

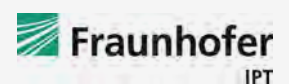


Tooling in China

Injection Molding

2016

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Michael Salmen
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Tobias Hensen
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Imprint

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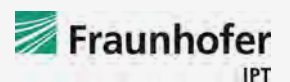
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Spotlight



In the past years, China has evolved to become the largest consumer of plastics while simultaneously becoming the biggest producer of injection molds. Due to the large number of companies manufacturing injection molds, the Chinese market has a large potential for acquiring these molds. However, the Chinese tool market remains very non-transparent and both the capabilities and structures of the companies are relatively heterogeneous. Hence, in order to successfully acquire molds in China, the Chinese tool and die industry first needs to be thoroughly studied to build reliable long-term partnerships. The present study gives an overview of the business environment in China, the offered molds, the process design as well as the resources available and the organizational structure of Chinese injection mold manufacturers.

40kg

... is the annual
plastics consumption
per capita in China

24%

... of the annual global
demand for plastics
comes from China

US\$4.7bn

... is the forecasted
revenue from injection
molds in China for 2016

30,000

... is the approximate
number of injection
mold manufacturers in
China

220

... is the average
number of employees
in a Chinese injection
mold manufacturers
(focus of the study)



Executive Summary

In the past few years, China has evolved to become the most important market for many sectors of the German economy. Despite economically turbulent times, the economic growth in China is still relatively high at 7%, thereby remaining unrivalled by established industrial nations. The sustainability of the Chinese mold manufacturers is guaranteed by high investment into the national infrastructure.

Hence, the significance of the Chinese market will remain high for German companies. This applies to the production, acquisition as well as for the sales of industrial goods.

In recent years, China has gained strongly in importance, especially from the perspective of the German tool and die industry. Following the so-called “local for local” strategy, in which production is located directly at the market, many German companies have opened production sites in China that need to be supplied with tools. This is especially the case for injection molds. As China can look back at a long tradition in the area of injection molding, required molds can theoretically be sourced from the local market. Since the 1990s, the majority of all globally distributed plastic toys has been produced in China. Thus, a lot of knowledge around injection molding could be built, in particular in the south of China, in the area around Shenzhen. Consequently, this region has asserted itself as the center of the Chinese injection mold manufacturing industry.

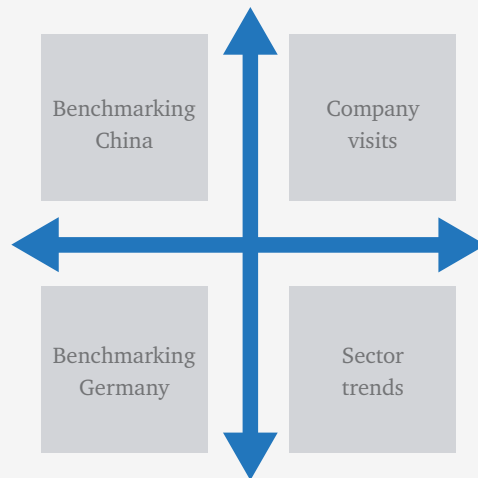
While there are numerous local suppliers of relatively simple injection molds with few cavities in China, the search for providers of sophisticated injection molds with a large number of cavities is significantly more difficult. Therefore, sophisticated molds are nowadays usually manufactured in Europe and then transported to China. This results in long

delivery times and complex logistics. The successful integration of a Chinese added-value partner for the production, maintenance and repair of sophisticated injection molds could be a decisive competitive advantage. Thus, in order to gain the necessary market intelligence, a study to assess the capabilities of injection mold manufacturers in China was carried out in cooperation with the industrial companies Gerresheimer AG, B. Braun Melsungen AG and Harting Applied Technologies GmbH as well as the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University and the Fraunhofer Institute for Production Technology IPT.

On the whole, it was shown that the injection mold industry in China is very heterogeneous. This applies to the quality of manufactured molds as well as the processes and the resources available to the companies. Individual manufacturers can keep up with German companies, while the majority of the visited companies are patently inferior. In general, Chinese mold manufacturers have very high capacities concerning employees and machines. This leads to low lead time, often with a low degree of capacity utilization. In the areas of design and mechanical production, most companies possess a good level of competence. In contrast, the assembly and try-out lack the necessary competence. Consequently, even today, it is not possible to obtain very sophisticated molds with a large number of cavities without intensive support and further machining, even in the best Chinese mold manufacturers. However, due to a high investment ratio and increased qualification activities by the companies, a promising basis for the cooperation with Chinese mold manufacturers is given. If used systematically in the future, this can lead to significant competitive advantages.



Study Design



The present study showcases the results of a jointly conducted project of the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University and the Fraunhofer Institute for Production Technology IPT as well as the three partner companies B. Braun Melsungen AG, Gerresheimer AG and Harting Applied Technologies GmbH. The content of the 2015 study is an analysis of Chinese mold manufacturers, with the goal of evaluating their capabilities in comparison to Germany. For this reason, the terms tool and mold manufacturer are used as synonyms for injection molds and mold manufacturers respectively throughout the course of the study. This study is a continuation of the 2014 study that focused on large sheet metal and massive forming tools.

The study's scope lies in evaluating the capabilities of Chinese mold manufacturers with regard to existing competence in the areas of product, process, resources and organization. Furthermore, an examination of the general industry took place in order to evaluate the tool and die industry in a macroeconomic context. An international comparison of the Chinese and German tool and die industry was carried out in order to be able to draw conclusions about the capabilities in China. The assessment of the capabilities results from detailed benchmarking

that comprises of three phases. First, the companies filled out a questionnaire with organizational and technological questions, which was subsequently analyzed by the project team. In addition, the benchmarking results were validated by impressions gained during visits to the companies in China. The study concludes with an interview of expert Hans Griessl from the Gerresheimer AG, who can look back on years of experience in mold acquisition in China.

For the study, a total of 482 potential mold manufacturers in China was identified that manufacture injection molds and fulfill the basic requirements with respect to their competences. Of these companies, 132 conformed to the criteria with regard to size and tool spectrum. In total, 41 of these companies showed interest in taking part in this study. By comparing characteristic figures, the respective capabilities could be evaluated in detail on an organizational and technological level. Subsequently, experts from both research institutes and the three German partner companies audited the 12 most successful mold manufacturers, based on the benchmarking. This approach allowed the validation of the characteristic numbers as well as the final ranking of the companies.



41

companies

**were evaluated in detail
for this study**



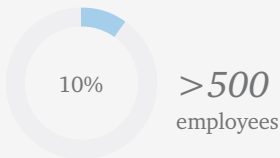
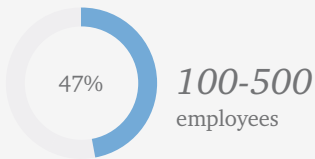
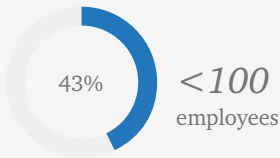
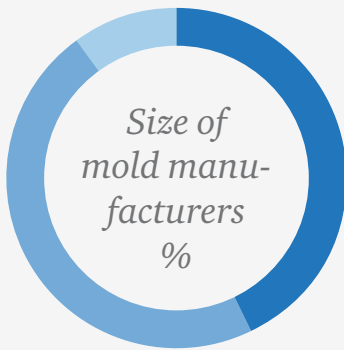
47%

of Chinese mold manufacturers have between 100 and 500 employees

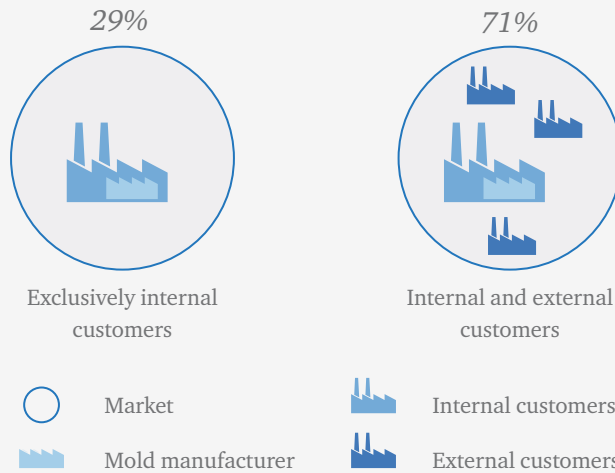
The approach described above is based on numerous international benchmarking projects carried out by the WZL and the IPT. This performance evaluation using characteristic numbers utilizes the worldwide largest database of mold manufacturers, which is shared by the WZL and IPT. It contains around 1000 data sets of mold manufacturers from over 10 countries, which are all less than five years old. For the comparison of characteristic numbers between German and Chinese mold manufacturers, the present study selected and evaluated 32 representative German mold manufacturers in the area of sophisticated injection molds with a high number of cavities. The evaluated group of 41 Chinese mold manufacturers is composed of companies with different market access. While 29% of the companies primarily manufacture molds for their parent company, 71% manufacture for both their

parent company and the external market. Looking at the number of employees, the German and Chinese mold manufacturers differ greatly. About half of the Chinese companies (47%) employ between 100 and 500 people and 10% even have more than 500 employees, whereas 43% have less than 100 workers. On average, the evaluated Chinese mold manufacturers have 220 employees. In Germany, however, the situation differs as the sector is characterized by small companies with an average of 20 employees.

In summary, Chinese and German injection mold manufacturers can be compared on the basis of both benchmarking results and on-site audits. Further, the findings of the study allow a valid outlook on the development of the industrial sector in China and its future capabilities.



Market access of the evaluated Chinese mold manufacturers



Economic environment

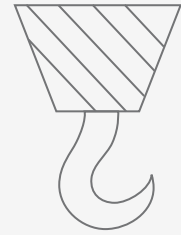
[With a population of 1.37bn, 19% of the world's total population, the work-force potential is very high.]

China comprises a total area of 9.6 million sq. km, making it the fourth largest country on earth, and a population of 1.37bn, which is about 19% of the worldwide total population. The annual population growth is held at 0.52% by government regulation. Nevertheless, the average age of 36 significantly undercuts those of western industrialized nations and thus does not pose a threat with regard to an aging demography.

In the last 20 years, China has evolved from a developing country to an upcoming economic power. The Gross Domestic Product (GDP) of China has grown considerably in this time period. Since 2000, the GDP has grown from US\$ 1.2tn to US\$ 11.4tn, rising to become the second largest economy after the USA. In 2006, China was still ranked sixth after France, the United Kingdom, Germany, Japan and the USA. Based on purchasing power parity, China also is in second position after the United States. In 2015 China exported goods with a value of US\$ 2.34tn making it the largest exporting country, ahead of the US (US\$ 1.62tn) and Germany (US\$ 1.5tn). With imports valued at US\$ 1.9tn, China was second to the USA (US\$ 2.4tn) and ahead of Germany (US\$ 1.2tn). In the first half of 2015, the most important trading partners regarding total trade volume (import and export) were the USA, Japan, Korea, Taiwan and Germany.

For Germany China already is the third most important trade partner after France and the Netherlands more important than the United States.

An analysis of the economic regions in the country shows that the enormous economic growth is not at all equally distributed. The majority of the GDP is generated in Eastern China. For example, in 2014, the GDP per capita in Shenzhen was over US\$ 20,000, while the average GDP per capita in China still was under US\$ 10,000, which is seen as the threshold to relative prosperity by the World Bank. In the Eastern Chinese conurbations the population density is also especially high. For example, in the urban area of the capital Beijing, the density is approximately 5,640 people per sq. km and thus 50% higher than the density in Berlin with 3,800 people per sq. km. The statistics about the economic power of China increasingly show that it is in crisis. In the first two quarters of 2015, China's economy only grew by 7 percent, which is the lowest growth rate since the financial crisis of 2008 but still is relatively high. The low value can be traced to generally weak worldwide economic activity, rising wages in China and a financing system that is increasingly dependent on loans from so-called shadow banks. Even more serious are the problems on the stock market.



US\$ 2.34tn

**was the value of
exported goods from
China, making it
the largest exporting
country**



Since the “seven-year high” of Chinese stocks in June 2015, they have lost nearly 40% in value. For the Shanghai stock market it has been the largest stock market crash within 20 years. The catalyst for this was a series of announcements by the stock exchange regulatory organization to tighten rules for buying stocks financed with credit, which led small investors to sell their stocks in pa-

nic. This development continued in 2016 so that trading had to be suspended after 7% drops per day during the first trading days. Paired with the relatively weak economic data, these are first indicators of a long-term crisis of the Chinese economy. The government in Beijing tried to counteract these trends with economic stimulus plans for the development of infrastructure.

[China is trying to counter the weakening economy with numerous megaprojects.]



US\$ 1.1tn

was the GDP of Guangdong in 2014

Two immense bridges are being built over the Pearl River Delta in the Southern Chinese province Guangdong.

On the one hand, it is the Hong Kong–Zhuhai–Macau Bridge, which is set to be finished in 2016. This bridge is supposed to merge the three cities into one economic center. The world’s longest bridge over sea with a length of 42 km will be opened mid 2017 at the latest, shortening the drive around the delta from four hours to 45 minutes.

On the other hand, a comparable megaproject was started in 2015 by building a bridge connecting the cities of Zhongshan and Shenzhen. The so-called Shenzhen-Zhongshan corridor is planned to be finished in 2021 with a length of 51 km and hence will dethrone the Hong Kong bridge record.

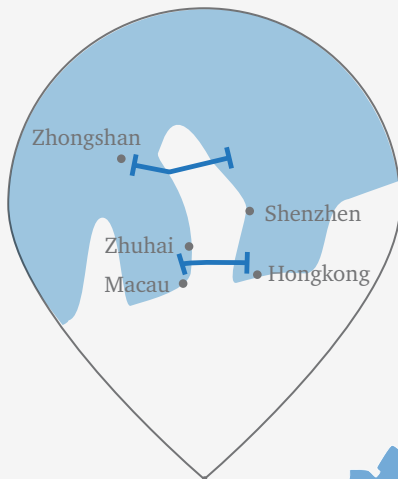
The cities Hong Kong and Shenzhen want to spread their influence to the western side of the Pearl River Delta and further into the province Guangdong (see figure).

Guangdong is among the strongest economic regions in China. In 2014, the GDP of the province was US\$ 1.1tn (by comparison Germany: US\$ 3.8tn). Approximately 85% of the GDP in Guangdong is generated along the Pearl River Delta, which was named the worldwide largest metropolitan area in 2015 with 42 million people. The competitive ability of the cities along the delta is also ranked at the top of a study published in May 2015 by the Chinese Academy of Social Sciences: Shenzhen overtook Hong Kong for first place, Guangzhou ranked fifth and Macao ninth. By comparison, Shanghai remained in third place and Beijing fell to eighth.

The region west of the Pearl River Delta has largely missed out on the economic boom of China. Zhuhai and Zhongshan are cities with a relatively low population density. Costs of wages, rent and real estate are far under the eastern level. Currently, for example, apartments in Zhuhai cost about half the price as in Shenzhen.

Hong Kong and Shenzhen both have recognized the advantages of this region. With the construction of those bridges, a large hurdle to build factories in the western part of the delta is taken away. People and freight can cross the delta significantly faster and thus also take advantage of the international airports of Hong Kong and Shenzhen. China's government, which supports both projects, has the aim of helping the western part of the region to achieve the same economic prosperity as the eastern part.

The exemplary visit of a mold manufacturer during the study shows that the construction of the bridges is met with a positive response. With respect to the new connection to Zhongshan, this mold manufacturer has already purchased property in the region around Zhongshan. The company is speculating on a quick completion of the bridge and has secured itself inexpensive property to unlock cost advantages in the western part of the delta.



Hongkong-Zhuhai-Macau Bridge

- Reduction of travel time from 4 hours to **45 minutes**
- Height of bridge pillars: **170m**
- Number of lanes: **6**
- Total cost of the project: **US\$ 30.7bn**



[The global plastics production will rise to 300 million metric tons by 2025, a quarter of which will be accounted for by China.]

The global plastics production was 241 million metric tons in 2012 and is projected to rise to 300 million metric tons in 2025. The economic growth of China is also visible here. With 24% of the world's total, China has the largest demand for plastics. In order to satisfy this demand, China is also the largest producer of plastics. In 2010, China produced more plastics than Europe for the first time, since then China remained at this high level. China's share of worldwide

plastics production amounts to 24% - more than North America. These large figures can be attributed to China's large population. The consumption per capita is only 40 kg per year in China, significantly lower than in Germany (125 kg per year). However, by 2025, the Chinese per capita consumption is projected to rise by 26%, compared to only 4% in Germany. These numbers illustrate the size and growth potential of the Chinese plastics market.

[With an export volume of US\$ 2.9bn China is the largest exporter of injection molds ahead of Germany.]

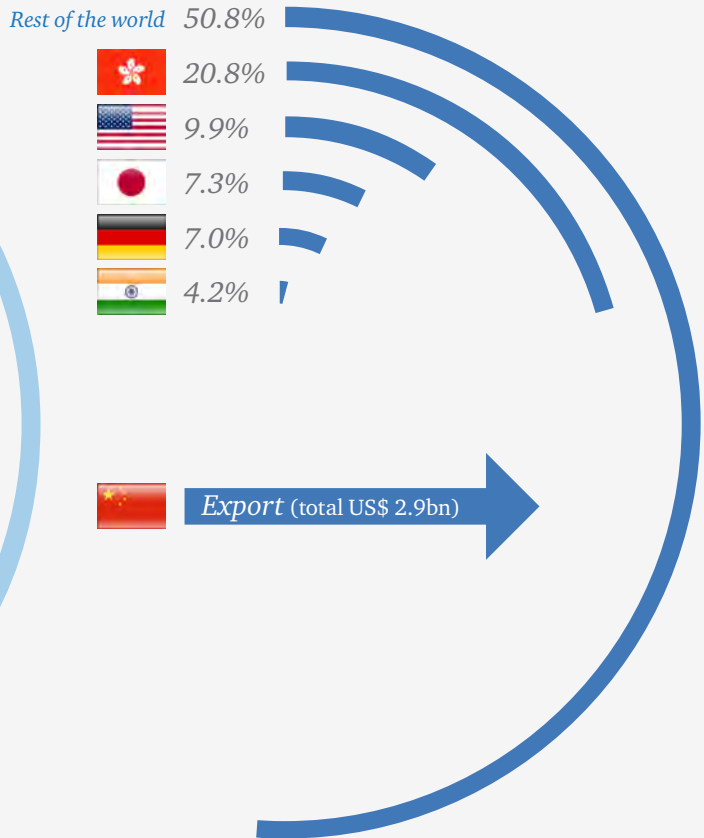
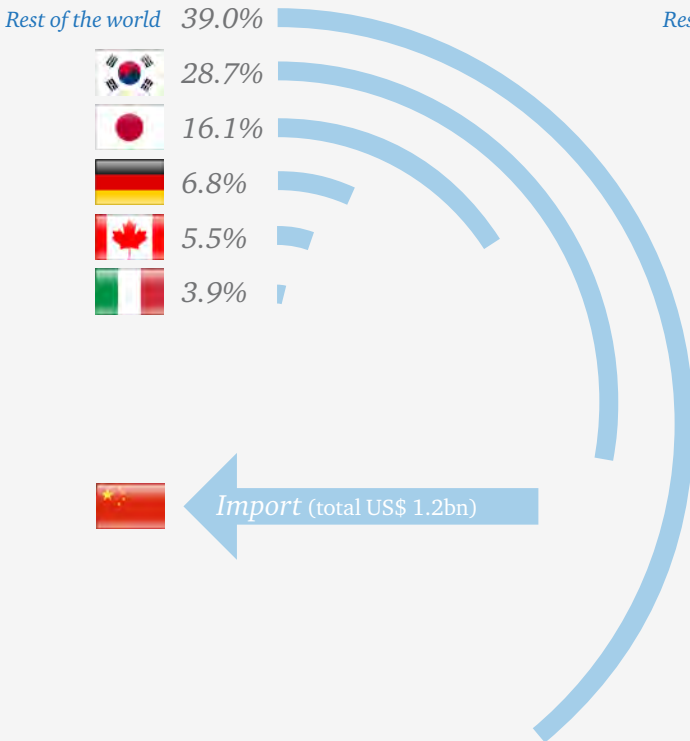
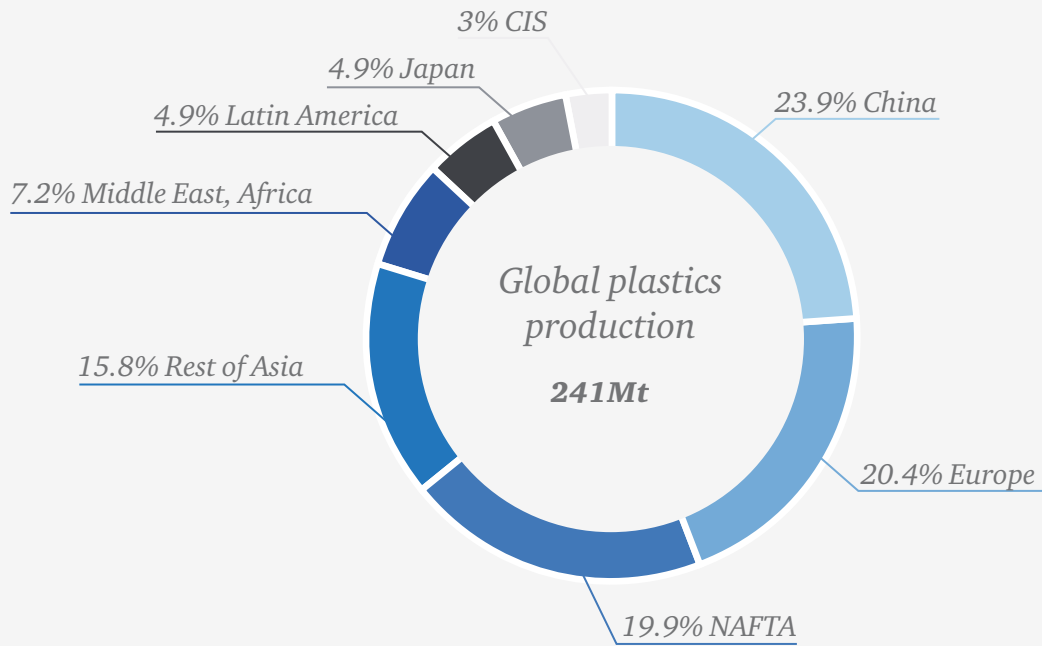


US\$ 4.7bn

revenue from the sale of injection molds expected in China in 2016

On the market for injection molds, China is both the largest exporter and an important importer. With an export volume of US\$ 2.9bn, China is far ahead of second-placed Germany (US\$ 1.0bn). The most important markets for exports from China are Hong Kong (20.8%), the USA (9.9%) and Japan (7.3%). With a value of US \$1.2bn China imports the second most injection molds from other countries after the USA (US\$1.4bn). South Korea (28.7%), Japan (16.1%) and Germany (6.8%) are the most important partners for imports.

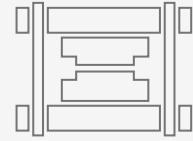
Overall, China's injection mold industry is experiencing a considerable upswing. The reason for this is the rapid development in the downstream markets. The revenue from sales of injection molds in China first rose above the US\$ 3.0bn mark in 2010 and reached a peak of US\$ 4.0bn in 2013. For the end of 2016, a revenue of US\$ 4.7bn is predicted in for China.





Product

[Only few mold manufacturers are able to manufacture sophisticated molds with a high number of cavities.]



In comparison to Germany, the number of mold manufacturers in China is very high. With around 30,000 companies, the injection mold industry is an important industrial sector in the Far East. This was primarily created due to the consumer and toy goods sectors, which have a long production history in China. Considering the limited requirements for the mold technologies, parts of the mold industry have evolved to providers of high-quality, complex molds. These molds, which have found application e.g. in the electrical, electronics or medical industry are also in the focus of the examination.

The automotive industry is the major customer for the majority of Chinese mold manufacturers that are evaluated as above-average both technologically and organizationally. On average, Chinese mold manufacturers

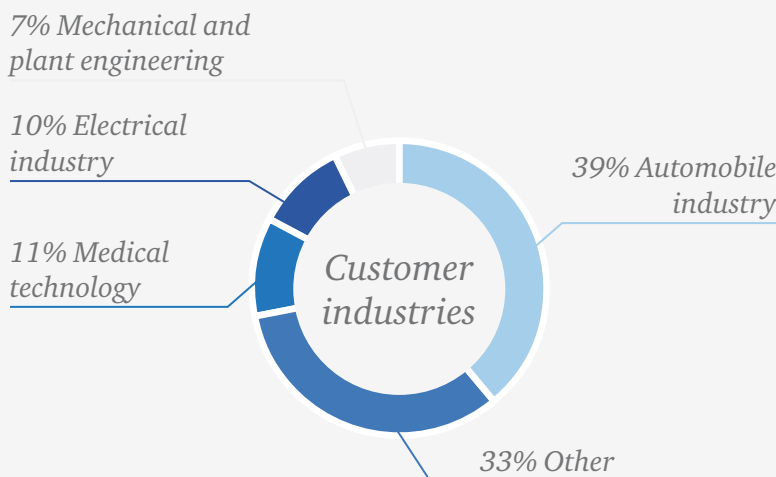
generate 39% of their revenue in this sector. Other important sectors are medical technology (11%), the electrical industry (10%) as well as mechanical and plant engineering (7%). This shows that delicate molds with a high number of cavities and form tolerances, such as those needed in medicine technology, can only be manufactured by select mold manufacturers.

The typical mold dimensions usually lie in a range of up to 500 x 500 mm or up to 1000 x 1000 mm. Over 70% of mold manufacturers respectively build tools of these sizes. However, dimensions of 250 x 250 mm are also widely represented with over 60%. This can be explained by designs with only one cavity. In total, the typical mold dimensions reflect the often unfocused product spectrum.

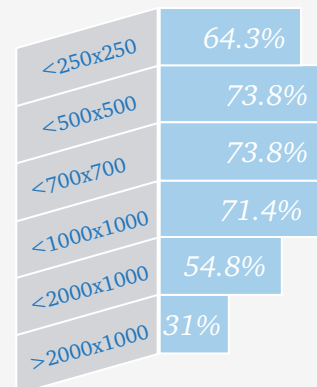


30,000 companies

form the injection molding industry, making it the most important part of the Chinese tool and die industry by far



Mold dimensions





[Young companies and short business relationships are characteristic for Chinese mold manufacturers.]



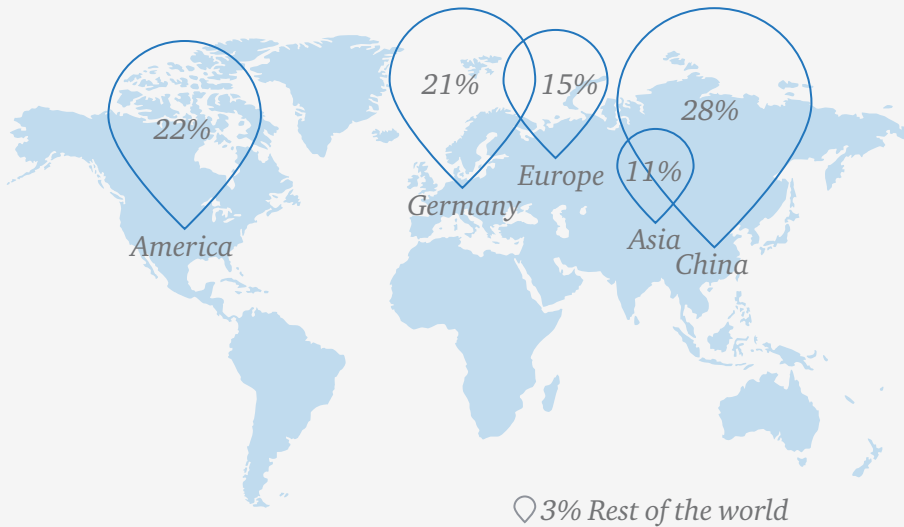
Two thirds of relations to customers with Chinese mold manufacturers last <5 years

The duration of business relationships in China is not as long-term as in Germany. On the one hand, this is caused by the young age of the companies and on the other hand by the higher volatility of business relationships. About two thirds of customer relationships of Chinese mold manufacturers are less than 5 years old. In the German comparison group this just amounts to 45%. The value for relationships lasting over 10 years is only slightly less in Germany with 37%, compared to 13% in China. In Germany, business relationships evolve to partner networks that are characterized by continuity and trust, enabling collaboration. In China, partner landscapes of this quality only develop

slowly. However, market leaders have recognized that customers can be retained by mutual trust and constant quality.

The evaluated Chinese mold manufacturers deliver to customers around the globe. Nevertheless, just about a third of all products remain in the country. Shortly after this follow Germany and the USA, both with around a fifth. In both of these target markets, the automotive industry is responsible for most of the sales. The remaining European countries buy 15% of tools built in China and further 11% are delivered to other Asian states.

Revenue distribution of Chinese mold manufacturers according to customer countries



Duration of business relationships

Duration	China	Germany
< 1 year	16.6%	12.3%
< 2 years	19.8%	10.5%
< 5 years	25.0%	22.9%
< 10 years	25.3%	17.2%
> 10 years	13.3%	37.1%

[The understanding of quality in Chinese mold manufacturers is highly heterogeneous.]



Quality is continuously sought in Chinese mold manufacturers. However, the tool quality can only fulfill the high standards of e.g. medical products in few cases.

Looking at the material hardness, the whole spectrum is available. Especially a Rockwell hardness of up to 60 HRC is available for tool steel.

The standards for the basic design of an injection mold are normed in China. Local norm providers stick to US or German standard dimensions. Thus, the companies can, in most cases guarantee the deliverability of tool dimensions used in Germany. Furthermore, 75% of the companies state that they also use steel from Germany or German manufacturers.

In particular, the local visits of various mold manufacturers show that the understanding of quality as an aggregate of organization, process and product is rather heterogeneous. Companies that assess themselves as a premium business are deemed absolutely unsatisfactory with regard to quality requirements of German medical technology and electronics companies. This means that objective evaluations as well as supplier development are imperative to create a basis of mutual understanding.

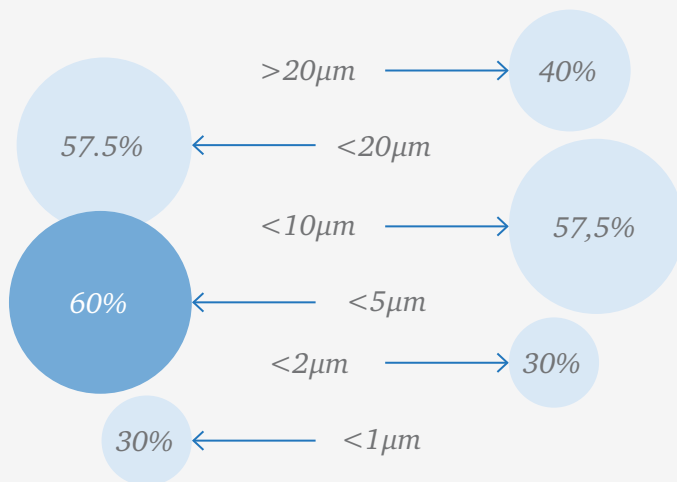
Apart from the material used, the achievable surface characteristics of the shaping parts are of significance for the quality of the injection mold. With regard to the surface finish, 30% of companies are able to reach values under 1 µm.



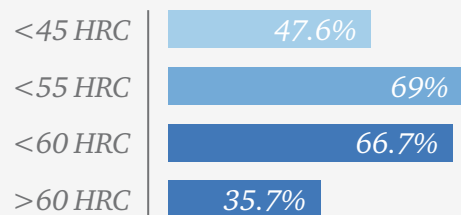
75%

of companies buy steel from German producers

Surface finish of manufactured tools*



Material hardness of manufactured tools*



*Multiple selections possible



[Chinese mold manufacturers offer a wide range of services.]

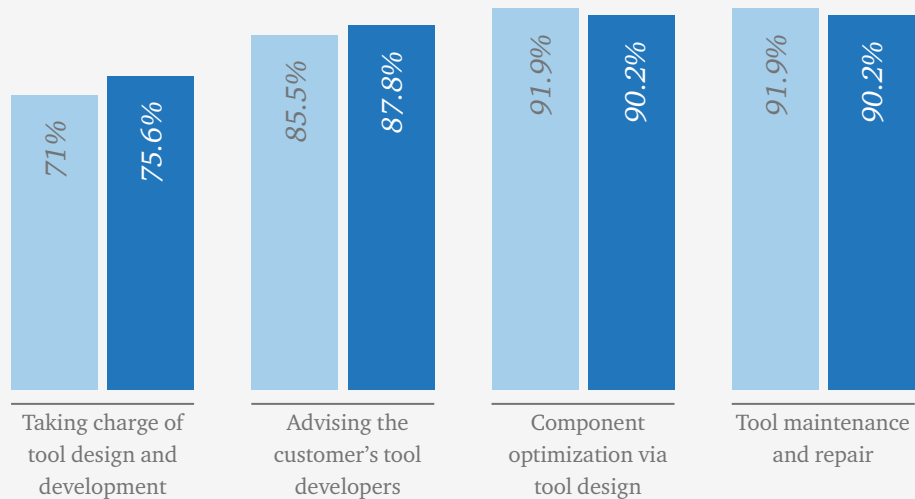


Services offered by Chinese mold manufacturers are often only taken on by Chinese customers

The majority of Chinese mold manufacturers offer their customers a broad service portfolio during both the product development and series production. Thus, precedently in the product development, the entire tool design is taken over (for 71% of offered tools) and the customer's tool developers are advised (for 85.5% of offered tools). Furthermore, component optimizations via tool design are offered for 91.9% of the tools. The share of services offered apart from the tool itself is comparable to the share in German mold manufacturers. Nonetheless, at this point it should be noted that the product and method-specific knowledge in design and production planning of Chinese companies

fall short of the level of German companies so that the offerings of Chinese companies are primarily accepted by Chinese customers with less complex product requirements. The downstream services include tool maintenance and repair for 91.9% of the companies, which is marginally higher than in Germany. The capabilities with respect to short reaction and lead time are also on a high level since Chinese companies are often not producing at full capacity due to high resource availability. There is also a rising trend for very successful Chinese companies to partner with companies in Europe or the United States in order to be able to quickly and reliably carry out maintenance and repairs.

*Services offered by mold manufacturers apart from the tool**



*Multiple selections possible

■ China

■ Germany



Expert commentary

Hans Griessel

Head of TCC China
Technical Competence Center
Gerresheimer AG

What do you think are the largest challenges with regard to purchasing molds in China?

Purchasing molds in China is barely comparable to buying molds in Germany or Western Europe. The lack of transparency in the market is the largest and most important challenge. For this reason, a local presence is inevitable to build the essential personal relationships. In this process, one needs to identify suitable companies while considering the key performance indicators of quality, precision and price. Comparing the companies solely based on the price does not lead to success as the capabilities of individual companies differ greatly and are not reflected in the price calculation. In our experience, numerous companies promise a high standard of work that they cannot deliver.

Is the Chinese mold and die industry competing with Germany with regard to tool quality?

Here one has to have a diversified look at the Chinese mold and die industry. In the area of the automotive, consumer goods and toy industries with cavity numbers of up to eight, Chinese companies are definitely capable of competing. For extremely complex demands with respect to the number of cavities, short cycle times, high edge requirements and delicate structures, only few Chinese companies can compete. These companies need to be identified and developed further. Collaborating in this area has taught us that, especially in the final optimization of the molds, the highest precision is not fulfilled by Chinese mold manufacturers.

Are molds designed differently in China than in Germany?

Like in Germany, tool design differs greatly among individual mold manufacturers. However, it can be observed that Chinese ones focus a lot more on the factor of economic feasibility. Hence, the mold design needs to be closely overseen and, as the purchaser, you always have to intervene to prevent a low-cost construction in time. A large proportion of Chinese mold manufacturers permit this. They are very patient with their customers. Thereby, late changes in the tool design caused by the customer are usually allowed and implemented. This is a significant difference to Germany.



How do you estimate the degree of work organization in China?

In order to understand different forms of Chinese work organizations, one needs to know that there are barely any skilled workers for the injection mold industry that were educated like in the German system. The employees are mostly semi-skilled workers that have only had few months to acquire mold and process-specific knowledge. The molding companies are trying to combat this through organized and hierarchical organization structures. They are barely comparable to German forms of organization. However, clearly defined roles and organizational structures have been established in China and have created a high degree of work organization.

In what direction do you think the Chinese mold and die industry is heading?

The Chinese mold and die industry is currently standing at a crossroads. On the positive side, the companies can expect that the rate at which wages are rising will slow down from the yearly rises of between 10% and 15% in the past. Due to the noticeable cost pressure from the enormous wage increases in the meantime, several companies are already opening factories in Thailand and the Philippines. However, due to the lack of skilled workers, this is rather challenging. Numerous Chinese molding companies built up a lot of overcapacity in the past. In the future, these companies are facing a rationalization of their capacities. According to our estimates, mostly medium-sized firms with average capabilities will disappear from the market, which will also lead to a rationalization of the Chinese mold and die industry as a market. A part of those already successful companies will increase their level of quality and develop into the precision area. It should be expected that a noticeable number of serious competitors for the German mold and die industry will appear. According to our assessment, the number of highly precise injection molds “Made in China” used in Germany in the coming years will depend on the exchange rate and the feasibility of necessary efficiency increases. The conditions change very quickly in China. The newest developments show that the tool prices of top Chinese companies have reached an European level and that their wage advantage is equalized by their low productivity.

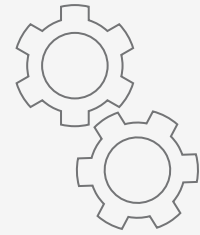


Process

[The process capability of Chinese mold manufacturers is at a high level due to short lead time and a deadline adherence of 75%.]

The capability of mold manufacturers correlates very closely with the mastery of the processes involved. A high process capability is primarily characterized by a short throughput time and high adherence to deadlines. The results of the present study show that the process capability of Chinese mold manufacturers is at a good level. Due to the almost unlimited availability of capacity in design, mechanical manufacturing and sampling, tool projects can be easily reali-

zed in China. Hence, it is not a rarity that, for example, up to three people work on the design of one mold simultaneously, meaning that the throughput time of designs is up to 50% faster in China than in Germany. It should be noted that, in total, the throughput time of comparable tool projects are 40% faster in China. The good process capabilities are also shown in the adherence of 75% to delivering before or at the deadline.



40%

lower is the average lead time in Chinese mold manufacturers than in Germany

[The processes of creating a quotation as well as the quality of the quotation in China have great potential for improvement.]

The handling of requests in China is usually very fast. However, the quality of the quotation is very different among Chinese companies and even the best ones of the sector require close supervision in order to achieve a level of detail and quality common for German mold manufacturers. This especially applies to the hot runners and the number

and type of sampling loops since Chinese companies, among other things, use these positions to try to keep the quoted price low. As a purchaser, one should study the quotations in detail to find out if the price matches the desired quality requirements and avoid later change costs.



[The missing know-how of numerous Chinese mold manufacturers is noticeable in the engineering.]

A detailed method plan in the quotation-generating phase is necessary for the molds to optimally function and perform. The majority of German mold manufacturers has large capacities in engineering and places a high value on the adjustment of the mold and on the interface to production. For complex mold concepts, Chinese mold

manufacturers need regular and intensive supervision of the method planning of the molds. Otherwise the focus lies on maximal profitability during molds design, through which costs are reduced in the mechanical production. The focus is often not set on the customers' benefit.

[The speed of creating the design at successful mold manufacturers can absolutely compete with European companies.]



5%

of Chinese mold manufacturers outsource tool design

Design in Chinese mold manufacturers has a huge potential for creating a competitive edge. In comparison to Germany (28%), only a small share (5%) of design is outsourced. This has two reasons: firstly, Chinese companies fear losses of their know-how when sharing it with external design offices and secondly, the supplying structures of the companies are generally not fully developed since only few mold manufacturers have a

systematic supplier management system. Via a high use of resources in development, the companies can compensate the deficit in external design capacity. Unlike in Germany, several designers work simultaneously on one mold in Chinese mold manufacturers. Along with a high work speed and large number of employees, this leads to short lead time.

[Only selected Chinese mold manufacturers possess competence in design – even these need tight supervision.]



The competences in the area of mold design are developed to a varying degree in the industry. A large number of Chinese mold manufacturers have potential with regard to the standardization in design and focusing on the development of innovative solutions for customers. Accordingly, numerous companies focus on the low and medium-class tool segment, in which the price is the most significant factor for customers. On the other

hand, the results of the study show that there is already a respectable number of mold manufacturers in China that is able to manufacture innovative and challenging tool designs based on their high degree of standardization and specialization of employees. These companies are increasingly focusing on the high-precision manufacturing as their core competence.

[Only a minority of Chinese mold manufacturers has a planning framework or system.]

A low share of employees is working in the scheduling, process planning and planning departments of Chinese mold manufacturers. With 6.6% of all employees working in planning and process planning, this is only about half as much as in the German comparison group of mold manufacturers (12.6%). This can be led back to the high availability of resources along the entire value creation process. Hence, possibly missed deadlines are compensated by increasing the production capacity and no added value is seen in planning activities. It is also conspicuous

that only a minority of the visited companies has a planning system, either digital or analog. However, it could be observed that, due to rising wages, there was an increase in PC-workplaces along the entire value creation process to capture the actual hours needed to process an order and to sensitize employees to adhere to the calculated target times. Based on these data, numerous companies carry out a detailed post calculation with system and depth of detail comparable to those of German companies.



6.6%

of all employees in Chinese mold manufacturers are working in work scheduling and process planning



[Chinese mold manufacturers employ 68% of their workers in manufacturing.]

Compared to German companies (61%), Chinese mold manufacturers employ a larger share of their workers in manufacturing. Here, the work organization and competence-based assignment of workers to work stations is very good at successful companies. These companies have a hierarchical top-down management in order to e.g. increase the order and cleanliness of the shop floor and waste due to missing process understanding of the employees in manufacturing. For this reason, measures for a continuous

improvement process are given by management and strictly followed. Contrary to this, there is a number of Chinese mold manufacturers that have not implemented an industrialization of manufacturing yet. These companies are characterized by a low degree of order and cleanliness as well as transparency on the shop floor. Additionally, some of the present young machines are in poor condition compared to their German counterparts as maintenance has been neglected.

[Chinese know-how concerning assembly and try-out is limited.]

The analysis of the present study shows that all of the Chinese mold manufacturers identified in the study carry out a try-out process. For more than 97% of the try-outs carried out, there is a protocol that is delivered together with the mold. In the try-out process, on average, a mold goes through 1.8 iterations in China and 2.1 in Germany, although the content of the iterations is not necessarily the same.

At first sight, the numbers determined by the study concerning try-outs in China appear positive and the impression of high operational performance in this area is conveyed. However, it should be noted that the process capability of Chinese mold manufacturers along the added-value chain is lowest in assembly and try-out. This is primarily due

to the low education level of Chinese tool-makers who cannot resort to a technical training similar to Germany. Further, the missing order and cleanliness of the workstations often lead to an installation of components covered in dirt or oil films, which has ramifications on the overall quality of the product. On the one hand, some unneeded parameters are recorded while other necessary ones are left out. Furthermore, the injection molding machines are often used for the internal series production so they cannot replicate the series processes of the customers. Therefore, in try-out as well as in design, the Chinese mold manufacturers should be closely supervised to obtain the optimal mold quality.



1.8 iterations

**are done on average
in a try-out process
of a mold in China**

Resources

[Quantitatively, Chinese injection mold manufacturers are well equipped in terms of workforce and machines.]



The pool of potential workers is large in China. However, the occupations in the tool and die industry, manually or at a machine, are so knowledge-intensive that the range of suitable employees is considerably reduced. This is because the education system does not have a vocational training comparable to the German one. Due to this, successful Chinese mold manufacturers invest high amounts in self-reliant qualification of the employees. To this end, they offer their own qualification courses to transfer knowledge to new workers or acquire external experts to take over training. Skilled workers primarily define themselves by their experience. This applies to technical activities as much as to machine handling or CAM programming. Apart from financial incentives, more

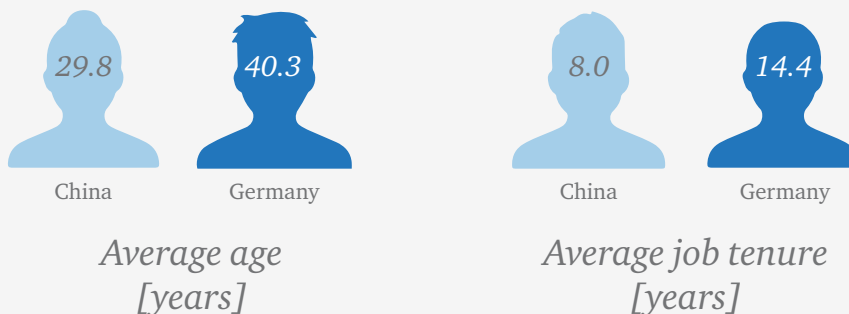
companies are building programs to create better employee retention. These include social events or sporting offers to foster identification with the company. In this way, the companies want to prevent employees from switching to other companies due to small differences in wages. Nevertheless, worker fluctuation remains one of the largest challenges in the Chinese tool and die industry, as seen by the average job tenure. In China it is 8 years but 14.4 years in Germany.

The Chinese population structure is very young compared to Germany. The average age of an employee in a Chinese mold manufacturer is 29.8 years, whereas German employees are 10 years older.



29.8 years

is the average age of employees in Chinese mold manufacturers





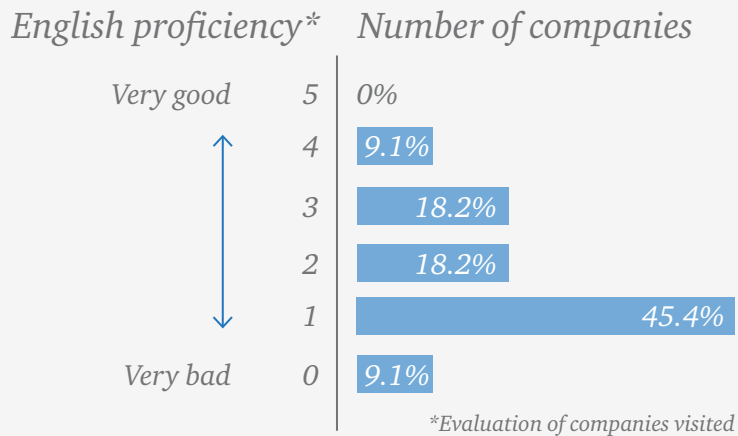
Good English skills are of central importance in international tool purchasing and is often the basis of success for a purchase. In particular, this is true for communication in knowledge-intensive areas of the value-added chain, such as design and try-out. In these areas, the tool functionality is definitively determined and communication between the mold manufacturer and customer is essential.

However, in Chinese mold manufacturers it can be observed that the knowledge of English is limited to the sales force that often possess little technical knowledge. Hence, a success factor in the communication during order processing is engaging a Chinese-speaking employee.



1.46

is the average value of English knowledge in a scale from 0-5 in Chinese mold manufacturers

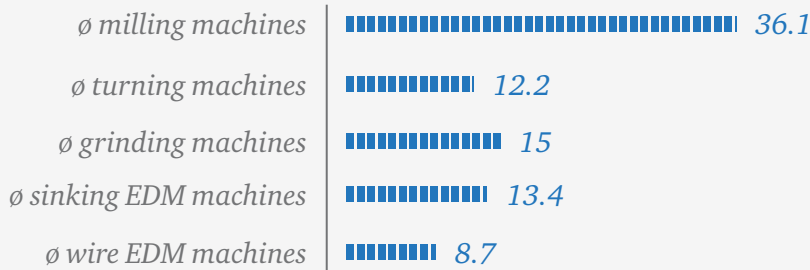


[Chinese mold manufacturers have 9.2 different production technologies on average.]

In almost all of the evaluated Chinese companies, the core technologies of the tool and die industry are present, namely milling, turning, sink eroding, wire eroding, and grinding. When looking more closely at the characteristic numbers, it stands out that Chinese mold manufacturers use a smaller number of production technologies than German companies. On average, 9.2 different technologies are used in China and 13.9 in Germany. Likewise, there is often a disproportional resourcing of the manufac-

turing facilities, which is why there are more machines in Chinese mold manufacturers than in German ones. Particularly, milling stands out, with 36.1 milling machines on average. Additionally, the companies have on average 12.2 turning machines, 15 grinding machines, 13.4 sinking and 8.7 wire EDM machines. At this point, it should be noted that a large number of them are rarely used as many machines are not productive and are operated manually.

Number of machines



The machines of the Chinese mold manufacturers are advanced and can definitely compete with the German comparison group. The average age of the machines is 4.8 years, whereas the machines of German companies are 9.1 years old on average. Especially grinding and turning machines are much younger in Chinese companies. The modern

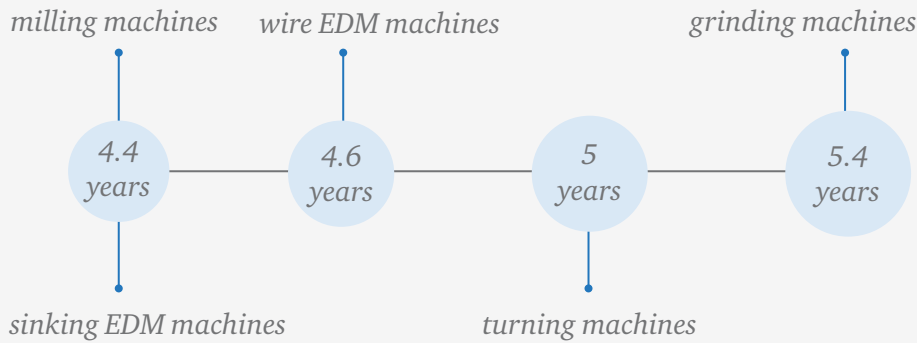
machines show a high willingness to invest by Chinese mold manufacturers. However, since the maintenance of the machines has largely been neglected, the operational performance of most machines still lies under the older ones of German mold manufacturers.



4.8 years

is the average age of machines in Chinese mold manufacturers

Average age of machines

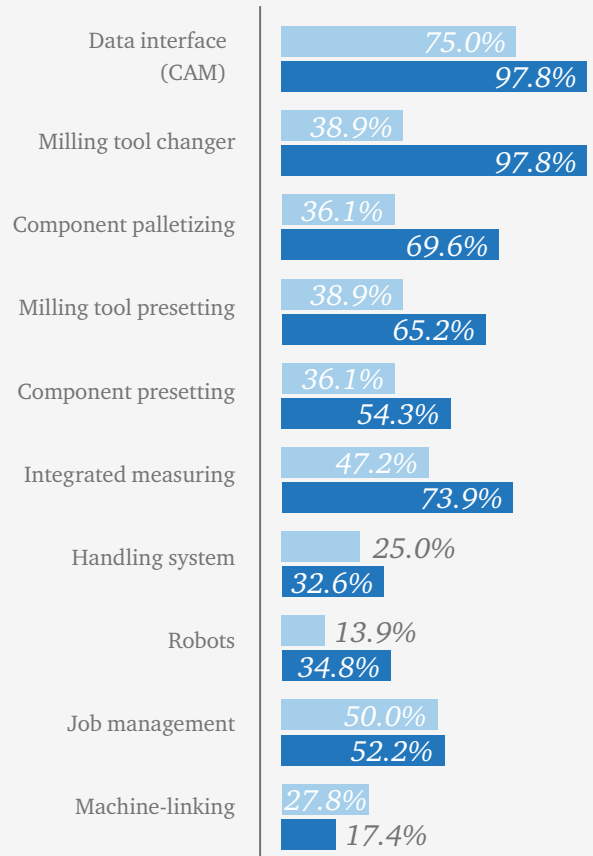




In their machine procurement, select Chinese mold manufacturers increasingly focus on precision machines, which usually come from Japan or Europe. This is particularly the case for milling machines as well as sinking and wire EDM machines. However, the average company still counts on machines

tools of Chinese origin that often cannot reproduce small form tolerances. Despite the low age, the share of HSC machines in milling is relatively small. Compared to 44.2% in Germany, HSC machines are only 16.5% of the total in Chinese mold manufacturers.

Automation of the milling machine



16.5%

is the share of HSC machines of all milling machines in Chinese mold manufacturers

China
Germany

Despite the low share of HSC machines, Chinese mold manufacturers achieve low lead time during order processing. This is not achieved by operative excellence or excellent technologies, but rather by resource availability including machines and workers. In addition, thanks to flexible employee contracts, a three-shift operation can be implemented as required, to compensate for missing process excellence.

Another indicator of technological capability of mold manufacturers is the availability of automation facilities. A high degree of automation shows to what extent investment is done for the technological sustainability of the company. A basic requirement for automation of manufacturing is the implemen-

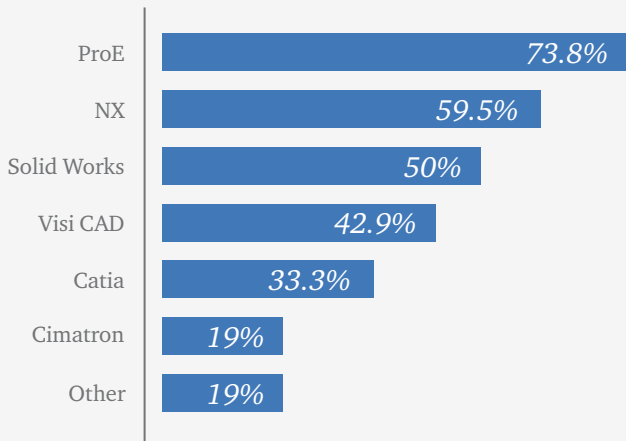
tation of CAM interfaces. With respect to the core technology milling, 75% of Chinese companies have data interfaces. This means that they are relatively badly equipped. In Germany (97.8%), this value is significantly higher and is an indicator for higher performance capabilities. For other automation measures, there are large differences in comparison to the equipment of German mold manufacturers. For example, milling tool changers are installed in only 40% of Chinese and almost 98% of German machines. Similarly, there are clear differences in the availability of machine-internal measuring: nearly half of the milling machines in Chinese mold manufacturers are equipped with it compared to 75% of machines of German companies.



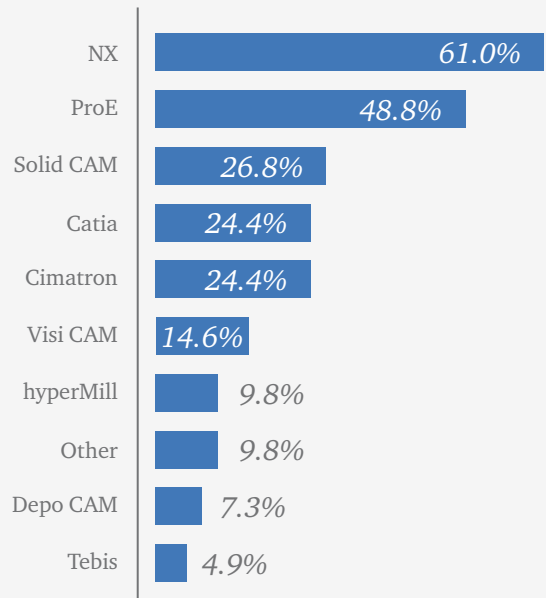
75%

is the share of milling machines with a data interface in Chinese mold manufacturers

CAD systems in Chinese mold manufacturers



CAM systems in Chinese mold manufacturers



*Percentage of responses, multiple selections possible



40%

**is the share of
companies that use mil-
ling tool changers**

The low degree of automation of Chinese mold manufacturers compared to Germany can be traced back to the very worker-based organization structure, which results from the still relatively low wages. Nonetheless, even in China, especially in the segment for high-quality tools, there are already highly interlinked automation solutions being implemented. Apart from the linking of graphite milling machines for electrode manufacturing and a component magazine, which is also common in Germany, individual Chinese mold manufacturers utilize complex manufacturing processes like electrode manufacturing, hard milling, sinking EDM and

cleaning in an automated, linear fashion. To achieve high-quality surface finishes as well as dimension and form tolerances according to the specifications, in particular, CAD and CAM systems need to be highlighted. External mold manufacturers in Germany as well as in China are generally dependent on 3D models from their customers or designers. Consequently, the capability of conversion software or the use of generic exchange formats can negatively influence the data quality. In order to prevent conversion problems, Chinese mold manufacturers use several CAD systems in parallel.

[The most prevalent CAD software solutions in Chinese mold manufacturers are ProE (73.8%) and NX (59.5%).]

The majority of Chinese mold manufacturers utilize several CAD programs to be able to use the program convenient for the customer. This results in a high compatibility with the systems used in Germany and enables a flexible exchange of design data with the customer. The most prevalent systems used are ProE, Siemens NX, Solid Works, Visi CAD and Catia, with ProE (73.8%) and Siemens NX (59.5%) being the most represented. Comparable to the CAD systems, Pro/En-

gineer and Siemens NX are the most common CAM systems. With respect to the level of knowledge of CAM systems, it can be seen that there is no detailed examination of e.g. milling strategies or path planning. Thus, CAM systems are largely not implemented according to specific requirements, for example for the ideal design of 5-axis machining or in the context of treating free-form surfaces.

[Grinding is a core technology in the tool and die industry in China.]



The study has already shown that in the Chinese tool and die industry all core technologies are present. Nonetheless, it can be observed that, in comparison to Germany, the application of technology differs. All of the companies visited in the context of the study showed large grinding capacities. Particularly, flat grinding, often with manual-feed, is widespread. The high share of grinding is

an indicator for the capabilities of milling and EDM, which are not yet on a German level. Only in exceptional cases Chinese companies have circular grinding machines or even coordinate grinding machines. If a customer has relevant surface requirements, the technological equipment of the company deserves close attention.

[Sinking EDM is a widespread technology for creating complex contours in China.]

Chinese mold manufacturers use sinking EDM very often for manufacturing of complex tools. The importance of the technology is also reflected in the low average age of the machines of 4.4 years. Both graphite and copper electrodes are implemented. Particularly noticeable is the use of large electrodes, especially out of graphite, which are used

as an alternative to milling whole cavities. Often several electrodes are eroding a workpiece on a component in parallel. This occurs on large sinking EDM machines with multiple sleeves that are not found in Germany like this. The electrode construction happens internally at the mold manufacturers. After being used, the electrodes are usually stored.



4.4 years

**is the average age of
sinking EDM machines
in China**



[Quality control also takes an important role in China.]

Due to higher humidity and air temperatures that are regularly far above 20°C, Chinese mold manufacturers have air-conditioned quality control. They have detached and air-conditioned measurement rooms that are also well-equipped. Apart from widespread

coordinate measurement devices, optical measurement devices are used in a large part of the companies. The modern equipment in quality control is sometimes even utilized after every production step.



23

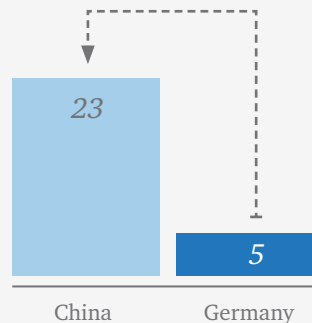
injection molding machines are owned by a Chinese mold manufacturer on average

[Chinese mold manufacturers possess high capacities in try-out.]

The try-out capacity for sampling in Chinese mold manufacturers is very high as a injection mold production is often directly attached to the mold manufacturers. Sufficient capacity for try-out is provided there. With an average of 23 injection molding machi-

nes, Chinese companies have far more than the German average of five try-out machines. In around half of the audited Chinese firms, there are powerful German or European try-out machines in use.

Number of try-out machines



[A structured outsourcing exists only in few Chinese companies.]



In the Chinese tool and die industry, outsourcing of the complete mold manufacturing is uncommon. Merely single components of a tool are partially bought. However, a structured criteria catalogue for an outsourcing of specific components does not exist in most cases. Most of the time the components are outsourced with regard to

capacity. By contrast, competence-based outsourcing of single processes is paramount for the production technologies. The evaluation of the suppliers is also not highly structured, meaning that the field of supplier management still has great potential for Chinese companies.

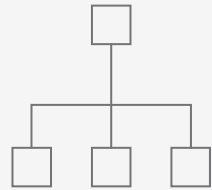


Organization

[Strict hierarchical structures result in low information transparency.]

The local audits of the mold manufacturers in China show that the companies are structured very hierarchically. In the majority of the companies, this is especially evidenced by the low transparency on the shopfloor. The strategic orientation and goals of the company are defined in large parts, but are not passed on to the personnel. It is particularly noticeable that many workers in production were not aware of the goals or customers of their current project, often resulting in a lack of understanding for the overall

project. This can be led back to the company structure, which is influenced by the hierarchical Chinese culture, as is politically reflected in the one-party system and rule of the communist party. Therefore, the companies do not recognize the importance of a communication policy towards the workers. This is in strong contrast to the current efforts in Germany, which aim at maximizing transparency in production via varying shopfloor management systems.



[Occupational safety is not a standard in Chinese companies.]

There is large potential in these companies with regard to occupational safety. In only four of the visited mold manufacturers, the workers had appropriate safety equipment and precautions. In many companies, the hall layout and the workplace design offer possibilities for improvement towards a safe workplace. Markings on the floor to indicate safe work paths are not a standard in China. Cleared work paths and sufficient room near machines, however, are usually still given due to the large production halls at many companies. Further, ergonomically advantageous workplaces are rarely found in Chinese companies, both in production and in of-

fices. Especially designers and programmers partly have to work in cramped work spaces with bad lighting.

The certification according to German norms is not widespread among the companies evaluated in this study. The application of the norms DIN EN ISO 9004:2009 and DIN EN ISO 19011:2011 is found in nearly every company. Nearly half of the companies have a certification according to the international environment norm ISO 14001:2004. On a positive note, 82.5% of the mold manufacturers are certified according to the quality management norm DIN EN ISO 9001:2008.



82.5%

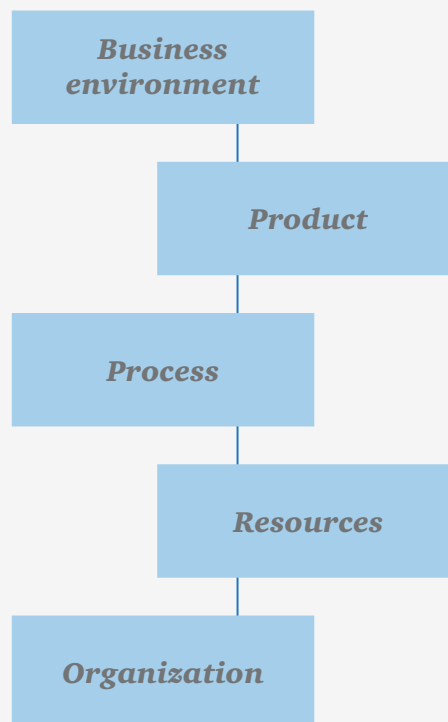
of the companies are certified according to the DIN EN ISO 9001:2008

Conclusion and Outlook

China has evolved to become one of the most important markets for mold manufacturers worldwide. Despite economic turbulence, the importance of the Chinese market will remain at a high level with economic growth still around seven percent. This applies both to the supply market and to the sales market of tools. The cooperation with Chinese value-added partners in the tool and die industry can be a decisive competitive advantage for German and European companies, especially for those with production facilities in China. Particularly with respect to injection molds, there is an enormous potential that can be used by German companies due to the long experience of the Chinese mar-

ket and the high number of companies in this field. This initial situation motivated the companies B. Braun Melsungen AG, Geresheimer AG and Harting Applied Technologies GmbH as well as the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH

Aachen University and the Fraunhofer Institute for Production Technology IPT to carry out this study concerning the capabilities of Chinese injection mold manufacturers. In total, 132 mold manufacturers were identified that met the requirements. Of these 132, 41 were analyzed in detail and the best 12 were locally audited. The following summarizes the most important findings:



Business environment

China's economy is currently facing the challenges of rising wages and a high level of debt for the private sector. This will lead to a shift of the center of the Chinese tool and die industry from Shenzhen to the hinterland. Through large infrastructure projects of the Chinese government, these regions are being prepared for industrial evolution.

Product

The manufacturing of delicate injection molds with the smallest tolerances and a high number of cavities is extremely challenging. Measured by these requirements, many Chinese mold manufacturers do not have the capability of producing molds of the highest quality without further refinishing work. However, simple molds or single mold components can be purchased easily on the Chinese mold market. After an exact identification and evaluation of potential suppliers, there is large potential in this area for German mold purchasers.

Process

Looking at the processes, Chinese mold manufacturers are definitely efficient, as demonstrated by a satisfactory deadline adherence and short lead time. This is particularly true for tool design, where enormous processing speeds and thus short design times are achieved. The assembly and try-out have the lowest capabilities. Here, the lack of vocational training for the workers is evident, which means that intensive supervision is required by demanding customers.

Resources

Compared to Germany, the Chinese tool and die industry possesses modern machinery thanks to high investment quotas. Thanks to high machine capacities, short lead time can be achieved in the mechanical production. There are also high capacities available in try-out. Nevertheless, the lacking know-how in this field is particularly noticeable.

Organization

The organization in Chinese mold manufacturers is very hierarchic. Shopfloor management concepts, such as those used to increase transparency in Germany, are uncommon in China. Further, ergonomic and safety precautions are at a very poor level.

The summary shows that the Chinese tool and die industry generally has great potential in the area of injection molds. However today purchasers of Chinese molds cannot expect to be able to buy highly sophisticated injection molds with a large number of cavities in China. Rather, building a lasting partnership with Chinese mold manufacturers is necessary for long-term supplier qualifications and sustainable improvements. In this way, the Chinese companies can continue to evolve and rise to the highest levels of demands.

Study participants



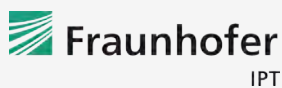
WBA Aachener Werkzeugbau Akademie

The WBA Aachener Werkzeugbau Akademie develops industry-specific solutions for the sustainable competitiveness of the tool making industry in a network of leading companies. Its activities focus on industrial consulting, further education, industry solution as well as research and development. Its own demonstration mold manufacturer enables the WBA to test innovative approaches in the laboratory and quickly make them accessible for its partner companies. Key issues are further addressed in the current studies. These provide information about trends and developments of the market and competition.



Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University

Across the world, the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University with its 900 employees stands for successful and forward-thinking research and innovation in the area of production engineering. Active in four different fields, WZL research activities not only relate to fundamental theories and findings, but also to the application of findings in an industrial context. Furthermore, practical solutions are developed to optimize production. The WZL covers all sub-disciplines of Production Technology with its four chairs of Production Engineering, Machine Tools, Metrology and Quality as well as Manufacturing Technology.



Fraunhofer Institute for Production Technology IPT

The Fraunhofer Institute for Production Technology IPT in Aachen combines knowledge and experience in all fields of production technology. The IPT offers project partners and clients individual, specialized solutions and results that can be directly implemented for modern production, divided into the areas of process technology, production machines, production metrology and quality as well as technology management. In cooperation with the WZL and WBA, the IPT carries out benchmarking projects in the tool and die industry, where the focus lies on evaluating the technological potentials of the sector.

Tool making of the B. Braun Melsungen AG

B. Braun provides the worldwide health market with products for anesthesia, intensive care, cardiology and surgery. The application in the medical sector necessitates highest quality standards. In 2015, B. Braun had 54,000 employees with a revenue of €5.43bn.

The tool making division B. Braun Melsungen AG supplies the own injection molds to its production, which is partly in clean rooms with high quality tools. These combine the special demands of medical technology concerning quality and retraceability with large output quantity via injection molds with many cavities.



Gerresheimer Werkzeugbau Wackersdorf GmbH

Gerresheimer is a leading global partner to the pharmaceutical and healthcare industry. The comprehensive product portfolio includes pharmaceutical packaging and products for the safe, simple administration of medicines. Worldwide, it employs 11,000 workers and had a revenue of €1.4bn in 2015.

With 60 employees, the Gerresheimer Werkzeugbau Wackersdorf GmbH is among the best mold manufacturers in German-speaking countries. This is shown by repeated top ranks in the renowned "Excellence in Production" competition. Gerresheimer Werkzeugbau is affiliated to the international Technical Competence Center, which has a location in Dongguan, China. In particular, highly complex, sophisticated tools with the highest precision are produced for the large series production in clean rooms.



Tool making of the HARTING Applied Technologies GmbH

The HARTING Technology Group is active in the fields of electrical, electronic and optical connection, transmission and networking, as well as in manufacturing, mechatronics and software creation. The group uses these skills to develop customized solutions and products such as connectors for energy and data transmission applications. HARTING has 4,200 employees worldwide that generated a revenue of €567m in the fiscal year 2014/2015.

HARTING Applied Technologies develops, designs and manufactures injection molds, die-casting tools, punching tools, assembly systems and special machines. They specialize in high-precision production engineering for applications within the electrical and automotive industry. They offer extensive experience in the manufacturing and processing of precision technology components and systems. In 2014, the tool making division won the competition "Excellence in Production" in the category "internal tool maker with over 50 employees".



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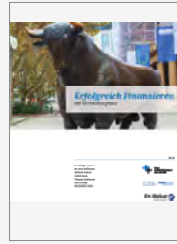
Our studies



Erfolgreich Performance Messen
2017



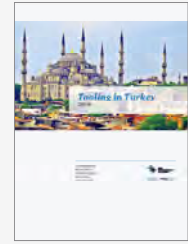
Erfolgreich Fertigungstechnologien Einsetzen
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Erfolgreich Finanzieren
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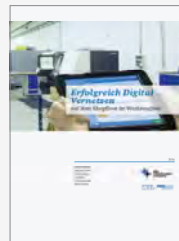
Smart Tooling
2016



Tooling in Turkey
2016



Tooling in China
2016



Erfolgreich Digital Vernetzen
2016



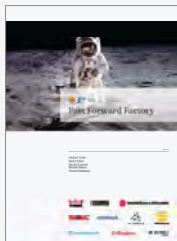
Tooling in Germany
2016



Erfolgreich Mitarbeiter Motivieren
2016



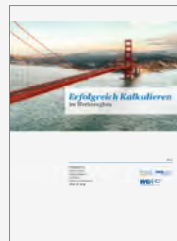
Fast Forward Tooling
2015



F³ Fast Forward Factory
2015



World of Tooling
2015



Erfolgreich Kalkulieren
2015



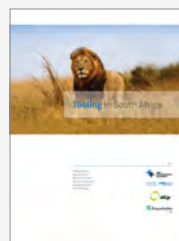
Erfolgreich Planen
2015



Getaktete Fertigung
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Tooling in China
2015



Tooling in South Africa
2014



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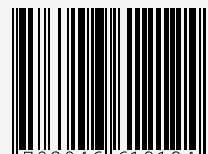
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