclined, able to work and solve problems independently, and capable of doing work that requires concentration and physical effort. As well as the artisan skills required, the major additional competencies required in the industry world wide are indicated in the following list:

**Table Six: High Order Skills Required**

Competency Category	Specific Skills
Product Design	CAD CAM Process Simulation Material Flow Simulation Verification Software
Prototyping	Various
Project Management	Manufacturing environment
Manufacturing Technologies	See trends above and; CAM High Speed Machining
Production Technologies	See above trends and; Automated Quality Control Data Management Robotic Material Handling Production Software Sensor Technology

*Source: R. Tinkler (2004) Enterplan*

Underpinning these high order skills there is a need to ensure that the level of general artisan training is of a high standard to enable easy progression from one level to the other. When the two major categories of artisan and high order skills required are unpacked, it becomes apparent that skills will vary to some degree as well depending on the type of technology platform in involved, that is, whether press tools, plastics and other moulds, or dies are being made. Variations are in some cases slight, but in other are marked. These too will be influenced by the developments in technology that permeate the industry. The following table offers a summary of the skills required by technology platform,

**Table Seven: Skills required: Broad Technology Platform**

Technology Platform	Skill
Plastic Moulds & Pressure Die Casting Dies	Estimating Project Management Design Purchasing Blocking Up General Machining Cutter Path Generation CNC Milling Spark Erosion (EDM) Benching Tryout Texturising Sampling & ISIR

Technology Platform	Skill
	Welding Metrology, Inspection, QA and QC
Press Tools	Estimating Design Purchasing Pattern Making Blocking Up Simulation Cutter Path Generation CNC Milling Benching Spark Erosion Fitting Tryout Commissioning Sampling & ISIR Heat Treatment Welding Metrology, Inspection, QA and QC

Source: R. Tinkler (2004) *Enterplan & Blueprint International*

### Skills Required by Job Function

For each major technology platform as outlined in the tables above, specific skills are required. Typically, these skills are organized around easily identifiable job functions which are described below. The table below indicates the skills required for each major job function in the plastic moulds and pressure die casting tool making process:

Table Eight: Skills required: Plastic Moulds and Pressure Die Casting

Job Description & Skills Needed	Job Content
<p><b>The Estimator</b> Estimators Tasks:</p> <p>to decide the split line of the component how it is removed from the tool once moulded how the tool will open so that the component can be produced and removed how the tool is to be fed (how you get the molten plastic or alloy in most efficiently in order to achieve product quality, economical use of raw material and shortest cycle time) How the tool is to be cooled</p>	<p>The Plastic Mould and pressure die tool making process starts from an enquiry from a customer. The enquiry may be in the form of:</p> <p>A CAD file in 2D or 3D format A CAD file in the form of a solid model A CAD file in the form of a surface model A CAD file in the form of a wire frame A printout of any of the above A 2D or 3D hard copy drawing A freehand sketch A physical sample made from an existing mould</p>

Job Description & Skills Needed	Job Content
<p>The Estimator needs to draw on a wide range of experience in order to envisage how the tool will work.</p> <p>An Estimator will need to be an experienced mould or pressure die tool maker. He/she will need to have spent several years as a Bench Hand, benching, assembling and testing tools.</p>	<p>A stereo lithography sample A set of photographs</p>
<p><b>The Project Manager</b></p> <p>It is essential to have a Project Manager to ensure that tool making projects are completed on time and to budget.</p>	<p>Many customers require formal weekly progress reports and this is achieved by the use of Gantt charts or by using computer software such as "MS Project". The Project Manager will design and maintain the Timing Plan.</p> <p>A good working knowledge of tool making is required but it is not necessary for a Project Manager to be a skilled tool maker.</p>
<p><b>The Designer</b></p>	<p>Designers often work for a subcontract design company, specialising in tool design. The reasons for this are that, in particular in small tool making companies, there is not enough work to sustain a full time Designer and Designers can generate very high incomes. Tool designs need to be started and completed very quickly after the start of an order and subcontract Designers, whether freelance or company based may be a more flexible resource.</p> <p>Tool Designers need to have good experience of the tools that they design and, traditionally, this will have been obtained by completing a time-served apprenticeship with a number of years experience.</p> <p>The modern day Designer will have good computer skills as well as tool making experience as tools will be designed using CAD techniques. Modern CAD packages, such as VERO International "Visicad", provide sophisticated packages that considerably help the designer. Apart from the mechanical actions of the tool, there are also software packages to</p>

Job Description & Skills Needed	Job Content
	<p>simulate the action of the tool and the flow of plastic material within it. The latter aspect is important in determining the feed system and is usually a service provided by the supplier of the feed system.</p> <p>The first objective of the tool Designer is to provide a General Assembly drawing (GA) for approval by the customer. Once approval is given, a Bill of Materials (BOM) can be produced so that all the long lead time materials and those necessary to get started in manufacture can be ordered.</p> <p>Detailing of the tool will follow and drawings will be produced in accordance with the Timing Plan.</p> <p>The Tool Designer works very closely with the Estimator, the customer and the tool making company.</p> <p>Like the Estimator, the Tool Designer will start with any or all of the following, plus a full specification of how the tool will work, what the estimator and customer: have agreed for the specification of the tool including the feed system:</p> <ul style="list-style-type: none"> <li>o A CAD file in 2D or 3D format</li> <li>o A CAD file in the form of a solid model</li> <li>o A CAD file in the form of a surface model</li> <li>o A CAD file in the form of a wire frame</li> <li>o A 2D or 3D hard copy drawing</li> </ul>
Purchasing	<p>Purchasing is carried out once the GA has been approved and the BOM prepared. In small companies, the Designer or the Estimator may order the materials. In larger companies, where strategic purchasing can be more effectively carried out, there may be a separate Purchasing Department.</p>

Job Description & Skills Needed	Job Content
<p><b>Blocking Up</b></p>	<p>Blocking Up is the process whereby, blocks of tool steel are prepared for later machining of the cavities or impressions (identical terms for the shape of the finished product in the tool, in effect, a negative image of the final product). These blocks may be to produce the actual body of the tool or slides which fit into the main body.</p> <p>Mould tools will often be made from custom components sourced from suppliers like Hasco. These are pre-prepared and may not require the Blocking Up process, other than to produce any slides.</p>
<p><b>General Machining</b></p>	<p>The impression blocks, which form the finished component are held in the tool assembly which is a series of plates, pillars, locking devices etc, which go to make up the mould tool. There is a "Fixed Half" and a "Moving Half" to the tool. The Moving Half, carries the ejector plate and the ejectors. All these components of the tool are produced by conventional or CNC machines, the operation of which requires capable machinists who are able to work from hard copy drawings or by utilising CAD/CAM techniques. A working knowledge of tool making is required but it is not necessary for the machinists to be skilled tool makers.</p>
<p><b>Cutter Path Generation</b></p>	<p>Cutter Path Generation is the process whereby a program (that controls the cutting tools that produce the impressions or cavities using a CNC machine) generates production from either a surface or solid model of the component. The cutter path will take into consideration the contraction of the plastic material when it cools in the mould. Cutter paths will be generated for cutting the impression direct or for machining electrodes for Spark Erosion Machines.</p> <p>In the past, before CNC machines were available, the process was carried out by a copy milling machine, using a model of the component.</p>

Job Description & Skills Needed	Job Content
	<p>Output may be directly to the CNC machine or by media such as CDROM or Floppy Disc.</p> <p>A person who produces Cutter paths will need to be skilled in CAD/CAM and have a very good working knowledge of the both the machining processes and mould and die tool making</p>
<p><b>CNC Milling</b></p>	<p>CNC Milling is now universally used for producing either the electrodes for Spark Erosion or for machining the impressions directly into the tool steel blocks.</p> <p>A rapidly growing CNC Milling process is that of "High Speed" milling, which utilises advances in cutting tool materials and design together with high speed computers. Apart from the reduction in floor to floor time, high speed milling can produce superior surface finishes which require little or no further work by hand.</p> <p>CNC Milling machines may have a Setter and an operator or a Setter/Operator. Once set up, machining times may be quite considerable, on big tools times may be several weeks, and so it is quite normal for one person to look after a number of machines at the same time. It is also normal, to operate the machines 24 hours a day and seven days a week.</p> <p>CNC Machinists will probably have served an apprenticeship followed by special training, probably provided by the machine supplier or by a specialist CAD/CAM company like "DEL/CAM".</p> <p>CNC Machinists will need a good working knowledge of tool making.</p>
<p><b>Spark Erosion or Electrical Discharge Machining (EDM) : Solid Electrode</b></p>	<p>Spark Erosion uses electrodes manufactured by CNC machine, conventional machine or even by hand to erode impressions or cavities into tool steel blocks and slides. Conventional Spark Erosion utilises an electrode that basically replicates the finished component with allowances for spark gap and contraction. In its simplest form. The process is a simple up and down movement, sometimes with oscillation in the horizontal plane. More recently, with the advance of computer technology, CNC Spark</p>

Job Description & Skills Needed	Job Content
	<p>Erosion machines have made big advances by allowing the use of simpler electrodes and by producing far superior surface finishes. These features also allow for reduced floor to floor times and better quality end products</p>
<p>Spark Erosion or Electrical Discharge Machining (EDM) :Wire</p>	<p>A wire Erosion machine utilise a very fine vertical wire to cut, basically, 2D shapes into tool steel, similar to a band saw but to very fine tolerances. The wire is constantly spooling from one reel to another in the vertical plane with the workpiece moving in the horizontal plane. Because of the ability to incline the vertical axis of the wire, it is also possible to cut tapered holes and slots.</p> <p>A Spark Erosion operator would also be able to set the machine and would likely operate more than one machine at a time. Spark Erosion machines are also run on a 24 hour, seven day a week basis if possible. Operators would likely have served an apprenticeship and would probably have specialist training by the machine producers, such as "Charmilles".</p>
<p>Benching</p>	<p>Bench Hands or Bench Toolmakers will prepare and assemble the components of a mould or die tool ready for try out. They will also make any necessary adjustments after tryout and fully complete the tool ready for production.</p> <p>Benching is an extremely skilled occupation. Bench hands will have served an apprenticeship and will need several years experience to become fully qualified. They may be responsible for tools that may cost many tens of thousands of Pounds Sterling or tools which may be critical for maintaining production schedules. In modern JIT environments, one item missing from an automobile production line can cost thousands an hour in lost output.</p> <p>The Bench Hand will put the final finish on the tool, or prepare the surface of the impression ready for "Texturising". Probably, the highest level of skill for a Bench Hand is to put the finish polish on a Lens or mirror tool. There are machines that can mechanically polish</p>

Job Description & Skills Needed	Job Content
	<p>impressions and these will usually be under the control or direction of the Bench Hand.</p> <p>In the final assembly of a mould or die, a critical operation is "bedding out" the faces of the mould or die that must seal and produce an acceptable split line on the final component. Any error in this process will produce a "Flash" - a thin piece of excess material, which would be unacceptable.</p> <p>The bedding out process is usually carried out on a special press and requires a great deal of skill and patience.</p>
<p><b>Tryout</b></p>	<p>Small companies are unlikely to have in house try out facilities and will either have to purchase time at a moulding or casting company offering a try out service or at the customers facility. It is possible to do some basic trying out of a tool by using hot wax on a bedding out press but this process has it's limitations.</p> <p>In small companies, Tryout is generally carried out by the Bench Hand. Large companies, with in house presses, may have people specifically trained to do Tryout. In such cases, the person would need to have had some tool making experience.</p>
<p><b>Texturising</b></p>	<p>Texturising is the chemical etching of a surface in order to achieve a cosmetic finish, such as a natural leather look, on a finished component. It is a specialist process usually carried out by a subcontractor but can be done "in-house" if the technology has been purchased. Texturising is a skilled operation and anybody carrying it out would need to have a good working knowledge of mould and die tool making.</p>
<p><b>Sampling and ISIR</b></p>	<p>Sampling may be carried out in house, with a subcontract tryout company or at the customers facility. It is very important that the sampling conditions replicate those of production. Apart from maybe overseeing the installation of the</p>

Job Description & Skills Needed	Job Content
	<p>tool on the moulding or casting press, it does not require a skilled toolmaker to be present when sampling a tool.</p> <p>An ISIR or Initial Sample Inspection Report, is the formalised sampling procedure that most customers require when they purchase a mould or die. Basically a Quality Assurance task, the ISIR will call for a full dimension and quality check of the finished, moulded or cast component. The requirements of an ISIR are laid down in a company's Quality System and the skills required are those of metrology. Many tool making companies will have sophisticated measuring equipment such as a Coordinate Measuring Machine, probably with links to the company's CAD CAM system so that measurements can be directly compared with the "native" data (original CAD model). Knowledge and experience of mould and die tool making are not necessary for measuring.</p>
<p><b>Welding</b></p>	<p>Welding is not something that you would plan to do when making a tool. However, accidents happen in the manufacture of a tool and in the operation of a tool. Tools also might need minor changes or become worn and some maintenance may be required.</p> <p>Mould and Die impressions can be repaired and modified by welding. This is a very skilled task as it is very easy to cause even more damage. Anyone carrying out the welding process needs to be very well trained and experienced as a welder. It is normally a task carried out by a subcontract specialist welder and unlikely to be a skill that a small or medium sized tool making company would have in house. It is a skill that a moulds and die tool making company would need to be able to access in emergencies.</p>

Job Description & Skills Needed	Job Content
Dimensional Metrologist	Maintenance care and calibration of instruments Calculation of uncertainty budgets Determination of sources of measurement errors Criteria for choosing certain measuring instruments Compiling of calibration procedures Generating and issuing of calibration reports Ensuring traceability to National Standards
Quality Control Inspector	Usage, maintenance and care of measuring equipment Interpretation of engineering drawings including geometrical tolerance Sampling methods Component measurement Use of standard measuring machines including roundness, surface roughness, hardness, profile projectors and co-ordinate measuring machines (3D designing and surface modeling, Reverse engineering, 3D scanning/laser digitizing, Rapid prototyping, creation of machining programs) Statistical process control Liaison with sub-contractors Generating of QC documentation including inspection reports, concessions, acceptance and rejection notes
QA Personnel	Implementation and evaluation of quality management systems eg ISO 9001:2000 Compiling of: Quality policy manuals Procedure manuals Work instructions Audit planning schedules (internal and external) Quality awareness training of staff members Conducting of audits (internal) Maintenance of quality management systems Liaison with certification organizations Quality costing and analysis Reviewing of systems and reporting to top management Machine capability studies

Source: R. Tinkler (2004) *Enterplan & Blueprint International / TASA*

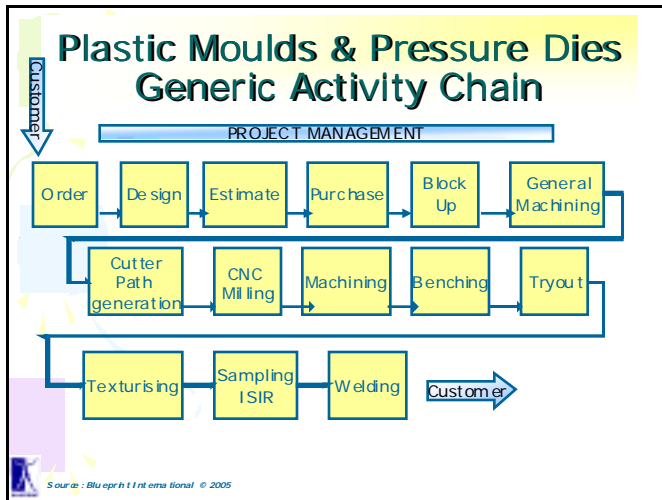
The career process and detailed skills required can be found in the Appendices at the back of this report.

### Activity Chains: Tool and Die

Each step in the production of a plastic mould or a pressure die is outlined here. It is important to note that variations in cost will occur in the area of raw materials used as well as in other key areas discussed above and importantly - in terms of what kind of item is actually being produced.

In **press tool making**, the roles of the estimator, project manager and designer are virtually the same as for the plastics and die process. Large Press Tools are usually made from castings. Patterns have to be made and because every one is a "one off", they are fabricated from polystyrene sheets. The glued together patterns are sprayed with a ceramic coating and then packed in sand to form a mould. Molten iron is poured directly into the mould, vaporising the pattern and producing the finished casting. A Pattern Maker that has trained as a Toolmaker will be able to produce a pattern from a drawing with far less detail than a patternmaker without tool making knowledge. Thus it is more cost and time efficient to manufacture polystyrene patterns in-house. The Patternmaker would work closely with the Designer and Bench Toolmaker.

Figure Two: Activity Chain- Plastic Mould and Pressure Dies



**Note:** Metrology and QC inspection functions will also occur in Figure 2 after each process in the manufacture from block-up to after the welding process. Proper QC inspection through the manufacturing process avoids further work being done on unacceptable stages in the process, thus saving costs.

**Blocking Up** is the process whereby, blocks of tool steel are prepared for later machining to form components in the final tool. This process is particularly important in the preparation of tool steel for blanking and form tools where a number of individual steels are fitted together to produce a profile shape. Press tools will often be made from custom die sets. These are pre-prepared and may not require the full Blocking Up process. Most of the components of a press tool will be individually machined to shape and drilled and tapped for fixing into the tool. Conventional machining process

such as milling, grinding, drilling and tapping, will be employed. Blocking Up Machinists will have served an apprenticeship and will tend to specialise in one of the standard disciplines. E.g. A milling Machine Operator.

**Simulation** in press tool manufacture is a relatively new process and has come about due to the advances in CAD/CAM surface and solid modelling and the development of high speed computers. Simple press tools that blank or fold metal do not require simulation. The technique comes into its own with "drawn" components. I.e. where the metal is stretched or compressed, as if you were pressing a hemisphere out of a flat sheet. The design of press tools for complex drawn components used to require tremendous skill and experience to avoid splits or creases in the finished pressing or even to get the tools to work at all. The only way to see if the tool would work would be to make it and try it out. Usually, it would not work at first but a skilled tool maker would gradually adjust it until it did. This process could take a long time and be very costly. Simulation offers a shortcut to getting the tool to work first time. Software predicts the flow of metal between the punch and die in the tool. Though the process can test out the tool design before the tool is made, it still requires the experience of a tool maker to make the virtual adjustments, although there is increasing help from the software. With the ever-increasing demand to reduce lead times and improve quality, simulation is rapidly becoming the norm for tool design companies. Operation of a simulation package requires someone with experience of tool making and tool design, plus good computing skill.

**Cutter Path Generation** is the same for both processes and CNC Milling is now universally used for producing either the electrodes for Spark Erosion or for machining the impressions directly into the tool steel blocks. A rapidly growing CNC Milling process is that of "High Speed" milling, which utilises advances in cutting tool materials and design together with high speed computers. Apart from the reduction in floor to floor time, high speed milling can produce superior surface finishes which requires little or no further work by hand. CNC Milling machines may have a Setter and an operator or a Setter/Operator. Once set up, machining times may be quite considerable, on big tools times may be several weeks, and so it is quite normal for one person to look after a number of machines at the same time. It is also normal, to operate the machines 24 hours a day and seven days a week. CNC Machinists will probably have served an apprenticeship followed by special training probably provided by the machine supplier or by a specialist CAD/CAM company like "DEL/CAM". CNC Machinists will need a good working knowledge of press tool making.

The use of solid electrodes is not widely used in press tool manufacture for spark erosion and the majority of press tools require punches or knives to cut the steel pressing form the flat material. Particularly for press tools, because of an ability to cut fully hardened tool steel, wire erosion is used to produce the cutting edges of blanking and piercing tools. It is possible to produce the punch and die from the same piece of steel at the same time. A Spark Erosion operator would also be able to set the machine and would likely operate more than one machine at a time. Spark Erosion machines are also run on a 24 hour, seven day a week basis if possible. Operators would likely have served an apprenticeship and would probably have specialist training by the machine producers, such as "Charmilles".

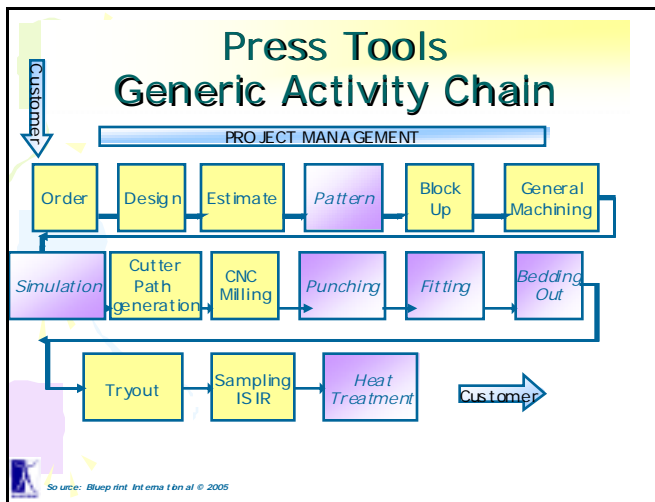
Press tools require more Fitting than Benching. Benching in press tools is confined to removing of machining marks on form tools. The two activities are effectively combined in Bench Hands or Bench Toolmakers, who will prepare and assemble the components of a press tool ready for try out. They

will also make any necessary adjustments after tryout and fully complete the tool ready for production. Benching is a skilled occupation. Bench hands will have served an apprenticeship and will need several years experience to become fully qualified. They may be responsible for tools that may cost many tens of thousands of Pounds Sterling or tools, which may be critical for maintaining production schedules. In modern JIT environments, one item missing from an automobile production line can cost thousands of pounds an hour in lost output.

For progression or tri-axis tooling, the Bench Hand will also assemble the “fingers” and transfer rails that carry the component from one station in the tooling sequence, to the next. Also for these types of tool, there may be a “Lead Toolmaker” and several other Bench Toolmakers, each making a separate tool in the tooling sequence, with the Lead Toolmaker taking overall responsibility.

In the final assembly of a press tool, a critical operation is “bedding out” the two halves of the tool must come together perfectly. Any error in this process will produce a “Burr or “Fraze” - a ragged edge on a sheared edge or hole, which would be unacceptable. The bedding out process is usually carried out on a special press and requires a great deal of skill and patience.

Figure Three: Activity Chain- Press Tools



**Note:** Metrology and QC inspection functions will also occur in Figure 2 after each process in the manufacture from block-up to after the welding process. Proper QC inspection through the manufacturing process avoids further work being done on unacceptable stages in the process, thus saving costs.

Most press tool making companies will have in house try out presses. If they are producing large progression or tri-axis tools, they may be only able to try out individual tools, one at a time. The try out of large progression tools may require using the actual press that the customer intends to use for production. In small companies, Tryout is generally carried out by the Bench Hand. Large companies, with in house presses, may have people specifically trained to do Tryout. In such cases, the person would need to be a skilled and experienced tool-maker. Commissioning is the activity of installing the tool(s), fingers and rails on a customers production press. For ISIR, see below) it is

usually a mandatory requirement to sample the tools in the production environment. The task is usually carried out by the Bench Toolmaker or Lead Toolmaker who has been responsible for making the tools.

Final sampling is usually carried out at the customer's facility. It is very important that the sampling conditions replicate those of production. An ISIR or Initial Sample Inspection Report, is the formalised sampling procedure that most customers require when they purchase a press tool. Basically a Quality Assurance task, the ISIR will call for a full dimension and quality check of the finished component. The requirements of an ISIR are laid down in a company's Quality System and the skills required are those of metrology.

Many tool making companies will have sophisticated measuring equipment such as a Coordinate Measuring Machine, probably with links to the company's CAD CAM system so that measurements can be directly compared with the "native" data (original CAD model). Knowledge and experience of mould and die tool making are not necessary for measuring. The components of Press Tools are produced in the "soft" condition, so all cutting edges and possibly forming tools will require final Heat Treatment, or in the case of components to be wire eroded, heat treatment before machining. The process is a metallurgical one and does not require the skills of a toolmaker. Welding repairs to press tools are not as critical as with moulds and dies.

### International Standards & Measures in the Tool and Die Industry

The following standards and measures apply internationally:

**Table Nine: International Norms and Standards**

Item	Comment
<p><b>Standards:</b>  In house  ISO 9000</p>	<p>The standards for most tools are set by the customers. Toolmakers, in general, will have experience of supplying a particular industry and if the customer does not have a specification, it is left to the tool makers judgement and they will supply the normal standard for that industry.</p> <p>The automotive and similar industry customers will have comprehensive standards which they will have developed themselves and which they will negotiate with their suppliers.</p> <p>Accreditation to National standards such as ISO 9000 will often be a requirement for smaller customers but the automotive industry has now set its own standards, based on ISO 9000 but going a lot further.</p>

Item	Comment
	<p>In the case of press Tools, the tools will often be produced to operate on a specific press but will almost certainly be able to run, with relatively minor modifications, on other presses of the same size or larger. There is generally more flexibility on moulds and dies.</p> <p>Standards will vary from industry to industry</p> <p>Tooling standards are often related to the life of a tool (expressed in the number of castings. Glass filled plastics have a much shorter life than, say zinc castings and straight polymers.</p> <p>Some sheet metals, such as stainless steel, are particularly difficult and require frequent adjustment or refurbishment of the tools to maintain the quality of finished product.</p>
Measures	<p><b>Tool Makers are measured and selected by the following characteristics:</b></p> <ul style="list-style-type: none"> <li>The number of skilled tool makers</li> <li>The number of years in business</li> <li>The age and experience of skilled toolmakers</li> <li>The range of skills</li> <li>The number and type of machining and other processes</li> <li>The size range of machines (usually x,y, z dimensions)</li> <li>The maximum size of tools produced</li> <li>The maximum weight of tools that can be handled</li> <li>Quality Standards</li> <li>Number and type of customers</li> <li>The range of "Tryout" facilities</li> <li>The lead Time</li> <li>The amount of in-house design capacity</li> <li>The availability of subcontract services</li> <li>The dependence on subcontract services</li> <li>The ability to provide Rapid and off-tool samples before tool completion</li> <li>The ability to carry out simulation of tools</li> </ul>

Item	Comment
	<p>prior to manufacture  Ability to contribute to the customers  product design process</p>

*Source: Blueprint & Enterplan*

### Focus Country Comparison

The following table offers a clear overview of the relative competitive capability of specified countries in TDM manufacture. No data on the Czech Republic is available.

Table Ten: Country Comparison on Major Competitive Factors

COUNTRY	Canada	Mexico	Japan	Portugal	China	Germany
Demand	US Auto (78%) Demand declining	Shifting from Plastics Low cost moving to China	Huge local demand Production shifting to cheaper areas	Exports= 90 % of production to 70 countries	Prices 50% cheaper than US. Lead times 6 weeks vs. 3 months Stable ex rate	Sales growth of 38% since 1997 80% for domestic market Net exporter
Technology	Moulds (280) Press Dies	Plastic Injection Moulding	All 5 Axis Advanced unmanned processes Rapid prototyping	Highly specialised Wide variety Specialised moulds and Dies	All No 5 Axis Rapid Prototyping	Precision machining Automated Focus on improving quality and productivity
Structure	SMME (under 50) High Wages 8 Largest mould-makers in NAFTA	SMME (under 12) Family owned Low wages Unskilled	SMME (90% under 20) Family owned Massive use of outsourcing and subcontracting	SMME (30)	3 <sup>rd</sup> largest in world Corporates dominate Cheap labour But higher than local average	SMME (80% less than 30 employees)
FDI Financial Performance	Invests Abroad Germany, Eastern Europe and US	US Firms follow their customers to Mexico. High cost of capital (25%)	Invests abroad in SE Asia, US and China	Little FDI	Many large foreign firms in EPZs and IDZs	Investment shifted to Eastern Europe
Clusters	80% in Ontario	Major cities and US border	Near South Tokyo	N/A	Three large city clusters	Four major clusters in eastern Germany
Government Support	Export development R & D Development	Duty protection from 10% to 20%	SMME support available but cumbersome	Export Promotion Training Common	FDI Support Duty Drawback	SMME grants Soft loans R & D

COUNTRY	Canada	Mexico	Japan	Portugal	China	Germany
	<p>t</p> <p>Training</p> <p>Import-Export Bank</p> <p>Soft Loans</p> <p>Export Intelligence</p> <p>Tax Incentives</p> <p>Integrated Advanced Manufacturing</p> <p>Technology Institutes</p> <p>Technology Networks with EU, Japan, US, Australia</p>	<p>Duty draw backs from local manufacturers</p> <p>32 FTAs signed to promote trade</p>	<p>Large Biotech &amp; IT Firms are supported</p>	<p>Tariff system EU Round the clock project with Germany, Mexico and China</p> <p>Collabourative approach</p>	<p>s</p> <p>Tax Incentives</p> <p>Special Economic Areas</p> <p>Preferential Tax rate 15%</p> <p>Special TDM support package</p>	<p>University research Projects</p> <p>Fraunhofer Institute</p> <p>Private institutes</p>
Customer Base	Auto GM, Ford, Chrysler	Large US firms	Automotive big 3 Consumer electronic giants Medical goods IT/Biotech All global majors	Glassware, automotive, electrical, packaging, toys and households	Growing large foreign investors for higher cost economies	Diverse including aerospace, automotives, electronics, machinery, consumer goods and medical
Customer Ownership	Listed largest 5 in the world	US subsidiaries	Large listed companies	MNCs and local consumer firms	MNCs	MNCs
Customer Quality Requirements	Highest Standards	High Standards	High Quality Lags EU & US	ISO 9000	MNCs	World Class
Customer Buying Behaviour	OEMS purchase for plant upgrades and model	Increasing preference for buying locally due to US	Buyers purchase locally due to short lead times and	Require high, complex quality and short lead	Buyers attracted by low prices and short lead	MNCs with world class purchasing practises

COUNTRY	Canada	Mexico	Japan	Portugal	China	Germany
	changes	subsidiaries	quality.	times	times from around the clock production	
Cycles	Technology & Automotive model cycles	Dependent on US economy	Moving offshore-cheaper	Demand less cyclical	Demand high and non cyclical	Demand less cyclical

Source: *Blueprint International (2005)*

### International Case Studies - Focus

The global TDM industry is experiencing a shift from high cost to low cost countries. The most important variables of the TDM industry compared were demand, technology, structure, FDI, clusters, government support and for the customers of the TDM industry, size, buying behaviour, ownership, quality and cyclicity of demand. Selected countries are Portugal, China, Czech Republic, Germany and the UK.

#### *Portugal* – Diamond Analysis

##### Firm Strategy, Structure and Rivalry

Despite Portugal's small size, it has emerged as a world leader in the production of industrial moulds. It is the eighth-largest producer of dies and moulds in the world and it exports to 70 countries. It also remains the world leader in precision moulds for the plastics industry. The TDM industry consists of 250 companies that employs 7500 employees, which are pre-dominantly SMME's employing an average of 30 workers each. They are clustered in the glassware region of Marinha Grande (60 percent) and the town of Oliveria de Azemeis (35 percent) in the northern part of the country. Since its accession to the EU, Portugal's TDMs have evolved from being labour intensive to capital-intensive industries.

##### Demand conditions

Industries served by the Portuguese TDMs are automotive, computer hardware, domestic appliances, electrical appliances, glass, household, medical equipment, packaging and preservation, pharmaceutical, toys, telecommunications and metal working. Several mould makers in the Marinha Grande region have shifted from being solely tool producers to become integrated suppliers of design and manufacturing services, mainly for the European market.

Portugal has a small domestic TDM market of about \$ 84 million in 2001 of which 59% are imported. Being a major exporter to 70 countries, demand is not seasonal but quality is of the utmost importance serving mainly the EU and US markets.

## **Factor conditions**

TDM producers have easy access to tool and mould steels, which are produced by German, Swedish and Austrian specialty steelmakers with a reputation for supplying quality products world-wide. Employment data for Portuguese TDMs are not available but since Portugal is such a large net exporter, the TDM sector is an important employer. Wage rates are also lower than the rest of the main markets in the EU and the US. A stable euro provides a long term stability platform which makes strategic positioning easy for the Portuguese TDM industry.

## **Related and Supporting Industries**

Portugal's TDM infrastructure is enhanced by having access to state-of-the-art machinery from leading German, Swiss and Spanish equipment suppliers. They have access to the latest generation of software, CNC and EDM machines, finite-element-analysis, machining centres, 3-D measuring machines and DNC and CAD/CAM/CAE systems.

Technology capabilities are wide and complex based on sophisticated world-class customers, which force the TDMs to invest 14 percent of sales in new technologies and equipment compared with the 5% in the US. The Portuguese mould industry is represented by Cefamol who has 130 members which produce 90 percent of total shipments. Cefamol lobby Government and include responsibilities such as technological research, professional training, and intelligence exchange between domestic and international groups. It helped found the Centimfe as an advanced R&D centre for Portugal's mould industry. It was provided with the latest computer-integrated manufacturing technology to support companies desiring to improve their quality control and productivity.

## **Government support**

Export promotion is the focus of all support as it is part of the common tariff regime of the EU with its vast market. Collaboration with Germany, Mexico and China is a priority project. Government support is mainly focused on export promotion and training. Cefamol works alongside ICEP (Foreign Trade and Tourism department) to plan and promote mould exports through trade missions and fairs and international conferences.

Portuguese TDMs benefit from the EU EUREKA program known as "around-the-clock" which was a 24 hour collaborative product-development program involving TDMs from Portugal, Germany, Mexico and China. Finally, Portugal has a common EU tariff structure which is very low and gives it preferential access to the EU markets.

## **Germany- Diamond Analysis**

### **Firm Strategy, Structure and Rivalry**

Germany is a major producer of dies and moulds in wide varieties in terms of size, complexity and precision. German TDMs are noted to be involved in downstream activities such as design and engineering of the part for its customer. There are approximately 5000 TDM producers, including captive die and mould producers, 80% of which employ less than 20 employees, 19% employ upto 100 persons and the rest 100 and more.

The industry is concentrated in certain regions serving particular industries. In the Nuremberg area of Bavaria, they serve the toy and electrical industries. In the Baden Wurttemberg region, they serve the metalworking and automotive industry. In the Nordrhein Westfalen region, they serve the lock, metal casting, plastics and metalworking industry and in the Berlin region, the electrical industry. In the former East Germany, there are about 50 independent producers and another 200 captive producers.

In the mid 90's, some German TDMs shifted production to Eastern bloc countries, especially to the Czech Republic or subcontracted parts in order to take advantage of low-cost labour and access to growing markets. Quality was poor and as a result some were forced to follow customers elsewhere such as Mercedes who established an assembly plant in Alabama in the US. Some foreign TDM companies have invested in Germany most notably from Canada and the US.

### **Demand conditions**

German production increased by 9% during the five years between 1998 and 2001. Production of dies and moulds declined to \$ 3,2 billion from a peak of \$ 3,6 billion. However, measured in Euros, Germany showed an increase of 38% over the same period and consumption grew by 45%.. Exports as a share of production fell to 40% from a peak of 45% in 1997. Likewise, imports also reduced to 28% from 30% in 1997.

The customer base is diverse, including automotive, electronics, machinery, consumer goods, aerospace, toys and medical goods producers. Many of these end-users are globalised with world-class products in design and quality. Many of the metal stampers and plastics moulders supply large German automotive and truck, electronics and consumer goods have started to follow their customers to foreign production locations. Data on German TDM consumption is not readily available but we estimate that TDM consumption follows growth in the manufacturing sector, which rose by 7% during 1997 and 2001.

Germany is a net exporter of TDMs with a significant export surplus. TDMs were increasingly imported from the Czech Republic, displacing Italy as the second largest source of TDMs behind Switzerland. The US was fourth largest source whilst very little was sourced from China and Hong Kong. Germany exports 47% to EU countries followed by exports to Switzerland, the Czech Republic and US.

### **Factor conditions**

German TDM producers have easy access to tool and mould steels, which are produced by German, Swedish and Austrian speciality steelmakers with a reputation for supplying quality products worldwide.

Employment in the TDM industry is around 34,000 persons in total. Shortages in skilled engineers and mechanical engineering students plague the German TDM sector. The large companies offer better wages and benefits thus increasing the labour cost to SMME and medium sized companies. The majority of TDMs are small and labour intensive which pushes up the cost of production of

German TDM. IG-Metall, the national metalworking union, is a strong labour campaigner which also make it difficult to reduce wage costs in line with neighbouring Eastern bloc countries.

### **Related and supporting Industries**

Germany's TDM infrastructure is enhanced by having access to state-of-the-art machinery from leading German and Swiss metal-cutting machine tool and other machinery as well as software suppliers. They are world leaders in introducing precision cutting and automated machinery functions aimed at improved productivity. Likewise also leading plastics machinery producers are in close proximity. Technology capabilities are wide and complex, based on sophisticated world-class customers. Access to capital is generally not an issue and German TDM producers are perceived to be leading investors in latest technology and production equipment.

### **Government support**

The German Government provides general support for all domestic manufacturing and along with the German States offers programs for SMME companies, many of whom are in the TDM industry. A specific focus is on R&D activities and generous EU support is also available to German companies. R&D is further supported via universities such as Aachen, Technology Institutes such as Fraunhofer and Bosch, Siemens and several other private research consortia. The federal Ministry of Economics and Technology support SMME assistance for advisory services, training and vocational education, trade fairs and R&D. Grants, soft loans and R&D assistance via the German States are also available.

TDM producers in the former East Germany are reported to have received substantial assistance via Federal tax breaks and States budgets. Assistance in the form of reimbursements for capital expenditure (25 to 30%) subsidised interest on loans, loan guarantees, accelerated depreciation, and reimbursements on R&D expenditures are the norm. In Western Germany, machinery can be depreciated in 3 years.

### **China – Diamond Analysis**

#### **Firm strategy, Structure and Rivalry**

The TDM industry in China is the third largest behind Germany and Japan measured in turnover and consists of 18 000 TDM's ranging from the smallest with 50 employees to the largest with 6,000 employees. Large and medium corporates dominate small family owned businesses. Less evidence of sub-contracting is taking place compared to Taiwan. Many large foreign firms were allowed to follow customers in the automotive, electronics and consumer goods industries in a number of Export and Industrial Processing Zones with its abundance of cheap but skilled labour and an amazing work ethic of long working hours around the clock seven days a week.

Firms encompass a wide range of sizes, based on the number of employees. At the top is Foxconn Precision Components, a subsidiary of Hon Hai Precision Industry Co of Taiwan with approximately 6000 employees who are mainly designers and toolmakers. Another large toolmaker is Altrust Precision Tooling Company with about 1500 employees. The large tool rooms typically employ 600

to 700 with mid-sized firms employing 150 to 300 employees with smaller firms of at least 50 employees.

Since 70 percent of TDM production is captive, which includes stamping facilities as well, it is likely that these producers have a corporate structure which is uncommon to most competing nations. Foreign-invested firms and state owned TDM producers are likely to have corporate structures. By contrast, newer, indigenous, privately owned TDMs were started by workers who have accumulated sufficient capital and experience to go into business for themselves, as owner-run operations. Many indigenous TDM producers lack financial management skills and few have cost accounting systems in place to prove profitability.

A cluster of the TDM industry is located in each of the three largest cities. In Zhejiang Province, south of Shanghai about 60 percent of all industrial moulds are produced with a sizable portion being captive or in-house production. Production in the Shanghai metropolitan area is focused on small, high precision moulds, as well as tooling for the automotive sector. In the Guangdong Province of southern China, TDMs are primarily for the production of toys, plastic appliances and electronic products.

In these clusters, a number of large contract manufacturers specialise in serving the multinational electronics companies with designing, moulding or stamping and assembly of electronic products. These contract TDMs have well equipped large facilities to build the necessary contract parts and components. If required, these firms will subcontract TDM production to outside suppliers. Contract manufacturers have hundreds to thousands of employees and hundreds of tooling designers and toolmakers on the payroll. These contract manufacturers tend to be foreign-invested companies, usually from Taiwan, Singapore or the USA.

Overcapacity is emerging in China, but with the growth in automotive production, the TDM industry will probably be able to sustain its growth. Nevertheless, company names are changing frequently which indicates consolidation and focused demand conditions. The market is normally defined by end uses and the degree of precision and complexity. Excess capacity results in very strong price competition mainly in the medium-level precision TDMs for the electronic and household appliance industries.

Given the size and diversity of the Chinese TDMs, specialisation appears to be market oriented. Many of the captive TDMs produce tooling for their own use. Many foreign owned TDMs serving MNCs in industries such as electronics, telecommunications and consumer appliances are now focusing on the Chinese automotive market and will displace foreign suppliers of automotive tooling. It is more profitable to produce automotive parts and a shift by TDMs towards component manufacture is emerging in China. The smaller indigenous TDMs are serving the market for simple household items or subcontracting.

The FDI TDM customers are demanding customers and to ensure delivery, high quality materials are sourced from Europe. Indigenous customers are less demanding and lower quality materials and machining is required at low prices. Lead times are generally better compared to US TDMs due to worker willingness to work 24 hour shifts 7 days a week. Lead times for similar tools are 6 weeks in China compared to 3 months in US.