SECTION THREE- SITUATION ANALYSIS

We commenced our work by holding a workshop with the counterpart group and other key stakeholders to brief them on the scope of our work and the participatory approach we wanted to adopt. Blueprint sought to secure agreement to this process and confirmation from stakeholders. We then reviewed the domestic, regional and international markets for Tools, Dies and Moulds (TDMs). This research focussed on segmenting the market and identifying primary end users and the supply chains they currently use to obtain product. We focussed on identifying typical volumes, price structures and quality standards that end users expect from their TDM suppliers as well as Quality Control (QC) mechanisms and trade and trade barriers.

We assessed the global and local industries through a process of industry, sector, diamond and cluster analyses. We conducted a competitor analysis as it was important that we understood how competitor nations developed and in particular how they engaged successfully with their markets. The competitor analysis enabled us to identify the competitive advantages of each of the major supply chains to inform the proposed strategy. Finally during this stage, we carried out a strategic review of the state of the sector in South Africa against the competitors; and identified the main gaps that have to be addressed in the strategy.

GLOBAL TDM INDUSTRY

Background

The International TDM industry is quite probably larger than official reports actually state. With growing world markets and the more frequent introduction of new designs of consumer products, the demand for new tools, dies and moulds (TDMs) will continue to increase.

Domestic tool making developed in Western countries, mainly by entrepreneurial toolmakers setting up in their own businesses in order to supply specific customers. Basic machining processes would support highly skilled people who had probably been trained on apprenticeships with large companies such as automobile producers and their first and second tier suppliers. The latter would be press shops and moulding companies. In the pursuit of lower costs and the fashion for reducing "indirect labour", larger companies with in-house tool-rooms either sold off or closed down their tool making activities. Redundant toolmakers with redundancy payments and a market have set up their own businesses. Those that invested in the new technologies have expanded and survived, though not all. There are many casualties due to loss of markets, shortage of cash, poor cost estimating and a shortage of skilled workers. The latter is due to few apprenticeships being offered.

Many tool making companies have gone out of business in the EU due to a shortage of cash as opposed to a shortage of orders. There are two principal reasons for this. Firstly, tool making is not an exact science, although with modern technology the situation is getting much better. Tool manufacturing contracts are mainly won by competitive tender, so margins are usually very tight. The cost relies on the ability of the cost estimator to get it right first time as normally one offs are manufactured. The cost estimator has to accurately determine the tool making process (how the tools work) and the toolmaker has to make the process work. In press tooling, mistakes are very expensive and one contract can destroy a whole company.

Payment terms for tooling can be very difficult for the toolmaker. For big press tools (transfer & progression), the payment terms have traditionally been 30% with order, 30% when ½ complete, 30% on delivery of Initial Sample Inspection Report (ISIR) and 10% on completion. With tool manufacturing times of up to 26 weeks and costs of $1 to $2 million, cash flow can become very problematical. Added to this are delays to the programme due to customer design changes and cash flow can become fatal. Western banks are not very supportive of tool-making companies. Because many of the invoices are not accompanied by deliveries (i.e., they are for stage payments), they will not lend money or provide overdraft facilities.

The development of the Pacific Rim countries has come about due to much reduced labour costs, investment in more modern machines and technology and a much more aggressive approach to developing new business. Up until the late 1990's, the labour cost of Western tool making was in the order of 50% due to the very high salaries that had to be paid to skilled workers. The de-skilling of the processes and the lower labour costs in the East and European countries such as Portugal, Italy and Spain have produced a lot of competition. Much of the UK automotive tool-making contracts go to Japan. Second and third tier suppliers are purchasing increasing numbers of tools from Pacific Rim countries, more latterly Korea, Vietnam, China and the Philippines. Price, payment terms and delivery times are strong motivators although there are many criticisms of quality, particularly with tools from China – mainly the robustness of design rather than for any other reason.

With the de-skilling of both design and manufacture of tools, due to improved technology, the choice of a tool supplier is swinging more and more to the best price and the quickest delivery. Robustness of design and quality of produced component will always be significant factors but often, the people making the decision of where to purchase their tools do not have the knowledge on which to base a quality decision. The quality of the tool design is paramount. Though software tools can contribute considerably, it still requires a skilled tool designer, Metrologist or input from an experienced toolmaker to interpret and use the software.

Proximity to the market is another important consideration. The market for the tools is the producer of the components and therefore not necessarily the producer or vendor of the finished assembly. Most Western purchasers of tools are not comfortable with dealing with the Far East. It is important to note that the person responsible for the performance of the tools, usually the Tooling Engineer, may not be the person who makes the decision where the tools area bought from. The converse is also possible. So, when looking at markets, it is important to know who the decision makers are.
Tools will always need to be serviced or repaired, often quickly. With JIT production methods, Statistical Process Control and accidents, the ability to do a quick repair is vital. Purchasing tools from a distant tool manufacture can put a component producer at risk. There will always be a need for local support.

Local Tool manufacturers in the EU and UK cannot win new tool making business and are finding it increasingly difficult to retain the skills necessary to offer a reliable service. One way around this problem is for tool manufacturers in high cost countries to form partnerships with tool manufacturers in low cost countries in order to import new tools and service and modify existing tools. In this way, a reduced but adequate level of skills can be retained and in the long term, as wage rates even out, local tool making may be able to be resumed.

Although the processes and technology of the Tool Manufacturing Industry are, in general, common to all activities, the individual tool manufacturing companies tend to concentrate on one area of activity only. There are two basic reasons for this: Firstly, there are different skills required for each sector of the industry. Though the machining and metal processing techniques are essentially the same, the design, assembly and finishing of the tools requires the relevant experience and skill. Secondly, it is necessary to try out or prove the tooling before it goes into production. Most tool making companies will be limited by the try-out facilities that they have in-house and may be heavily dependent on their customers for this activity. Try-out facilities are very expensive for tool makers.

Tool manufactures vary in size from one-man operations up to global enterprises. Reports indicate that 80% of tool making companies are SMEs. The reality is that this figure is probably conservative. Many tool manufacturers are fairly anonymous, having a very small number of customers and not appearing on any lists or in any directories. They may be categorised as just "engineers" or "precision engineers". Some tool-makers may be "tool rooms" within a larger company, producing tools for in-house use and producing tools on a subcontract basis for other companies. Many tool - manufacturing companies employ specialist subcontractors to smooth out widely fluctuating manufacturing capacity. This is because tool contracts tend to come in "lumps". These subcontractors may work entirely for tool manufacturers and do not appear on any lists or in directories under too manufacturing. Typically, these subcontractors would supply CNC machining and EDM (Spark Erosion). Similarly, tool manufacturers often employ subcontract tool designers. These may be self-employed people or tool design companies. Consequently, their numbers may not show up in tooling industry surveys.

Central and Eastern Europe (CEE) is emerging as a strong competitor for Western toolmakers. Labour costs are a principal consideration. The CEE tool making companies have an abundance of skilled labour and are fairly well equipped but their technology is about 10 to 15 years behind the front-runners in Europe and the Far East. They have good, up to date, CAD facilities and skills but lack the latest CNC technology, particularly CNC EDM and High Speed Machining. Many of the tool-manufacturing companies have been born out of state military equipment manufacturers. They have skills and equipment but lack marketing and business skills. As mentioned earlier, in Bulgaria at least, all tools are called "instruments" and the tool making industry sector is referred to as the "machine building" industry. Consequently, potential customers looking for suppliers and even government agencies are unaware of the capacity for tool making within their country. Up until the emergence of democracy in the CEE countries, there were substantial resources for training and teaching tool making skills and for research into new techniques and technologies.

International Industry Production, Consumption and Trade

According to the International Special Tooling Manufacturers Association (ISTMA), total turnover in the global industry grew by approximately 9% from 2002 to 2003 in US$ terms, but declined by approximately 11% in Euro terms over the same period. *(ISTMA (2005) Business Statistics Report*). The industry was valued at over US$ 22,000,000,000.00 in 2003, and average value added per employee also increased in US$ terms. Value added per employee as a percentage of turnover per employee ranged from a low of 41.9% for Switzerland to a high of 68.5% for the UK. Average operating profit for the ISTMA members was down in 2003, to 8.&% to 10.9% in 2002.

Table One; Factory Costs as a Percentage of Sales (Turnover)

ISTMA Members	Standard Parts for Tools	Value of Subcontracting	Material Expenses
Australia	N/A	9.3	43.9
Canada	N/A	11.0	17.5
China	N/A	N/A	N/A
Chinese Taipei	N/A	N/A	N/A
Estonia	6.9	3.3	34.5
Finland	7.0	6.0	13.0
France	N/A	N/A	N/A
Germany	14.1	12.3	32.3
Great Britain	7.8	15.2	32.6
India	N/A	N/A	N/A
Italy	4.4	11.4	22.8
Japan	N/A	N/A	N/A
Korea	7.0	26.0	32.0
Malaysia	13.0	2.1	50.3
Philippines	N/A	N/A	N/A
Portugal	5.2	16.2	38.5
Singapore	N/A	N/A	N/A
Slovenia	5.3	6.9	18.5
Spain	6.2	15.7	29.5
Sweden	N/A	N/A	N/A
Switzerland	8.6	22.8	31.5
USA	3.5	6.3	28.5
ISTMA Average	7.4	11.8	30.4

Source: ISTMA (2005) Business Statistics Report

Costs of standard parts for tools ranged from 3.5% of turnover in the US, to a high of 14.1% in Germany, while material expenses, by far the largest factory cost, ranged from a low of 18.5% in Slovenia to a high of 50.3% in Malaysia. This excludes China, which did not report these figures. The value of sub contracting was highest in Korea, closely followed by Switzerland, and lowest in Malaysia.

The following table indicates costs of personnel (this includes all employees including part time but not subcontractors). Again excluding China, the lowest cost of personnel as a percentage of turnover is reported by Korea (and it is likely that China is lower) and the highest cost was reported by Italy, Finland and the US.

Table Two; Total Personnel Costs as a Percentage of Sales (Turnover)

ISTMA Members	Personnel Costs As % Of Turnover	Benefits As % Of Wages & Salaries
Australia	42.3	27.7
Canada	37.6	22.4
China	N/A	N/A
Chinese Taipei	N/A	N/A
Estonia	35.3	33.5
Finland	62.0	71.4
France	N/A	N/A
Germany	45.7	75.6
Great Britain	41.8	35.0
India	N/A	N/A
Italy	48.6	10.1
Japan	N/A	12.7
Korea	18.0	12.0
Malaysia	22.1	36.0
Philippines	N/A	N/A
Portugal	42.0	52.0
Singapore	N/A	N/A
Slovenia	42.5	38.9
Spain	39.5	36.0
Sweden	N/A	N/A
Switzerland	38.0	34.1
USA	48.4	30.1
ISTMA Average	40.3	41.2

Source: ISTMA (2005) Business Statistics Report

The report indicates fairly limited investment across the board in new machinery and equipment (again expressed as a percentage of turnover) at under 15% for most, with the exception of Estonia which invested 16%, and falling as low as 0.2% for Canadian firms.

The industry overall relies heavily on overtime as a strategy for dealing with periods of higher workloads. In Korea and Malaysia, actual hours worked in 2003 averaged approximately 130% of normal working hours per annum, while in the developed economies actual hours worked were lower than normal hours.

Wages and salaries vary enormously- although India and China did not report theirs. As the following table indicates, Switzerland, followed by the US and the UK, pay the highest hourly rate for mould makers and skilled tool and die makers (in Euros) while Estonia, Korea and Portugal pay the lowest rates. It seems reasonable to assume that Chinese and Indian rates will be as low or lower.

Table Three; Wage and Salary Comparison-1, Euros, May 31st 2004

	Skilled Mould maker Wages Per Hour			Skilled Tool & Die Maker Wages Per Hour		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Australia	9.97	15.47	12.16	9.97	15.47	12.16
Canada	9.93	22.57	15.46	10.53	22.57	16.97
China	N/A	N/A	N/A	N/A	N/A	N/A
Chinese Taipei	N/A	N/A	N/A	N/A	N/A	N/A
Estonia	1.92	4.15	3.51	1.92	4.15	3.90
Finland	10.90	14.20	12.80	10.90	14.20	12.80
France	N/A	N/A	N/A	N/A	N/A	N/A
Germany	12.64	19.22	15.85	12.64	19.22	15.85
Great Britain	15.33	18.04	16.91	15.05	16.91	15.99
India	N/A	N/A	N/A	N/A	N/A	N/A
Italy	10.79	14.10	12.32	10.79	14.10	12.32
Japan	11.01	19.02	13.90	N/A	N/A	N/A
Korea	4.89	6.46	5.76	3.76	5.49	4.67
Malaysia	12.31	16.41	14.77	12.31	16.41	14.77
Philippines	N/A	N/A	N/A	N/A	N/A	N/A
Portugal	6.00	15.00	9.62	N/A	N/A	N/A
Singapore	N/A	N/A	N/A	N/A	N/A	N/A
Slovenia	10.58	16.65	N/A	11.38	18.02	N/A
Spain	12.50	16.95	14.73	12.50	16.95	14.73
Sweden	N/A	N/A	N/A	N/A	N/A	N/A
Switzerland	15.18	33.76	23.49	15.18	28.13	22.83
USA	15.59	20.51	18.05	14.77	18.07	16.41

Source: ISTMA (2005) Business Statistics Report

Designers are more highly paid in Switzerland and Germany than anywhere else and are the highest paid of all skilled workers. In the absence of data from China and India again, Estonia, Korea and Portugal are the nations where the lowest Euro rates are paid. The pattern is repeated for machine loaders and foremen.

Market Share

Germany had the highest sales in US$ terms in 2003, followed by the USA and then Japan. Together these three countries made up 61% of all industry turnover. Canada, Italy, Malaysia and Spain form the second tier and together made up approximately 28% of industry turnover. Of the third tier suppliers, the UK, Australia, Portugal and Switzerland dominate.

From an export perspective, as the following table indicates, Germany is the largest exporter, followed by Canada and the US. Canada exports virtually all of its production, primarily to the US while Germany and the US both generate approximately 20% of their total turnover from exports.

Table Four; Exports of Moulds, Tools and Dies by Country, by Category

		Moulds for plastic and rubber	Moulds for metal or metal carbides	Jigs and fixtures for specific applications; sets of standard jig and fixture components	Standard Tooling Components	Precision Machined Parts	
	CN code 8207 30 10	CN codes 8480 71 00 8480 79 00	CN codes 8480 41 00 8480 49 00	CN Code 8466 20 10	CN Code	CN Code	
Exports in $US							
Australia	10,148,016	46,695,754	12,168,406	N/A	4,332,529	N/A	73,344,704
Canada	202,460,227	859,633,247	21,568,946	17,209,989	N/A	N/A	1,100,872,410
China	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chinese Taipei	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Estonia	928,937	9,662,266	109,583	3,321	N/A	N/A	10,704,107
Finland	592,244	3,603,867	567,042	693,051	0	0	5,456,204
France	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Germany	493,695,753	848,967,732	112,106,725	103,917,378	67,949,274	N/A	1,626,636,861
Great Britain	60,900,389	66,702,382	N/A	N/A	N/A	N/A	127,602,772
India	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Italy	168,577,341	663,084,426	264,935,413	6,226,729	N/A	N/A	N/A
Japan	296,958,438	311,475,410	125,919,564	N/A	10,913,402	N/A	745,266,814
Korea	23,412,866	16,192,714	N/A	N/A	251,805	N/A	39,857,385
Malaysia	118,940,000	208,620,000	28,500,000	9,880,000	N/A	N/A	365,940,000
Philippines	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Portugal	10,231,897	358,139,578	13,347,040	622,505	N/A	N/A	382,341,020
Singapore	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Slovenia	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spain	297,574,824	96,930,161	9,044,950	N/A	N/A	N/A	403,549,935
Sweden	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Switzerland	79,519,650	281,551,280	11,798,647	23,354,856	N/A	N/A	396,224,433
USA	365,962,739	478,026,091	85,886,470	147,766,646	47,658,599	N/A	1,125,300,545
Total							6,403,097,191

Source: ISTMA (2005) Business Statistics Report

The US is the largest importer of Moulds, Tools and Dies followed by Malaysia. Both countries import substantially more than they export, while Germany, Canada and Japan are net exporters.

NORTH AMERICA

Canada

The Canadian tool making industry developed to supply the USA automotive industry in Detroit. Many skilled UK nationals emigrated to Canada in order to work in the tooling industry.

Most of Canada's Tool, Die and Mould (TDM) production is exported to the U.S. automotive sector. The United States is Canada's leading trading partner for TDMs, with total trade (imports plus exports) far exceeding trade with all other countries combined. Overseas-based motor vehicle producers are increasing their investment in North America and these transplant producers tend to import TDMs from their home countries. As the transplants share of North American automobile production increases, Canadian TDM firms may be facing a declining demand for tooling in this market, unless they are successful in winning business from the non-traditional North American automotive producers.

Exchange rate fluctuations make a difference - the Canadian dollar depreciated against the U.S. dollar during 1997-2001, giving Canadian TDM producers a potential competitive advantage on sales to the US. Some sources contend that with a favourable exchange rate, prices of Canadian produced TDMs can be as much as 40 percent lower than comparable US tooling, while Canadian sources consider the prices of Canadian-produced TDMs to be roughly equal to U.S.-produced TDMs. Costs for the manufacture of moulds are estimated to be very similar to those in the U.S. in terms of raw materials and capital costs. Canadian mould makers must purchase materials and equipment on a U.S. dollar basis but labour costs, however, are affected by fluctuations in the exchange rate.

As a result of the efforts of the Canadian Tooling & Machining Association in November 2004 the Ontario government introduced an Apprenticeship Training Tax Credit program to ensure that employers in Ontario have the means necessary to expand their commitment to skills training. The legislation for the tax credit received Royal Assent in the Ontario Legislature on December 16, 2004 and is now part of the Corporations Tax Act under Section 43.13 *(http://www.e-laws.gov.on.ca/).* Businesses are now eligible for a 25 percent refundable tax credit on wages and salaries paid after May 18, 2004 to eligible apprentices during the first 36 months of an apprenticeship. Businesses with total payroll costs not exceeding $400,000 are eligible for a higher tax credit rate of 30 percent. The maximum tax credit per apprentice is $5,000 per year over the first 36 months of the apprenticeship. The tax credit can be claimed on the annual corporate income tax return beginning with 2004.

Canadian TDM demand is generated almost entirely from the North American automotive market. 78% of all TDM production is automotive tooling aimed at the big three, GM, Ford and Daimler-Chrysler. From a technology perspective, moulds and press dies are the dominant technology used. Most TDMs are SMMEs employing under 50 permanent workers, but these firms are larger than the US firms. Eight of the largest mould makers in Canada are also in the top 20 mould makers in the US in terms of size. The industry in Canada is characterised by high wages but is still 1,8% cheaper than US competition. Over 80% of TDMs in Canada are in Ontario province, and use the technology required by the US Automotive OEMs. The North American auto giants are constantly developing new models to be introduced in the market globally and as such demand plant upgrades and tooling investment to support new styling and technology in their vehicles. However, the downside is the impact of lower sales of autos in the US- when this occurs, the OEMs push out new model production and this factor impacts negatively on the Canadian TDMs. Also, GM, Ford et al are pubic listed companies with global operations. The serious decline of profitability in GM and Ford poses a threat to Canadian TDM industry as these customers will be forced to source cheaper tooling from low cost countries like China.

Government interventions to assist this industry in Canada emphasise Exports, R&D and skills development. Soft loans from the Canadian Import Export bank, competitor intelligence and tax incentives are well developed support measures. An Integrated Advanced Manufacturing Technology Institute and a technology network cluster with US, EU, Japan and Australia is well utilised

MEXICO

Despite Mexico's rise to prominence as a North American manufacturing platform for a wide range of TDM-using sectors, its TDM industry is small and limited by comparison. Indigenous producers are relatively few in number and are predominately small-scale operations (1-12employees) generally family-owned or with a single owner, and often service a primary customer or are captive operations. Mexico's TDM industry is clustered in three major industrial and manufacturing centres. For example, there are more TDM shops in the central interior cities of Celaya, Guadalajara, Mexico City, Querétaro, Puebla, San Luís Potosí, and Toluca, and in the northeastern cities of Monterréy and Saltillo than anywhere else in the country. Likewise, TDM shops, which are predominantly U.S. owned, are concentrated along the U.S.-Mexico border area, particularly in the cities of Tijuana, Ciudad Juaréz, and Reynosa, among others.

In the Mexican TDM industry, there are reportedly some good "B-class" shops, but reportedly no world-class mould makers whereas high-quality "class-A" tools are largely sourced from the United States. For indigenous firms, shortages of skilled TDM builders and limited technology hamper their ability to produce high-quality TDMs. Likewise, there is the perception that some Mexican shops can produce smaller or less complex TDMs for small customers at lower prices, but not in sufficient quantities to satisfy domestic consumption. Hence, many TDMs, particularly new, larger, or more complicated products required by manufacturers and assemblers operating in Mexico are almost always sourced from abroad, primarily from the United States. The majority of Mexican TDMs typically do not have ISO 9000 certification and are unable to meet the ever-increasing production standards of major TDM-using customers.

Because of growing demand for skilled TDM builders and an inadequately skilled workforce, manufacturers have had to invest in training on their own or form training partnerships with local schools. A number of trade and technical schools are turning out several hundred TDM builders annually, but not to the extent necessary to meet current demand.

Mexican TDM demand is generated almost entirely from the North American plastics market. Recently, there has been a shift towards metal and glass packaging , auto parts and consumer goods industries products as well. The Mexican TDM's are severely threatened by Chinese competition in the lower tolerance markets where cost of tooling is key. The traditional Mexican TDM industry was established for low cost and quality plastic injection moulding aimed at the electronics industry of North America. Now, the big North American auto giants and electronic and IT customers resident in North America forms their customer base.

The Mexican TDM industry largely consists of SMME's, which employ less than 12 permanent workers and are traditional family owned repair shops for North American customers. They are ranked as among the best B-shops in the world as opposed to the high tolerance A shops. They employ unskilled cheap labour and often, material prices are less competitive. The North American subsidiaries of the large TDM's are increasingly based in Mexico to enjoy access to lower labour costs. The TDMs are spatially located in the large central cities but also along the US – Mexican border.

There is little evidence of FDI in the Mexican TDM industry but North American electronic and IT giants such as Hewlett Packard and Lucent Technologies have invested in transplant operations. The banking sector is poorly developed and the high cost of capital of between 25% and 35% hampers investment in the TDM sector. Demand is largely linked to the North American market and Mexico suffered recently due to the contraction of that market. Duty protection of between10% to 20% exists but local TDM's qualify for duty draw-backs. Mexico also focuses on trade enhancement via FTA's with 32 countries globally, some of which are large competitors.

Certain import duty, value-added, and inventory taxes, and standards-compliance certification exemptions are offered to manufacturers by the Mexican Government. However, few, if any, directly promote domestic TDMs but several facilitate competition from foreign TDMs. For example, although imports of most TDMs and parts thereof into Mexico are subject to a normal duty rate of 10 to 20 percent ad valorem, a great majority enter exempt from duty or at reduced duty rates under various free-trade agreements (FTAs) and export promotion programs. Mexico has negotiated FTAs with 32 countries, most which exempt or are phasing out import duties on TDMs. Moreover, the recently enacted Mexico-European FTA will provide NAFTA-like benefits to EU producers similar to those currently enjoyed by U.S. TDM producers exporting to the Mexican market.

USA

The U.S. industry is made up of about 7,000 firms, with more than 90 percent employing fewer than 50 persons. Tool, Die and Mould (TDM) operations are concentrated in areas that have historically supported extensive manufacturing activity: Michigan, Illinois, Ohio, California, Pennsylvania, Indiana, and Wisconsin. Many US domestic producers have invested in up-to-date production equipment and sophisticated computer software resulting in decreasing lead times and increasing productivity and capacity.

Adverse conditions in recent years have resulted in downsizing at many firms, according to recent industry information, and the exit of many firms from the industry (at least 200 firms in the past three years). Shipments and average hourly earnings rose during 1997-2000. During 2001-2002, however, publicly available data indicate sharp declines in employment and average weekly hours. Data show a 20 percent drop in shipments. *(International Trade Commission (ITC) of the US (2002); Tools, Dies, and Industrial Moulds: Competitive Conditions in the United States and Selected Foreign Markets ITC Investigation No. 332-435)*

Since demand for tooling is heavily dependent upon new product introduction in the automotive industry (which absorbs nearly 50 percent of tooling), the industry weakens when automotive manufacturers delay new product introduction in order to build up their balance sheets. At the same time, many of the industries supplied by U.S. toolmakers, such as appliances, have become very cost-competitive, forcing many tooling customers who produce in the US to reduce product costs by sourcing their tooling from less-expensive foreign locations.

The compression of product cycles in many key industries (such as automotive, appliances, electronics and telecommunications) due to competitive pressures has required toolmakers to adapt to these product cycles by shortening their lead times to supply tooling to OEMs. In many cases, these shortened lead times have favoured foreign toolmakers, particularly in Asia, who frequently operate their plants 24 hours a day to supply customer orders.

For many items that are easy to ship, such as small appliances and electronics or telecommunications items, it has become cost-effective for manufacturers to produce in low-cost foreign locations, such as Asia, for shipment to the U.S. market. This is especially the case for products like air conditioners, radios, vacuum cleaners, power hand tools, televisions, and telephones, which are increasingly produced abroad. This has adversely affected U.S. toolmakers who no longer supply the tooling for many of these items because the TDM sourcing has shifted to foreign locations along with the manufacturing.

Canada is the largest U.S. trade partner accounting for 41 percent of U.S. TDM import value and 34 percent of export value in 2001. Other important trade partners include Japan (accounting for 33 percent of import values) and the EU (almost 16 percent of import value). Although the value of U.S. TDM imports from many countries peaked in either 1999 or 2000, imports from China and Korea, among other countries, continued to rise to higher levels in 2001. During 1997-2001, U.S. TDM imports from China and Korea rose by 191 percent and 248 percent, respectively, albeit from relatively low bases.

The major U.S. export market, other than Canada, is Mexico which accounts for 27 percent of total TDM export value in 2001. Canada and Mexico overshadow all other markets with the third largest export destination, Germany, accounting for only about 4 percent of total TDM export value.

U.S. TDM producers ranked competition from low-cost imports as their number one concern in their responses to Commission questionnaires. The second biggest concern was the shift of production by U.S. customers to foreign production locations. They also listed, in descending order, high U.S. labour costs, healthcare costs, and insurance costs.

US Government Assistance Programmes

At the Federal level, six programs offer loan guarantee or financial assistance. These programs are geared towards facilitating loans to companies that have short-term needs or that may not acquire loans under normal financing circumstances. At the state level, ten programs currently exist for the selected states that offer loan assistance to firms. Both Federal and state governments provide assistance through various consulting services that offer firms advice on how to improve daily operations and adjust to the challenges of competition and the changing marketplace. In addition, there are five training assistance programs that can be used by TDM firms to facilitate training for apprentices and workers.

Many TDM firms in the US have access to loan guarantees and diverse financing/working capital assistance through a variety of widely available Federal and State programs, which are intended to help with short-term needs by acquiring loans that may not be feasible under normal financing conditions.

Programs also provide assistance for improving a firm's competitive ability. Such assistance has been used for a variety of activities, including the acquisition of International Standards Organization (ISO) or other quality assurance standard certifications, materials engineering research, computer design and manufacturing software implementation, apprenticeship programs and workforce training, productivity improvement and business planning, market analysis, energy audits, application of information technology and electronic commerce, and tax abatement.

Some government programs facilitate services to individual firms through extensive networks of various local assistance centres. These include assistance offered through Trade Adjustment Centres (TAACs), the Manufacturing Extension Partnership (MEP) nationwide network, SBA's Small Business Development Centres (SBDCs), as well as State and regional offices of other Federal and State programs that work with local leaders.

ASIA

China

During the 1990s, China emerged as the chief competitor to the TDMs of the developed nations. The Chinese government has liberalized regulations on foreign-owned companies, thus making it more attractive for large manufacturers of consumer products to locate plants in the country. As long as Chinese suppliers were unable to meet international quality standards or to satisfy delivery schedules the developed country's die/mould shops enjoyed a substantial measure of protection but this seems to be no longer the case. Most of the TDM shops in Shenzhen (. A substantial portion of China's export metalworking industry is based in the Pearl River delta area north of Hong Kong in the fast-growing city of Shenzhen) have been built recently and have up to date equipment and the average shop employs 100 to 350 machinists. The larger shops may have as many as 1,000 employees and produce 200 to 500 moulds per year.

China initiated a nationwide program known as the quality advantage strategy in 1991. This program has now been extended to every sector of Chinese industry. The country has also enlisted the services of mass-marketing consultants from the United States and other nations to develop strong international brand identities for Chinese products. A major thrust of this new approach involves upgrading Chinese manufacturing practices to conform to international standards. In 1991, the government began to encourage manufacturing plants to pursue ISO 9000 certification. By June 2000, Chinese officials reported that more than 27,000 enterprises had been certified. At the same time that quality improved, the Chinese government cracked down harshly on producers of substandard or defective products.

According to China's National Bureau of Statistics, the country currently has more than 8,000 metalworking enterprises. The Bureau also estimates that current annual sales in China's metalworking industry total approximately $23.5 billion. In addition to Asia's rapid technological development, the competitive challenge faced by developed economies is heightened by the region's substantially lower labour costs and well-organized training programs. Technical schools in Hong Kong and Singapore are currently graduating substantial numbers of fully trained, young metalworkers.

In a rigorous and uninterrupted 3-year program, ITE turns teenage students into competent mould makers who, when they graduate, are ready to cut metal and are capable of designing and building moulds, and can operate all related machine tools. The school's curriculum begins with a foundation of classroom studies that includes a strong emphasis in computer science. Students then begin hands-on training with simple, manually operated machines, working their way up to the most sophisticated CNC equipment.

China has a massive oversupply of labour that is caused by the migration of a huge number of poor people from rural areas to the country's fast-growing cities. The majority of these migrant workers are women who typically are paid only $40 to $60 per month. In Chinese machine shops, this equates to an unlimited supply of extremely cheap labour for supporting tasks such as polishing, assembly and packaging. Although China's machine shops are surprisingly well-equipped, employees have very few workplace rights compared to their U.S. counterparts.

According to the China Die and Mould Industry Association (CDMIA), China has experienced substantial growth in its industry (15% per annum since 1995 is claimed) due to the increase in manufacturing activity in the country. The CDMIA reports that China has approximately 20,000 tool and die making factories in China employing over 500,000 people. In 2004, the industry turnover was 45 Billion RMB or approximately 6 Billion US$. This makes it the largest turnover in the world, ahead of Germany at US$ 4 Billion turnover and the US at US$ 3,5 Billion. Growth has been phenomenal and reflects China's performance in other industries over the same period. Of this turnover, press dies makeup 41%, followed by plastic moulds at 39%. Foundry dies make up only 9.5% of total turnover.

Notwithstanding its high levels of local production, China is a major importer of moulds, tools and dies. In 2003, it imported US$13,69 Billion and exported only US$ 3,37 Billion. However, the rate of growth of Chinese exports (36% increase from 2002 to 2003) is beginning to exceed the rate of growth of imports (7% over the same period), albeit from a much lower base. Over 70% of its imports are for plastic and rubber moulds (56.9%) and press dies (34,9%). 67.6% of all China's imports are from Japan, Korea and Taiwan, and 7,2% are imported from Germany. Hong Kong, Indonesia and the US are the major export markets, which make up 56.8% of all exports from China. (*Source: CDMIA (2004): The situation and development trends of China Mould and Die Industry. Refer CD for full presentation)*

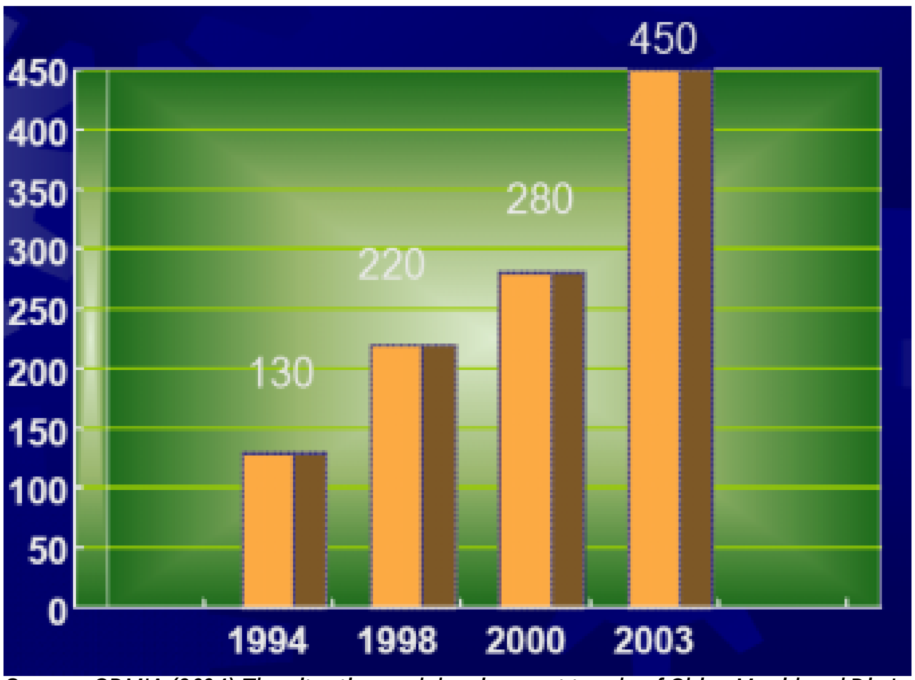
About 70 percent of Chinese TDM production is integrated, allowing such companies to provide both tooling and parts production. Unlike other major TDM producers, China has a substantial number of large, foreign-invested TDM producers. Foreign investment has largely resulted from integrated foreign tooling suppliers following their customers to China. *(International Trade Commission (ITC) of the US (2002); Tools, Dies, and Industrial Moulds: Competitive Conditions in the United States and Selected Foreign Markets ITC Investigation No. 332-435)*

Chinese TDM demand is large and growing due to its ability to supply 50% cheaper than the USA- this secures spectacular growth. A stable and undervalued currency also stimulates demand to the frustration of the developed TDM market. Accession to the WTO opened new markets abroad and the short lead times of the Chinese makes them highly competitive. (6 weeks vs 3 months western world norm). The Chinese TDM industry benefited from the latest technologies investment from foreign companies but does not focus on man-hour saving technologies such as 5 axis machines in

Japan. Rapid prototyping is well established due to a history of IP infringements and reverse engineering (copying) of western world technologies. Large and medium corporate companies dominate the TDMs along with small family owned businesses.

Many large foreign firms were allowed to follow customers in the auto, electronics and consumer goods industries in a number of Export and Industrial Processing Zones with an abundance of cheap but skilled labour and a work ethic of long working hours.

Figure One: Production Value of the Chinese Tool and Die Industry (RMB millions)



Source: CDMIA (2004) The situation and development trends of China Mould and Die Industry

China has the advantages of a low cost, well-educated labour force and a large, growing domestic and international customer base. Chinese wages for toolmakers are among the lowest in the world. Nonetheless, in China, toolmakers are the highest paid profession in manufacturing. *(Source: ISTMA 2005*) However, Chinese toolmakers' wages reportedly are among the lowest in the world. Although official data are not available, labour cost data were gathered from interviews primarily with foreign-invested Chinese TDM producers and trade association officials. The following tabulation shows ranges for average annual wages paid to workers in the TDM
industry (in U.S. dollars):

Table Five: Range of Average Annual Wages 2002 (US$)

Worker Type	Low	High
Unskilled entry-level worker	585	732
Moulding machine operators	732	1,463
Skilled TDM Builder	1,463	5,853
TDM Designer	2,927	5,853
TDM Production Supervisor	4,390	5,122
TDM Manager	7,317	10,243

Source: ISTMA (2005) Business Statistics Report

In addition to employee wages, employers must also pay for unemployment insurance, pensions, allowances (housing stipends, transportation stipends, worker heating and training expenses), health care insurance, disability/work-related insurance, and bonuses. The amount that these costs add to the total labour costs varies by company and location, and as industry sources report, ranges anywhere between 4 to 100 percent. In southern China, TDM producers or parts producers with TDM operations also provide hostel-type housing and cafeterias for their workers.

Its disadvantages include a lack of sophistication and creativity in tooling design, high costs for imported inputs, and low quality domestic TDM inputs. Currently, China appears to have difficulty producing low-cost TDMs of low and medium precision and complexity.

The Chinese Government has provided tax incentives to attract foreign TDM investment and also offers import tariff exemptions on machinery, including TDM production machinery. These incentives are part of a larger set of policies aimed at encouraging foreign manufacturing investment in China. Chinese Government policies and programs benefiting the TDM industry are, for the most part, a subset of those promulgated to attract FDI to China and promote domestic economic stability. At the same time, the Government of China has been reducing the number of State-owned companies and selling many to private investors. China undertook economic reforms beginning in 1978, but foreign investment began to surge in the early 1990s when the government reaffirmed its commitment to allow foreign participation in the Chinese economy. Therefore, policies that encouraged TDM customers to invest in China were also beneficial in attracting TDM producers. Such policies use tax incentives and import-tariff exemptions and/or rebates.290 Chinese TDM producers indirectly benefit from China's stable foreign exchange rate regime.

Hong Kong & Taiwan

The Hong Kong industry has contracted significantly from a peak of 2,000 firms in the mid-1990s to its present level of approximately 50 firms. Much of the industry moved manufacturing operations to low cost facilities in China. Therefore, the Hong Kong tooling industry is highly integrated with, and largely dependent upon, tooling and other manufacturing enterprises in China. Proximity to China combined with Western business infrastructure allows Hong Kong TDM producers to integrate Chinese production with a modern business infrastructure gateway to the world market. Hong Kong tooling producers are able to produce many types of medium and high precision TDMs and can produce TDMs within short lead times. *(International Trade Commission (ITC) of the US (2002); Tools, Dies, and Industrial Moulds: Competitive Conditions in the United States and Selected Foreign Markets ITC Investigation No. 332-435)*

The Hong Kong Government provides assistance to its TDM producers principally through support of a rapid-prototyping centre and financing for R&D projects on dies and moulds conducted at Hong Kong universities. Hong Kong also provides its small and medium-sized businesses with programs to assist with loan guarantees for facilities and equipment, export marketing, training, and business development. In 1994, with funding from the Innovation and Technology Commission, the Productivity Council and the City University of Hong Kong established a Rapid Prototyping Technology Centre. This centre also sells rapid-prototyping services, and thus competes with private companies offering such services. Hong Kong Polytechnic has established a Rapid Product Development Resource Centre equipped with rapid-prototyping machinery to train students in rapid-prototyping production. The City University of Hong Kong, Hong Kong Polytechnic, and Hong Kong University also conduct specific research projects on TDMs. Some projects for the TDM industry are funded by the Innovation and Technology Commission of the Hong Kong Government. Hong Kong Polytechnic opened a Centre for Advanced Manufacturing Research with almost $6.5 million in equipment in 1996 that, among other projects, researches ultra-precision machining for the mould industry. The centre was funded by the Industry and Technology Development Council of the Hong Kong Government.

The Tooling industry in Taiwan developed to meet demand for electrical goods. It has traditionally centred on the plastic injection mould tool industry and small progression tools for mechanical components for electronic/electrical assemblies. Initially Taiwan toolmakers had a cost advantage but this has been eroded over recent years.

The current production and design capabilities of *TDM producers in Taiwan* are primarily based on technologies transferred by Japanese companies that invested in Taiwan in the 1960s and 1970s and trained Taiwan toolmakers. Such training allowed the Taiwan TDM industry to advance rapidly from the production of simple products to the manufacture of medium precision and more complex TDMs. Taiwan producers are known for their short lead times and competitive prices. In the future, the industry intends to focus on the production of high precision TDMs and cultivate the region's expertise as a design and management centre for tooling production. A number of Taiwanese firms operate manufacturing facilities in China. *The combination of manufacturing in China with design and business functions in Taiwan* allows TDM firms to take advantage of low wage rates while controlling key processes. Taiwan firms are also reportedly strong in terms of computerization and international sales and marketing. At the same time, the relocation of numerous manufacturing industries from Taiwan to low-cost productions locations such as China has reportedly hurt those firms that continue to manufacture TDMs domestically. *(International Trade Commission (ITC) of the US (2002); Tools, Dies, and Industrial Moulds: Competitive Conditions in the United States and Selected Foreign Markets ITC Investigation No. 332-435)*

Certain tax, investment, and R&D benefits are available to manufacturing industries by Taiwan authorities; however, only a few are applicable or accessible to TDM firms. Producers of TDMs may be eligible for tax breaks and preferential loan treatment for upgrading or adding production machinery, or they may acquire research grants for product development. Exporting companies might also receive a break on sales and import taxes. Taiwan authorities report that use of such programs by TDM firms is low. With respect to R&D support, for example, approximately $30 million is allotted to all industries per year, but only $148,000 or 0.5 percent goes to firms that produce TDMs. Sources also report that in any given year, there are no more than four TDM companies that apply for R&D grants. Duties on imported TDMs range from none to 11 percent ad valorem. Tariff rates are 5 to 10 percent ad valorem on dies and 4 percent on most moulds, with certain plastic injection and compression moulds having a tariff rate of "free."

India

India has quite a wide range of tool making skills. Tools made in India tend to be of poor quality but very cheap and there is a huge local market.

Japan

Japan is large and well established. In 2000, there were 12,125 producers manufacturing TDMs in Japan, down from a peak of 13,115 producers in 1990. Rather than a consistent decline over the past decade, the industry witnessed periodic increases in the number of establishments during 3 separate years, with the most recent expansion occurring in 2000.

According to industry sources, an irregular flux of new entrants as well as exiting firms generated such spurts and has kept the overall number of producers fluctuating around 12,000 for the past few years. A characteristic of the Japanese industry is the overwhelming preponderance of very small firms. The vast majority of Japanese TDM producers are privately run businesses, with more than 90 percent consisting of fewer than 20 employees. Of that amount, more than 89 percent employ only 1 to 9 workers, with the remaining 11 percent supporting 10 to19 employees. Such businesses are often compact, modest facilities tucked into the residential areas of Japanese cities or suburbs. In many cases, the manufacturing operations are not detached; rather, they are abutted on either side by neighbouring small businesses and private dwellings.

Larger producers with over 100 employees account for less than 1 percent of companies, and only 11 firms operate with 300 workers or more. The larger firms are more likely to operate one or multiple buildings on relatively broad expanses of land outside the city, or within the industrial zone of a particular location. Of the larger companies, only the few truly sizeable firms, e.g., those with more than 1,000 employees or those with multiple domestic and international establishments, are publicly traded. Even those firms considered medium to large operations tend to be privately run enterprises with significant family linkages throughout the corporate management structure. With respect to the cycle of family management, most independent TDM producers, both large and small, are generally in the second generation of operation.

Production of TDMs in Japan is concentrated in areas near and to the south of Tokyo, generally in locations central to Japan's overall manufacturing infrastructure. For example, over 14 percent of total TDM production originates from Aichi prefecture, a key centre for automobile and automotive parts production, with facilities for Toyota, Honda, and Mitsubishi. Aichi is also home to several appliance firms, as well as notable foreign enterprises, with independent TDM operations serving these OEMs as well as Tier 1 and Tier 2 suppliers in the region. With respect to product distribution, Aichi prefecture leads in the production of nearly all types of TDMs, including press dies, forging dies, die cast moulds, and plastic injection moulds. Osaka prefecture, the second largest production centre for forging dies, plastic injection moulds, and rubber and glass moulds, accounts for an additional 9 percent of total sector production. Key consuming industries in this region include consumer electronics, medical goods, and information technology. Other key production centres include Kanagawa and Shizuoka prefectures, each accounting for 7 percent of total TDM production. Notwithstanding the relative concentration of the industry in these key regions (37 percent of TDM production), Japanese TDM manufacturing is dispersed throughout the country, with the top 10 producing prefectures together accounting for 66 percent of the industry's total output.

Investment in skills and technology to produce tooling for the electronics and automotive industries has been the Japanese strategy. Japanese companies have been successful in attracting large tooling orders from UK automotive producers using a range of marketing techniques, including very generous payment terms. The Japanese TDM demand is generated almost entirely from the large electronics industry but a large part serves the automotive industry. Due to the migration of investment of the auto and electronics customers globally, the TDM industry has had to follow their customers abroad and hence a period of slow growth and contraction is now evident in Japan. Many have moved to China and South Korea.

The traditional TDM industry was established for demanding customers in Japan and all the technologies required to produce tools and dies are well established in Japan. The Japanese are global leaders in 5 axis machining technology, rapid prototyping and advanced unmanned processes using more robot technology. Japanese TDMs are largely SMME's , 90% of which employ less than 20 permanent workers There is a stable TDM base of around 12 000 small family owned companies where the business is attached to the residence. Massive outsourcing and sub-contracting is evident but due to the migration of the Japanese customers abroad, opportunities for consolidation exist. A cluster of the TDM industry is located near the south of Tokyo. Massive overcapacity of 40% exists in the TDMs and specialisation is preferred to diversification.

The big three Japanese auto giants and multi national electronic, consumer goods, medical and IT customers are based in Japan and forms the TDM customer base there. Japanese customers prefer local sourcing due to the strict and demanding lead times required from the TDM sector. The latest technology is also a reason for high local content. Demand is slumping currently due to the status of the Japanese economy and the migration of investment of the large multinationals abroad. A hollowing out and shrinking TDM sector is evident in Japan.

Specialization by technology, process, or market is more common than diversification and has afforded Japanese TDM producers a means of survival in a highly competitive industry. Through specialization, which might include building moulds for use with unique materials, manufacturing a particular type of die or mould, or focus on high precision tooling used in a certain market segment, TDM producers are able to differentiate their businesses from the competition. In one area of Japan, for example, it is reported that there is a large concentration of TDM firms, each proficient in a particular and separate field. One Japanese producer with only 13 employees states that specialization provides sufficient business to survive and ensures that the company remains ahead of other Asian producers that as of yet cannot perform the same type of work. Apart from the financial aspect, producers also consider it more important and commendable to achieve global leader status in a specific area than to allocate resources across a wide variety of production areas and activities. Industry sources foresee more firms in the future, especially small producers, will chose to direct their engineering and production resources toward leveraging expertise in a particular niche in order to favourably position themselves against the myriad firms in the Japanese market and growing overseas competition.

The Japanese industry supported 113,206 workers in 2000, up 1 percent from 1999 levels, but below the industry's peak of 118,213 workers in 1991. In 2001, the average age of workers in the TDM sector in Japan was 38.2 years, and the average length of service in the industry was 14 years. Given the predominance of small firms in the industry, the average number of employees per establishment averaged only 9.3 in 2000. According to industry sources, employees in the TDM industry are mainly high school graduates. (*Source: ISTMA 2005*)

In terms of working conditions, the average employee in the TDM industry works approximately 257 days per year. Whereas the total number of hours worked per annum averages roughly 2,300 per person, the typical workday for employees exceeds 8 hours in the TDM sector. According to industry sources, average conditions or a lull in business would keep workers on the normal schedule of anywhere from 7 hours on Saturday workdays to 9 hours on weekdays. However, busy periods or times when the shop is under strong delivery pressures from the customer compel workers to labour over 12 to 13 hours a day, as well as on weekends. Industry sources note that daily work hours are often long because the system of multiple shifts is not widely adopted. As such, a core group of workers is responsible for additional hours when the production workload necessitates overtime.

With respect to wages, the average annual income for a worker in the TDM sector was $41,175 in 2001, including bonuses. The average monthly salary was $2,896, with annual bonuses averaging an additional $6,418 per worker. Compensation in the TDM industry varies according to an individual's level of experience and particular responsibilities in the company. For example, an entry-level male with no previous experience earned an average of $27,837 per year in 2001, whereas a male worker with 31 or more years of experience received $56,020. Likewise, according to one TDM producer, a designer may earn double the monthly wages of a toolmaker in the same shop. Hourly rates in the TDM sector average just over $15 per hour but can range from between roughly $8 to almost $22, depending on age and experience.

The Japanese Government does make available a variety of support programs directed at small businesses. However, such initiatives are not specific to the TDM industry, but are open to all small and medium-sized enterprises, defined in the manufacturing sector as businesses with no more than 300 employees and 300 million yen in capital. A guidebook on government programs for such businesses is published by the Small and Medium Enterprise Agency of the Ministry of Economy, Trade, and Industry, but TDM producers indicate that even with a clear understanding of the available support, they are rarely able to take advantage of such programs because of the cumbersome application processes. Government officials further acknowledge that, in general, support is directed to more prominent industries such as biotechnology or information technology, since projects and activities in these fields tend to attract more attention and are often considered important areas for development.

Japanese TDM firms do not report receiving benefits from Government policies and programs. One large producer with roughly 1,000 employees indicates that it will receive funds for R&D for two specific projects during the next 3 years.216 Another small producer with only 30 employees dismissed its workers for 3 months with full compensation under an employment adjustment program whereby the Government pays approximately 60 to70 percent of the workers' salaries and the company pays the remainder. The firm reports that this program allowed it to ride out a downturn in business, but notes that ironically most Japanese TDM producers cannot use the program because they are unable to pay the 30-40 percent share of the workers' earnings. TDM manufacturers are encouraged that the Japanese Government has recently shown a greater interest in the industry and has encouraged firms to approach the Government for assistance. This could lead to greater use of the available Government support programs and preservation of some of the industry's cottage facilities.

South Korea

South Korea is a newcomer to the market. It is developing as a result of the rapidly growing automotive market. Additionally, the opportunities to export to the west have been noted by the tool-makers. Currently, South Korea is considered to be a big threat to EU toolmakers.

EUROPE

Central & Eastern Europe (CEE)

Toolmakers in CEE are seen to be very competent but behind on investment in technology. They make up for that by being very competitive on price. (Refer data for Estonia earlier on in this report) Very well trained operatives produced from state institutions now closed down are available and these people are a good source for training in SA. CEE toolmakers are currently being targeted by UK, German and Italian toolmakers as subcontract toolmakers. Wage rates are expected to rise quickly and will erode their competitive price advantage in just a few years. The Czech Republic has won markets in Germany and UK but customers are already looking towards Bulgaria and Rumania.

The European Union

As a region, the EU likely ranks as the largest producer and consumer of TDMs in the world with a relatively small number of tooling producers in each EU member country. Two TDM industries in the EU stand out in particular- those of Germany and Portugal. Additionally, emerging facilities in Eastern Europe cannot be discounted.

The principal issues affecting the TDM industries in developed nations include rising labour costs and a migration of EU customers to low cost foreign production locations and emerging markets. EU customers have shifted production to Spain, Eastern Europe, and Asia. *High cost EU tooling producers are turning to foreign direct investment to take advantage of lower labour costs in Spain, Portugal, and Eastern European countries such as the Czech Republic, Poland and Hungary.*

The German TDM industry ranks as the largest exporter and importer in the EU, and is a world leader in the production of high precision and high complexity TDMs. TDM sales increased 38% since 1997 mostly driven by local demand representing 80% of production .German TDM's are net exporters. Germany is also one of the largest producers of tooling in the world. High labour costs and stringent labour regulations combined with a well educated and highly skilled work force have focused German TDM producers on high-precision and complex TDMs. In this regard, the German tooling industry benefits from a strong tradition of craftsmanship, as well as strong apprenticeship training programs and extensive TDM research and development efforts. The TDM industry is the 8th largest in the world made up of only 250 small and medium companies employing less than 30 employees. The TDMs are highly specialised in a wide variety of sectors and are leaders in highly complex moulds and dies specifications and development. German TDM customers require at least

ISO 9000 as a common standard of quality with ISO 14000 also a recent requirement. The recycle-ability of end products is the norm in Germany due to environmental concerns.

Portugal has emerged as one of the world's leading exporters of industrial moulds. In 2001, despite limited production of dies, Portugal was the eighth largest producer of dies and moulds in the world and it exports to more than 70 countries. The Portuguese TDM industry success in exporting and adoption of the latest computer technologies has occurred despite the fact that Portugal has a small industrial base on which the TDM industry can depend. Since joining the EU in 1986, Portugal has focused on serving customers in the common market. The share of total Portuguese exports of industrial moulds going to the U.S. has declined from 65 percent in 1997 to less 11 percent in 2001.

Turkey is a rapidly expanding tool producer. It has a reputation for poor quality but that is mainly due to local customers deliberately buying "cheap" tooling. Many EU countries are now starting to buy quality tools from Turkey. With a population of 70+ million and a rapidly growing economy, plus the possibility of joining the EU in 15 years time, Turkey is a big potential threat to established EU markets.

The UK has been at the forefront of tooling development, mainly as a result of the Automotive industry. The UK tooling industry has declined in size due to competition from abroad. Those companies still in existence have remained so because they have formed partnerships with foreign manufactures where labour is lower cost, taking responsibility (or providing) designs and they are involved in developing new products and work closely with their customers. Additionally, the UK TDMs have very good relationships with their customers, and work more as "partners" than as suppliers with them. This confers advantage as there is a close dependency by the customer on the knowledge and skill of the toolmaker. *(R Tinkler, Enterplan (2005) Briefing Note on UK Tool and Die Industry)*

There has been less been less investment in large automatic presses in the UK compared with other countries. Consequently, press tools have had to be more ingenious in order to fit the required number of operations on one tool or in one press. UK toolmakers have developed particular expertise in this area and it is more difficult to find it elsewhere. The TDMs in the UK have a special ability to produce big, heavy tools

International Technology Trends

Background

Complex contoured surfaces are the defining element of dies and moulds. The ability to mass-produce the shapes that these surfaces impart to formable materials is a cornerstone of modern manufacturing. As design and engineering become more sophisticated and daring, many of the dies and moulds they call for become more complex and more tightly toleranced. Technically, such moulds and dies are more difficult to produce. At the same time, product life cycles are growing shorter. Time to market, the period that lapses between product conception and its introduction to consumers, has to be reduced. In addition, productivity pressures create growing demand for moulds and dies that can make more parts per hour, run longer without maintenance, consume less energy, resist wear, require less time for setup or changeover, and offer greater degrees of flexibility. All of these pressures come to bear as mould and die shops consider their options for machining mould and die components, especially those that have the critically important contoured surfaces.

Compression

Demand from customers for faster delivery of completed projects is another major issue. Many mould and die buyers are willing to award substantial premiums to the supplier who can deliver a week or two earlier than other shops bidding on the job. Companies have managed to achieve these time-savings by speeding up processes, by performing steps simultaneously, and by minimizing or eliminating steps. It appears that many die and mould shops are justifying capital equipment purchases on this basis. *(Albert, M., & Beard T., (2004) Die Mould Machining on the March, MMS-online)*

High Speed Machining

High speed machining is probably the most significant technological impact on die/mould machining. High speed machining allows certain trade-offs to be made, and these trade-offs can be manipulated to advantage. One of these trade-offs is between time on the milling machine and time on the polishing bench. The key is making passes with very small step-overs at very high feed rates, usually at high spindle speeds to achieve adequate chip load on the cutter. In roughing operations, a smaller depth of cut using positive rake cutters often achieves higher overall metal removal rates than attainable conventionally, even though the cutting tool is of a smaller diameter, compared to typical roughing operations involving fewer, slower, heavier cuts. Tool life also improves. In many cases, after high speed roughing, stock remaining on the work-piece is close enough to the amount allowed for finishing that a semi-finishing operation can be eliminated. . *(Albert, M., & Beard T., (2004) Die Mould Machining on the March, MMS-online)*

Eliminating operations is also the goal for finishing passes at high speed, but in this case, operations after machining are the ones to be eliminated or reduced. Smaller cuts taken closer together typically result in an inherently smoother surface. Typically, stepovers may be as little as 0.001 inch, leaving cusps only 0.00005 inch high. On many work pieces, the surface quality may be so fine that little or no benchwork is required. By vastly increasing feed rates during finishing operations, the stepover from pass to pass can be greatly reduced without adding excessive machining time. Eliminating or reducing subsequent polishing or grinding at the bench preserves the as-machined surface and its link to geometry defined in computer-aided design (CAD).

For reference, it is generally agreed that a machine tool capable of achieving at least 1200 surface feet per minute (sfm) and at least a minimum of 8000 rpm from the spindle will deliver the benefits described here. A high speed spindle can be retrofitted to an older machine tool to achieve these speeds, although the overall stability of the machine may be a limiting factor. However, a number of machine tool builders are now offering machining centres specifically designed for high speed machining, with superior stiffness being one of their principal characteristics. Using high speed machining techniques to reduce or eliminate benchwork is a strategy that has made considerable headway in the United States. It appears to be even more widespread in Europe, where almost all mould and die work is now at the high end of tolerances and complexity. The situation is similar in Japan, although eliminating operations often means eliminating equipment. That is a great benefit in Japanese shops, which have access to very limited floor space.

Hard Milling

Another process shift that high speed machining opens up is machining mould and die cavities in fully hardened materials. This has been especially valuable for forging dies, which usually require higher hardness than other types of moulds and dies. Both roughing and finishing are performed as one continuous process on the same machine. In concept, high spindle speeds and small diameter tools in light cuts create sufficient torque to machine materials as hard as 64 Rc. Fine finishes are achieved with small stepovers in the finishing passes.

This capability reduces or eliminates the need for electrical discharge machining on ram-type (die sinking) units. Because the work piece material is already hardened, no subsequent heat treating is required. Not only is the heat-treating step bypassed, but also bypassed are the grinding or stress relieving operations required after heat treating to compensate for geometry changes induced by the heat treating. This technique has been catching on in Japan, where it originated, but it is now getting more serious attention in the United States. It is also moving ahead in Europe, where tightening of environmental laws has made EDM more expensive due to fluid disposal costs.

High speed machining of hardened materials puts tremendous demands on the machine tool. For this reason, several machine tool builders have developed milling machines specifically designed for this operation. High spindle speeds and feed rates are required to keep light cuts from resulting in excessive cycle times, but thermal stability and very high dynamic stiffness are also required. High pressure coolant is another feature these machines often include, although some builders promote dry cutting as another approach to avoiding thermal shock of the cutting tool. Dry cutting also reduces environmental concerns. Most of the machines in this category are suitable for forging dies, small- to medium-sized moulds and the like. However, deep recesses and thin walls pose a limitation for which EDM remains the only alternative.

A representative sample of high speed machining of hardened materials is a forging die for a lever that was produced by Japanese machine tool builder Yasda (Yasda Precision America is in Elk Grove Village, Illinois). Work piece dimensions are 164 by 106 by 32 mm. Hardness is 60 Rc. Using coated carbide end mills and oil mist as a coolant, the cavity was cut in 1 hour, 49 minutes. Machines in this category tend to be expensive because of the technology involved, and the added cost seems to be a factor in U.S. reluctance to embrace this approach more enthusiastically. In contrast, one machine that can take the place of a separate machine for roughing, another for finishing, and another for EDM-ing represents an attractive option in space-conscious countries such as Japan.

CAD/CAM

Probably the three biggest developments in CAD/CAM for the world's toolmakers right now are *hybrid modelling, knowledge-based* design and manufacturing systems and *shop floor 3D programming*. These issues are becoming highly interrelated in the on-going debate over how and where NC programming is best accomplished.

The industry need for hybrid modelling became apparent several years back as solid modelling technology, which had made huge inroads in product design, started to move downstream into tooling design functions. The great advantages of solid modelling are that it allows a complex volume of material to easily be represented and manipulated as a single entity, and that it allows two such entities to be added to or subtracted from one another. That's a boon to design engineers, particularly when their product designs are largely comprised of relatively standard features such as holes, slots, bosses, pockets, ribs and so on. Constructing such features with solid modelling can be done in a small fraction of the time it would take to model with surfaces.

Solids can also be a big help to tool designers. In some cases, imported 3D product models can simply be subtracted from mould core or cavity blocks as a single operation, for example. Or, simple "shelling" operations can be performed that automatically size a core to provide the appropriate moulded wall thickness for a given cavity—a job that can be downright onerous with surfacing. Having a solid is also generally advantageous when it comes time to program, since the model is by definition a single "airtight" entity, with none of the gaps or overlaps common in surfacing that can confound the best tool path algorithms.

Solid modelling can fall short in creating the complex, free flowing surface geometry that many toolmakers require. In general, surfacing is still better at generating most asymmetrical forms, and in particular, the forms that are derived from sections and drive curves as well as the blends that join one irregular surface form to another. To create this kind of geometry, surfaces are needed. Moreover, if shops are receiving surfaces files from their customers, they will invariably need surfacing to manipulate and repair that geometry to make it ready for generating tool path data.

Hybrid modelling—which is increasingly supported by CAM vendors both in the United States and in Europe—allows shops to get the best of both worlds with the ability to construct geometry with solids, surfaces and wire frames all in a single model. With some CAM systems these entities can remain separate if desired, or all can be joined together into a single, solid model—and machined as a solid.

This is not to say, however, that solid modelling has taken the world tooling market by storm. America is probably a bit further along in this regard, driven by the much needed efficiencies that solid modelling delivered to design departments in larger companies over the last decade, and more recently by the advent of low cost solid modellers that have put this technology within reach of almost any company. As such, many American shops are already accustomed to dealing with solid models provided by their customers. But Europe and Japan are not far behind. Moreover, rapid product development requirements on all three continents are further fuelling the trend. That's in part due to the high degree of associativity that solids help facilitate—allowing engineering changes to be executed more quickly and easily. *(Albert, M., & Beard T., (2004) Die Mould Machining on the March, MMS-online)*

Knowledge-Based Systems

But perhaps more important to many tooling shops are automated CAD/CAM functions that ultimately pay dividends on their shop floors using knowledge-based systems. For instance, rather than having to construct standard mould components in bases from geometry, they are pulled from a library of objects, based on industry mould component catalogues. Once a designer indicates the size and location of a component the system automatically adds an appropriately sized hole in the cavity block and adds the pin to the assembly drawing. Moreover, when CAD and CAM functionality are tightly integrated, it provides a platform on which design intent can more smoothly and quickly be converted to a proven machining process. CAD/CAM technology has finally arrived at the point where standard design features can be recognized automatically in CAM (a capability referred to as "automatic feature recognition") and associated with a pre-planned manufacturing process. *(Albert, M., & Beard T., (2004) Die Mould Machining on the March, MMS-online)*

CAM systems are being developed in Germany with the capability to analyze a sculpted 3D form and to automatically suggest appropriate machining strategies for different portions of the model. An early example of this type of functionality is "slope machining," which detects and creates boundaries around surfaces that are steeper than a given limit angle. This capability allows the CAM system to machine the flat and steep areas of a model with the most appropriate machining strategies, without having to draw boundaries manually.

CAM systems are also getting much better at recognizing where the stock remains at any time during the machining process. That knowledge facilitates such features as "rest milling," where the system automatically recognizes corner material left from a tool and confines subsequent cutter paths with a smaller tool only to the un-machined material. Another increasingly common feature is the ability to automatically recognize all areas where the stepover between two cutter paths is too wide. These areas are then re-machined perpendicular to the original machining axis to ensure optimum surface quality. Moreover, knowledge of stock remaining is particularly important in high speed machining. The ideal situation is for semi-finishing cuts to leave an extremely consistent stock condition so that finishing cuts can encounter as constant a cutter load as possible. The aim is to have a CAM system that scrutinizes the entire 3D form and automatically generates best practice machining strategies for the job at hand.

Shop Floor Programming

Many shops initially tried programming in the shop during the last 20 years but given the historical complexities of creating 3D tool paths, most moved it to the more controlled environment of the CAD/CAM room. As tooling has grown increasingly more complicated NC programming has become a predominant bottleneck across the industry. Moving programming back to the shop is increasingly relieving that limitation, made practical by the advent of extremely easy-to-use programming tools.

A milestone in the recent resurgence of shop floor programming in this country was the introduction five years ago of the Lemoine Real Time Machining CNC (Multinational Technologies, Walled Lake, Michigan). Sold mainly as a retrofit, the CNC has the ability to import a 3D CAD model directly into its memory. The operator then creates a tool path essentially by electronically "tracing" over that model, not unlike what is done with a pattern on a conventional tracer mill. Then stand-alone CAM systems were introduced by other companies that similarly lend themselves to a shop environment. While each of these systems has a distinctive approach to 3D programming, successfully operating any one of them is well within the skill range of a qualified machinist.

Facilitated by such tools, shop floor programming caught on quickly in Detroit, for a variety of reasons. Properly applied, it cuts out the vast majority of lead-time required for NC programming, since most of the tool paths are created concurrently with the machining process. Also, it eliminates the back-and-forth between the CAD/CAM and production departments to get a workable NC program, providing better utilization of shop floor people and equipment, as well as a more flexible