Abstract number: 011-0617

Differentiation through industrial product-service-systems in the tooling industry

Authors: Günther Schuh, Bastian Schittny, Fabian Gaus

Organization: Chair of Production Engineering, Laboratory for Machine Tools and Production Engineering, RWTH Aachen University

Address: Steinbachstr. 19, 52074 Aachen, Germany

E-mail: b.schittny@wzl.rwth-aachen.de

Phone: +49 241 80 28 199

POMS 20th Annual Conference

Orlando, Florida U.S.A.

May 1 to May 4, 2009

Abstract

Today's turbulent economic environment confronts the global tooling industry with serious challenges. Cost competition and the high demands of globalized value-adding chains put pressure on small- and medium-sized toolmakers. As an exclusive differentiation in price is not an option, new means for achieving sustainable competitive positions have to be found.

A promising approach for differentiation is to enhance the existing range of products by offering customer-specific services within so-called industrial product-service-systems. However, the lack of local presence inhibits the toolmakers' abilities to deliver these services to their global customers.

To address these challenges the European R&D-project TIPSS has the objective to develop suitable methods, techniques and technologies, for toolmakers to improve their local and global performance thus enabling them to offer industrial product-service-systems on a global scale. Based on an extensive survey, a global footprint of the existing service landscape and a

portfolio of value-adding services are created. The findings of the survey with respect to designing industrial product-service-systems are presented in this paper.

1 Introduction

1.1 Challenges of the Tooling Industry

Tool and die companies take up key positions within the production industries of most major economies (IRN 2002, Holmes et al. 2005, Menezes 2004). This crucial role arises from their responsibility for the entire industrial value chain in terms of time, cost and quality – the adherence to schedules of the customer's production is decisively determined by a tool of superior quality delivered on-time to its production site.

It can be stated that the quality of every product is directly linked to the quality of its tool. Every start of production depends on the completion of the required tools and their integration into the existing production facilities. A tool's technological abilities have significant influence on set-up and cycle times of the machine tools, thus having a tremendous effect on the manufacturing cost. The tooling costs themselves can contribute up to 60% of the final product's over all manufacturing costs (Benchmark 2004, DuPont 2007).

While being a key component of every major economy, the tooling industry faces fierce competitive pressures which have continually intensified due to the financial crisis. However, the root of the problem goes far beyond the current global recession. It is the inability of the tooling industry to adapt to globalized markets as well as the resulting challenges and opportunities which puts the very existence of many a toolmaker into jeopardy.

Against this background today's situation of toolmakers needs to be described both concerning their local and global performances:

Local performance

- There are no adequate interfaces, but only sporadic, undefined loops between the product development process of the customer and the tool development process of the toolmaker.
- Only few toolmakers offer product-services along the product development process, hardly any offer product-services along the production phase.

Global performance

- Established markets migrate eastwards, new markets emerge.
- Western SMEs are locally-focused and have limited capacities, general conditions in western economies in terms of labor costs, legal requirements or interminable administrative processes narrow their abilities to be competitive.
- Many toolmakers think and manage their companies conservatively – thinking of "fear", lacking risk appetite and being inflexible: they do not realize the chances of globalization, not even in terms of sourcing and purchasing.
- Hardly any toolmaker pursues a proficient external presentation, nor does the entire branch as a whole. Established platforms and associations are barely taken advantage of.

In general, only a small number of toolmakers uses global cost potentials, markets and flexibility to cope with this situation. Toolmakers mostly stick to their own value-adding chains. The strategies of forwards and backwards integration are not common practice in this specific industry. Without the integration of suppliers and partners into one's own value-adding process or integrating oneself into the product development and production phases of the customer, a toolmaker becomes replaceable for the latter (Cleveland 2002, Holmes et al. 2005, Menezes 2004).

1.2 Establishing a Sustainable Competitive Position

It is the main objective of the European Union funded TIPSS project (Tools for Innovative Product-Service-Systems for Global Tool and Die Networks) to meet these challenges by developing suitable methods, techniques and technologies which enable toolmakers to improve their local and global performance in order for them to establish a sustainable competitive position.

A promising approach for differentiation over competitors is to enhance the existing range of products by offering customer-specific services (Lindahl et al. 2001). However, this is not as easy as it sounds in a branch, in which customers force quotes and offers have to contain a detailed listing of efforts for all manufacturing steps. In this branch, services are usually offered as an add-on. They represent some kind of "feel good factor" for the customers instead of realizing extra margins (Schuh et al. 2007). Thus the challenge is to identify the customer's critical processes to develop product-services in order to support these processes and to offer product-service-systems (Salminen et al. 2007). The latter is an integrated product and service offering that delivers value in use (Roy 2008). Thus a product-service-system (PSS) depicts an intelligent bundling of individual services with the core product (speaking of the tool itself) and can also be described as a hybrid product (Lifset 2000, Meier et al. 2005, Kortmann 2007).

Offering product-service-systems and making money with them is an issue, which cannot just be carried out on the level of operations. As the success of a company is founded in its business model (Ansoff et al. 1993, Mintzberg et al. 1999, Truch et al. 2004) the latter needs to be re-designed to align strategic and operational objectives. A holistic approach to offer industrial product-service-systems is introducing a business model which addresses the customer's needs by adding value to his processes generating sources of income along the tool's entire life-cycle.

Following this line of thinking one has to ask how added value for the customer can actually be achieved while delivering a return for the toolmaker at the same time. So far this was hardly possible due to a lack of appropriate technologies with regard to the provision of tool-related services. Within TIPSS new technological solutions are being designed that will qualify toolmakers to develop such business models. These business models are based on so-called “smart tools”, which represent injection moulds equipped with state-of-the-art sensor technology delivering real-time data from the production process. On the basis of these „smart tools“, the toolmaker gets an “inside” view into the tool. Thus a broad knowledge of the actual condition of the latter can be gained. A cost-effective and rapid creation of both knowledge- and technology-based industrial services is made possible.

A prerequisite for designing new business models based on industrial product-service-systems is having profound knowledge of the customer’s needs and demands. Only if the toolmaker knows how he can generate genuine added value for his customer he will be able to offer adequate services at an acceptable price. Therefore, the first task of the TIPSS project was to conduct a global survey among toolmakers and their customers. As a primary result, the requirements for satisfying the customer’s demand for tool related services were identified, laying the base for developing a service portfolio for the creation of industrial product-service-systems. The survey’s second aim was to inquire how customers value possible services and how high a monetary compensation for these services might be.

In this paper, the findings of the survey are evaluated with regard to the creation of business models based on tool related services. To give an overview on the relevant aspects of industrial product-service-systems, the theoretical base as well as the technological enabler for business models relating to industrial product-service-systems are laid out.

2 Business Models for Industrial Product-Service-Systems

Business models are subject to change due to constantly changing interests of the customers (Schuh et. al 2008). Regarding the objective of TIPSS, which understands a toolmaker as the manager of global partner and customer networks, conventional entities of the strategic management (such as business unit, branch, company) do not take these changes into consideration adequately. Moreover, they lack collaborative aspects in designing trusting business relationships. Thus business models that embrace the idea of creating added value through cooperation need to be developed.

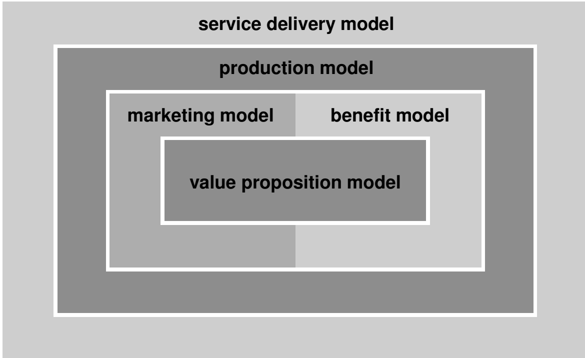
2.1 Business Model Design

2.1.1 Service Oriented Business Models

With regard to the extensive business model research over the past years (McKinsey & Company 2002, Schuh et al. 2003, Bauernhansl 2004, Müller-Stewens et al. 2005, Schuh et al. 2007a, Copani et al. 2007, Schuh et al. 2008a), a business model for industrial product-service-systems in the tooling industry consists of five sub-models as shown in Figure 1:

- Value proposition: Which value is offered to the customer?
- Marketing: How can appropriate customers be attracted?
- Benefit: How is the profit mechanism to be designed?
- Production of goods and services: How shall the output be generated?
- Service delivery: How does the toolmaker integrate himself into the value-adding chain of his customer?

Figure 1 Business model paradigm for product-service-systems of tool and die companies (Schuh et al. 2008b)



Value proposition model

Against this background, the value proposition model defines which products and services are offered to which customers and how differentiation over competitors can be achieved. The latter notably results from the combination of a premium core-product and a one-of-a-kind service portfolio. As services are even harder to copy than physical products, the existing service landscape is extended by customer-specific product-services within the portfolio. Such product-services can be a guaranteed availability, preventive maintenance and financing mechanisms.

Marketing model

The marketing model is closely related to the definition of service to be rendered. It sets off activities to identify and address the needs of economically attractive customers. This process is supported by adequate communication tools and the corporate claim.

Benefit model

The benefit model specifies what is sold and which services deliveries are put down to the customer's account. An important aspect of this sub-model is the price policy along with the pricing itself, which results from the concrete design of the profit mechanism. Thereby the different stages of benefit for the company are determined. Profit can thereby also be realized in the operation phase of the tool's life-cycle.

Production model

The production (of goods and services) model describes in which way the products and services are generated by the own or an external company. This leads to the discrete phases of value creation along with the allocation of abilities and resources. In a holistic approach to business models it is therefore essential to examine the creation of value throughout the enterprise as a whole.

Service delivery model

The service delivery model links the toolmaker's value proposition model to the customer's production model and vice versa. Within this fifth sub-model both parties agree on a specified way for the exchange of information between the two business models. The tools and resources needed for providing a reliable control of the operation parameters of the tool in service are determined. This contains the way of data exchange and the choice of appropriate soft- and hardware equipment. Therefore the service delivery model is the fundament for the delivery and rendering of services like a guarantee of availability or preventive maintenance activities.

Figure 1 shows that four sub-models enclose the value proposition model. This goes back to the fact that a business model is based both on the value proposition model and on combining the core product with a company's service portfolio to product-service-systems. Besides, total assets, profit, return on investment and other measures are in the center of interest of a company's complex shareholder groups and structures.

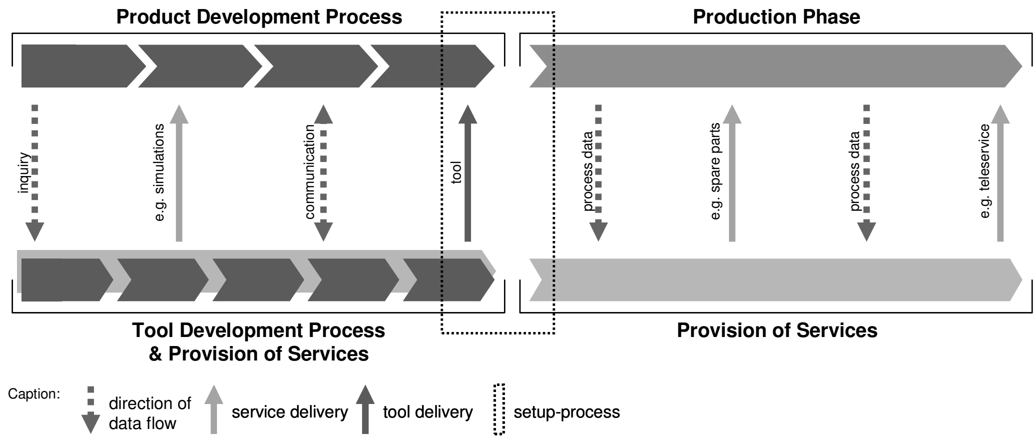
The service delivery model encloses all other sub-models as the utmost layer of the model. This fact points out that the integration of sensor technology into the tool is of high importance for a functional technology-based business model; but at the same time the other four sub-models are also able to function without being connected to the customer's business model through the service delivery model.

Nonetheless, the entire benefit can only be achieved by applying the full model including the service delivery model: Both business models of the customer and of the toolmaker need to be considered and combined. This combination makes all benefit potential accessible and assures sustainable success for both parties (Müller-Stewens et al. 2005).

2.1.2 Added value for tool and die companies

On this basis the service delivery model puts the toolmaker in the position to configure customized services it had not been capable of rendering before: It becomes capable of monitoring the process and of installing a preventive maintenance; forecasts for proper service intervals can thereby be made and be scheduled to non-production times. The operational availability of machine and tool can be increased. At the same time the tool and die company is now able to integrate the knowledge gained into new product development processes (see Figure 2).

Figure 2 Modern business models bundle the processes of product development and service provision (Schuh et al. 2008)



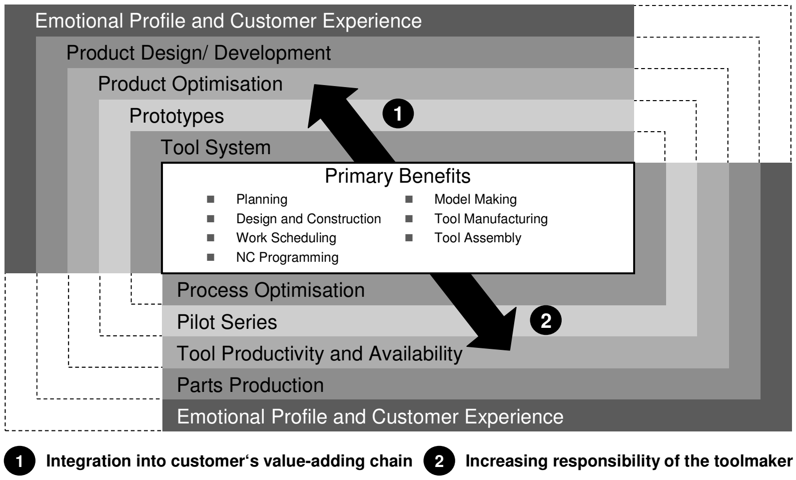
This new approach to new business models for the tooling industry links products and services through the direct coupling of the processes of tool design/ development and the provision of services. The toolmaker is now able to offer its customer product-service-systems, which allows itself to expand its range of service provision to the production phase of the customer. Whereas up to now the provision of goods and services has ended with putting the tool into service, now the service portfolio can be supplemented by new services rendered in the production phase.

2.2 Industrial Product-Service-Systems

As products get more and more exchangeable companies have to find a way to differentiate themselves from their competitors. Linking new innovative services to the core product and thereby creating industrial product-service systems is maybe one of the most promising ways to create more customer value and to gain a true competitive advantage. Especially the tool and die industry has not yet benefited from this "new manufacturing" that enables producers to profit from higher service profit margins, growth opportunities in mature markets and longer lasting customer relationships that often result in exclusive collaborations on a par that prevent purely price based competition.

In the TIPSS project, the concept of industrial product-service-systems encompasses the integration of the toolmaker into the customer's value chain. The toolmaker thus becomes an integral part of the customer's production process, increasing the dependence of the customer towards his toolmaker. Figure 3 illustrates the increasing integration of the toolmaker into the customer's processes as the portfolio of offered services expands. Starting at the core product, the tool, each layer adds another service. While moving outward in the diagram the degree of connection to the core product decreases, meaning that vertical integration into the customer's processes increases.

Figure 3 Extended product-services within the TIPSS Business Model



The challenge for achieving the optimal added value for both sides is to adequately configure the industrial product-service-system with respect to the service portfolio as well as the technology to enable the service provision.

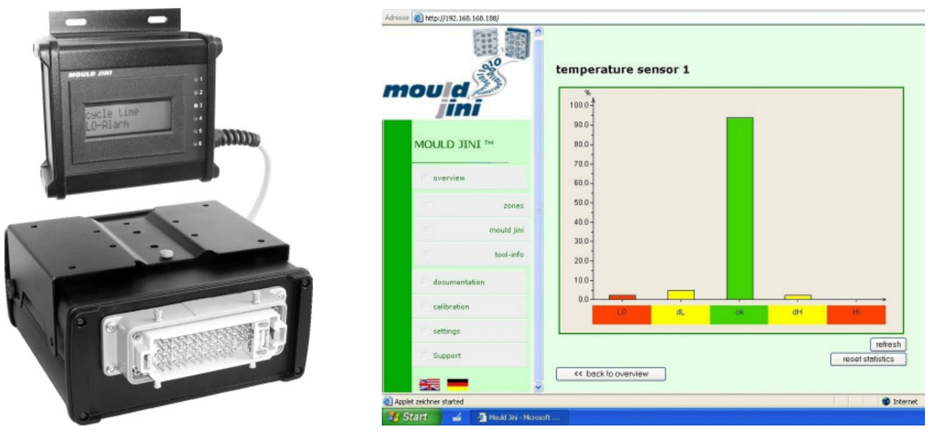
2.3 Technological Enabler

The main enabler for a business model based on industrial product-service-systems is the availability of data from the production process. Such data allows the toolmaker to determine which service is needed by the customer at any given point of time.

'Intelligent' tools, which are to deliver data from the production process from both tool and machine, can represent a solution. Therefore a prototype injection mould with sensors integrated into an injection mold's cavity is being developed in the TIPSS project. The so-called "mould jini" (see Figure 4), developed in the TIPSS project, is a device incorporating sophisticated sensor technology, which is directly connected to the tool. It collects data such as the number of closures and shots, cycle times, temperatures, forces and pressures. This data is called documented in an “electronic tool book”, which represents a log-book of the tool being in service.

The “mould jini” supervises and stores the actual values of each injection cycle allowing stored data to be used for further analyses enabling the user to avoid damages and loss of production by early detection of upcoming malfunctions. Depending on the equipment of the mould different data may be stored for nearly all sequences of injection and maintenance. The data stored in the “mould jini” can be accessed via a Web-browser allowing a toolmaker to operate it at any desired location.

Figure 4 Mould jini via web browser



In the TIPSS project algorithms and methods for an intelligent interpretation of collected data are developed in order to draw conclusions about the tool’s actual condition. This will allow the toolmaker to offer services to the customer at the appropriate point of time up to the point that real time tool surveillance will enable the toolmaker to guarantee his customer the productive availability of the tool.

3 Service landscape in the tooling industry

In order to develop the TIPSS business model, a large scale survey addressing both toolmakers and their customers was conducted. The survey was carried out in two parts, starting with the customers and ending with the toolmakers themselves. In total around 170 companies in relevant economies all over the world have participated in the survey. either by phone, regular mail or e-mail. The projected level of participation in the two parts of the survey was between 2.5 and 5 percent.

The central question within the creation of the TIPSS business model is which services would be most suitable for integration into a toolmaker's industrial product-service-system. The goal of the survey was to build up an empirical basis of information to answer this question. In particular, two sub-models were addressed by the survey:

- Value proposition model: Which value is to be offered to the customer?
- Benefit model: How is the profit mechanism to be designed?

As input for the *value proposition model*, the results of the survey were taken for drawing up a service portfolio for toolmakers. The portfolio was to be modularly configurable, which means that it can be easily customized by a toolmaker to fit his specific business conditions.

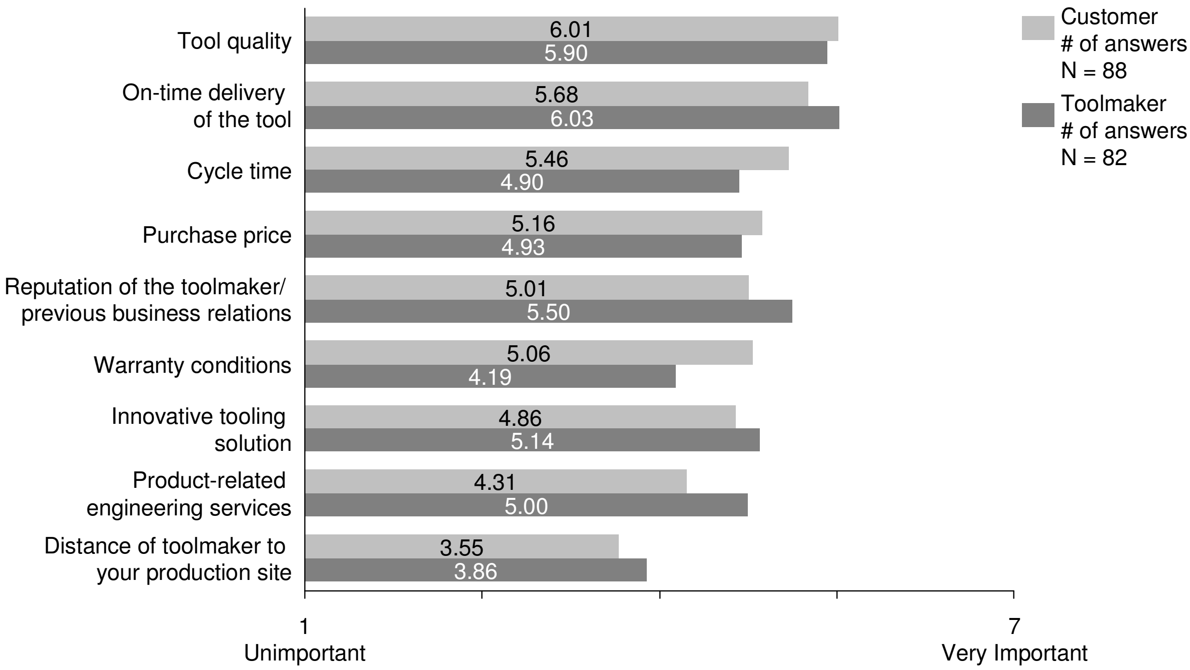
Within the *benefit model* achievable benefits from transactions are estimated and benefit levers selected. Furthermore, pricing policies and cost estimation models for product-service-systems are defined. Therefore the survey aimed at gathering information on how possible services are valued by the customers from a monetary point of view.

Selected findings of the survey, addressing both the *value proposition* and *benefit model,* are illustrated in the following.

3.1 Findings of the survey

One initial question that was directed both at toolmakers and their customers was what would be the most important criteria for choosing a toolmaker when acquiring new tools (see Figure 5).

Figure 5 Criteria for choosing a toolmaker



The widespread assumption that the most important criterion for a customer would be the purchase price of a tool has been disproved. Superior criteria turned out to be the quality of a tool followed by on-time delivery and short cycle time, showing that total cost assessment is gaining in importance.

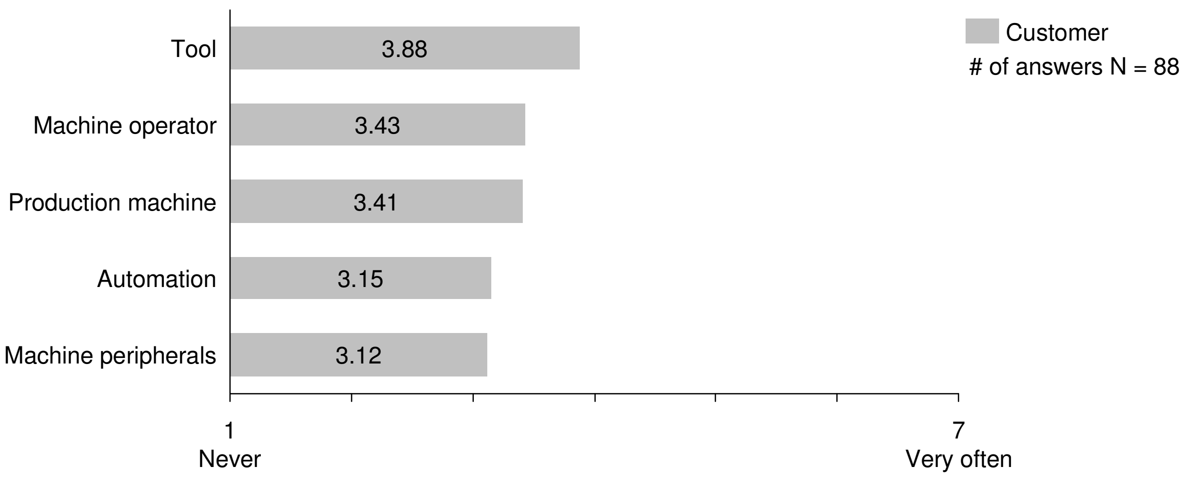
Next to the absolute evaluation of the criteria it was especially interesting to note the differences between the toolmakers' evaluation and the actual evaluation by their customers. While toolmakers generally believed that previous relations to a customer would secure them future contracts, the customers displayed a much higher willingness to switch suppliers. Vastly underestimated by the toolmakers was the necessity of offering adequate warranty conditions. The fact that both toolmakers and their customers evaluated the distance between customer and supplier as relatively unimportant shows that both sides do take part in the globalization of markets. However, this is no indication of how well they perform within these markets.

When designing a portfolio of tool related services to be offered, the main focus needs to be on the added valued for the customer. Therefore one goal of the survey was to identify which challenges the customers of the tooling industry face and how high their willingness would be to pay for a solution to these challenges. The challenges where categorized into malfunctions in the production process as well as maintenance measures for preventing or resolving malfunctions. Each category was explored by a series of detailed questions.

3.1.1 Malfunctions in the production process

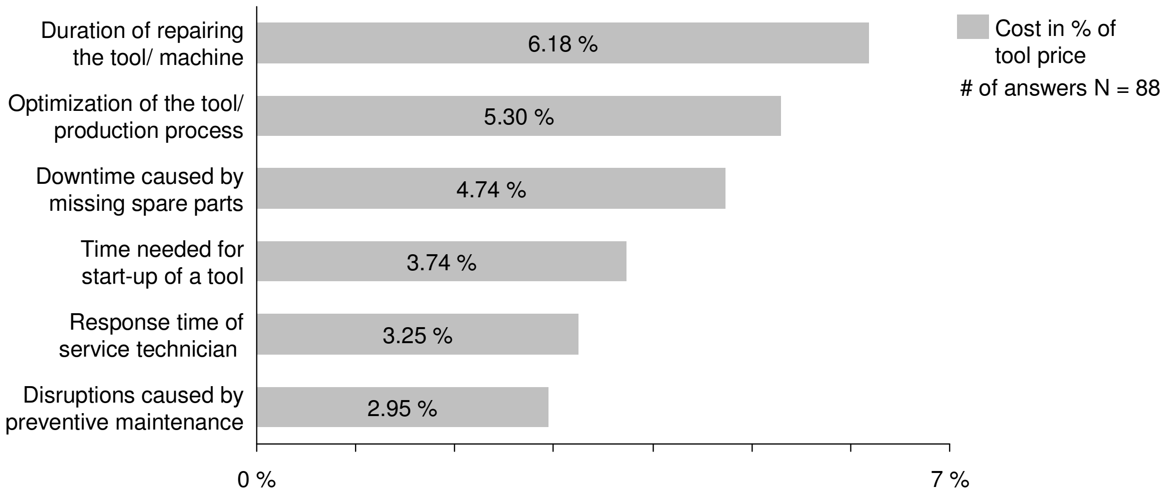
As anticipated, the main cause for malfunctions in the production process turned out to be the tool itself, followed by the production machine and the machine operator (see Figure 6). This outcome confirmed our assumption that there is a relevant need to improve the cooperation between toolmakers and their customers. As each tool is more or less a prototype, only close cooperation can lead to the desired results.

Figure 6 Causes for malfunctions in the production process



In order to get a clear picture of the economic consequences of tool related malfunctions, the customers were asked to estimate the costs they incurred by different types of interruptions of the production process (see Figure 7). To achieve a high level of comparability among various types of production processes, the cost of an interruption was to be specified in percent of a given tool's purchase price.

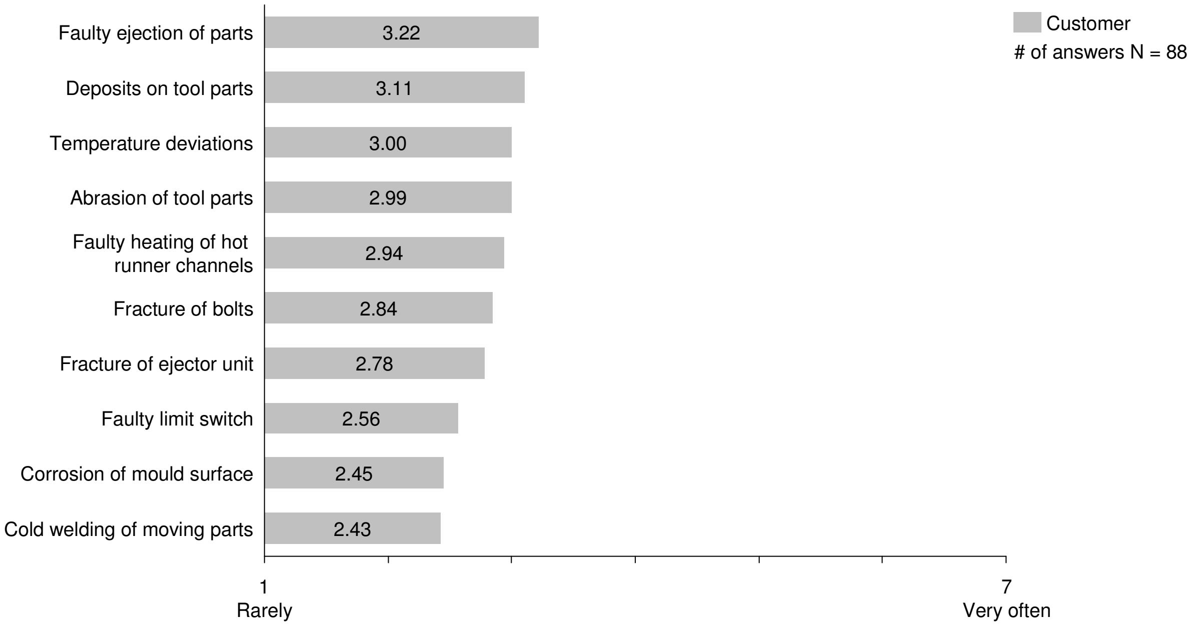
Figure 7 Cost of typical production process interruptions



The results show that the most costly interruption of the production process is the time needed for repairing a broken tool. It can be concluded that services aiming at the reduction of tool downtime, e.g. a faster tool repair process, have great potential for providing added value to the customer. The interpretation of process data collected by smart tools offers the possibility to improve a tools optimization process again reducing downtime of the tool.

Figure 8 shows possible causes of a tool malfunction. It becomes clear that while some causes are more frequent then others, every one of them needs to be addressed by the customer in order to have a functioning production process. For the toolmaker this creates the opportunity of offering value adding services resolving these issues.

Figure 8 Causes for tool malfunctions



As a result of frequent tool malfunctions, many parts producing companies choose to inspect their tools on a regular basis. The survey showed that 90 percent of the companies have their tools inspected every month. 53 percent even inspect their tools on a weekly or daily basis. This high frequency indicates the importance of having up to date information on a tool's condition. It also gives a hint of how much time and money the companies have to invest, binding valuable resources which thus are not available for value adding tasks.

3.1.2 Maintenance and Service

When choosing appropriate tool related services for the service portfolio, a toolmaker has to take into account not only if a service is needed by his customers, but also evaluate the willingness to pay for it. In order to give guidelines to this selection, we asked the participating parts producers to evaluate a selection of services that were listed in the questionnaire. The services were divided into six categories:

- General services
- Data and diagnostics

- Documentation and standards
- Support for the production process
- Hardware related services
- Preventive maintenance

Participants were asked to rate each service according to the importance for their production process, the current availability of the service as well as their willingness to pay for it. For the evaluation of the economic potential of each service we developed the following model. The model was based on the assumption that importance and acceptable cost of a service increase its economic potential while a high availability of the service on the market reduces its potential.

1. The ranking according to importance was to be done on a scale from one to seven (i_n), one being the lowest value and seven the highest.

Importance $I = (\sum i_n) / N$, where $i_n \in (0, 1, \ldots, 7)$, $n \in \{0, 1, \ldots, N\}$, N = number of answers

2. The participants were to mark whether a service was offered (a_n) to them by their toolmaker, another supplier or not offered by third parties. To fit the one to seven scale, the results were multiplied by seven.

Availability $A = (\sum a_n) / N * 7$, where $a_n \in \{0, 1\}$, $n \in \{0, 1, \ldots, N\}$

3. The accepted cost was to be specified in percent of a tool's purchase price, which was classified in five classes: 0 percent, 0-2 percent, 3-5 percent, 6-10 percent and more then 10 percent of the tool price. As the economic evaluation was not an absolute one but rather compared the individual services with each other, an arbitrary value for each class was chosen in order to fit into the one to seven scale.

Accepted Cost $C = (\sum c_n) / N * 2$, where $c_n \in \{0, 1, 4, 8, 12\}$, $n \in \{0, 1, \ldots, N\}$

4. The relative economic potential of each service compared to each other was derived by multiplying the Importance by Accepted Cost and dividing by the Availability. The result was scaled by 7/9.

Potential $P = (I * C / A) * 7/9$

The resulting evaluation of each service is given in Figure 9 through Figure 14

Figure 9 General Services

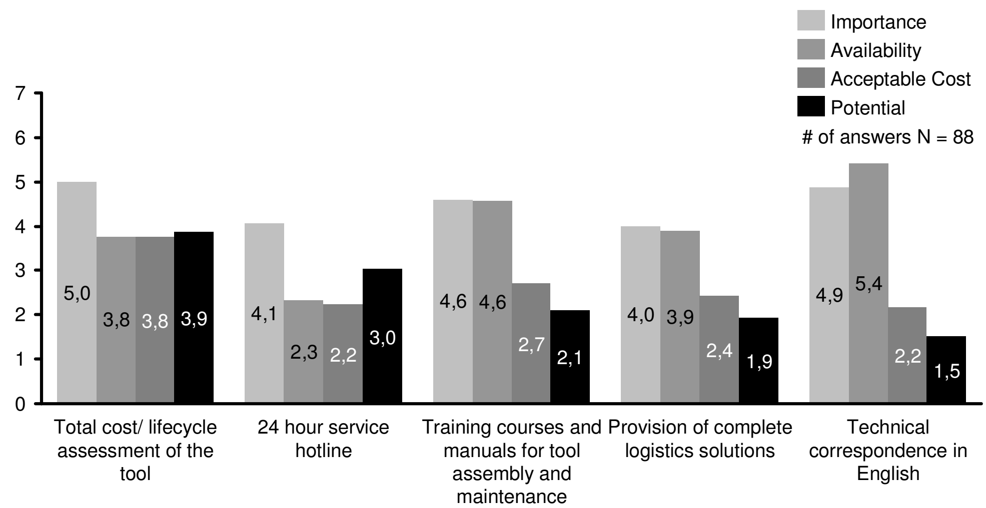


Figure 10 Data and Diagnostics

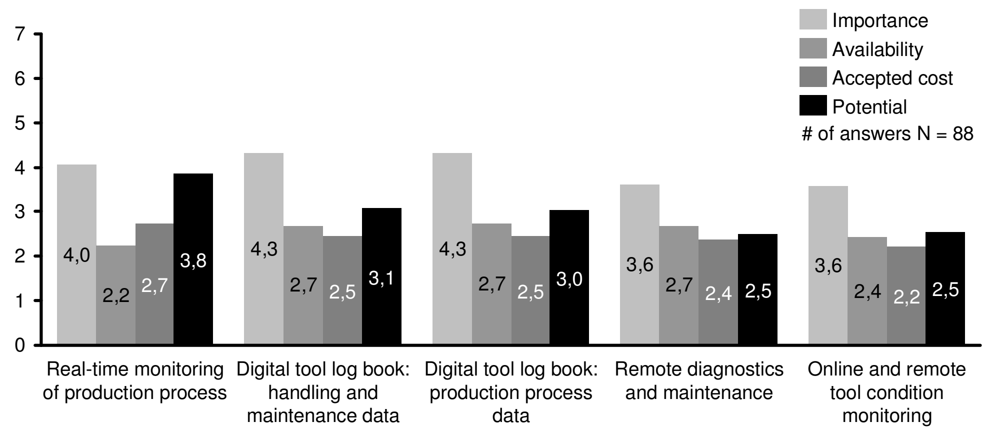


Figure 11 Documentation and standards

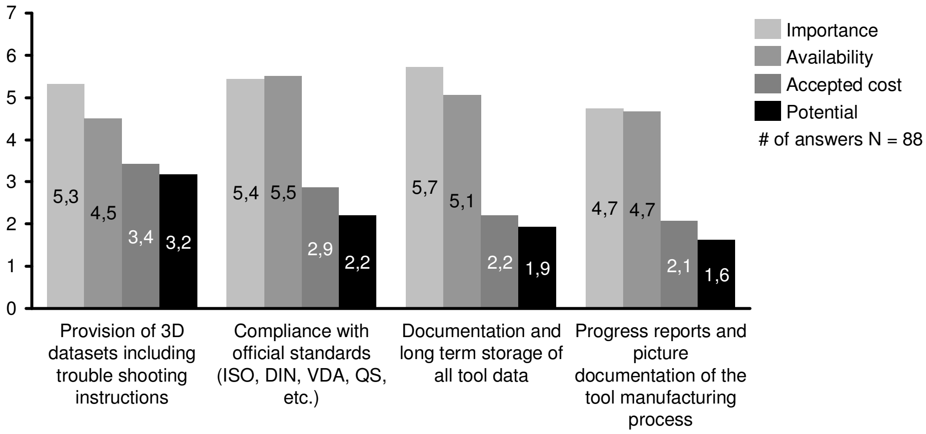


Figure 12 Support for the production process

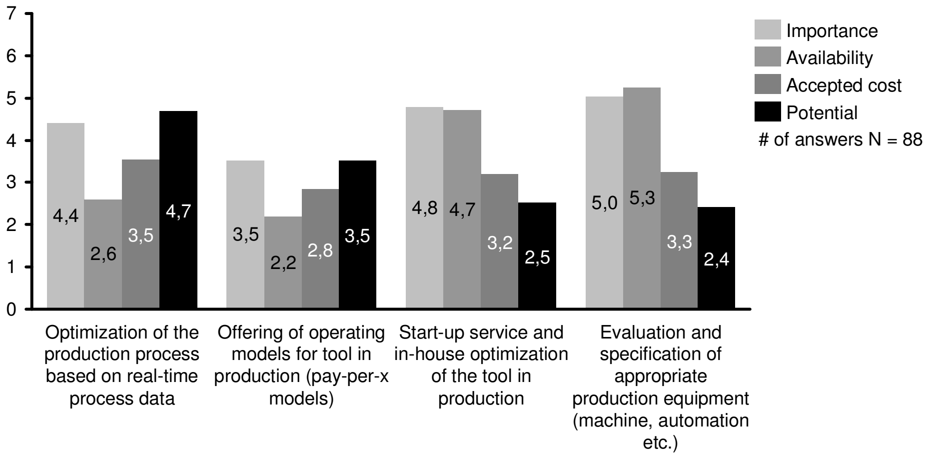


Figure 13 Hardware related services

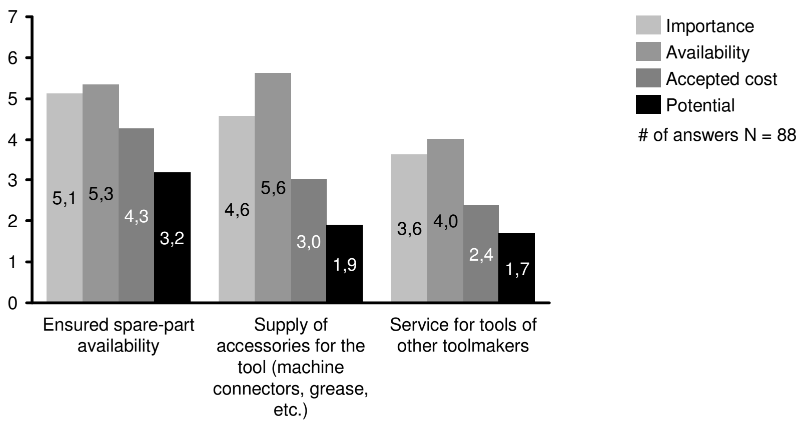
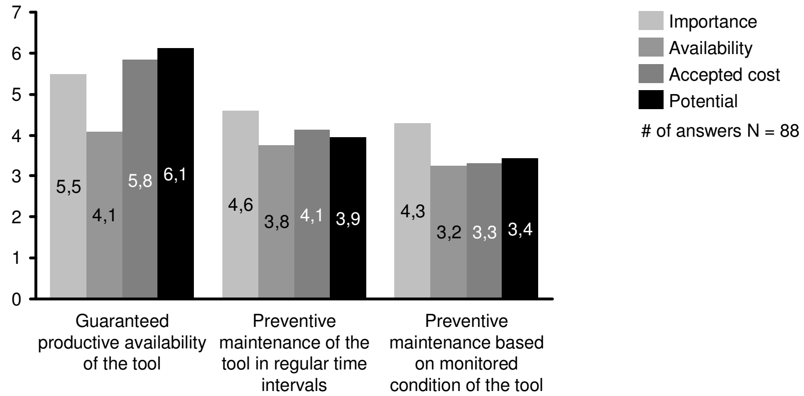


Figure 14 Preventive maintenance



Over all, the highest potential was received for the services "guaranteed productive availability of the tool", "optimization of the production process based on real time data", as well as "preventive maintenance of the tool in regular time intervals". Clearly some services which are generally deemed very important by both customers and toolmakers did not score very high in the indicator for economic potential. This is due to the fact that the customers either expect the toolmaker to deliver these services at a very small fee if any or because they are readily available on the marked.

The findings of the study show, that there is a demand for service and that customers are willing to pay for them if they generate added value for them.

Based on the identification of frequent tool malfunctions and resulting production process interruptions technological solutions for improving the production process will be developed in the TIPSS project. As described above, the technological enabler for these solutions will be smart tools that allow constant surveillance of tool related process data. The evaluation of tool related services from the customer's point of view has shown which services have a high economic potential for the toolmaker. These services will be included in a service portfolio to be tested within the prototype industrial product-service-system.

4 Conclusions and Outlook

Today's toolmakers face the challenge to maintain their competitive position in a changing globalized market. Focusing on cost cutting or differentiation through high quality tools is no longer sufficient to meet this challenge. A possible key to success is offering the tool in combination with value adding services. These so-called industrial product-service-systems bind the toolmaker closely to his customers and generate additional income along the lifecycle of the tool. In order to be able to provide value adding services together with the tool, toolmakers have to adapt new business models, based on so-called smart tools. Smart tools collect and analyze tool related data from the production process, which can be used to improve maintenance efforts and reduce tool downtime via services offered by the toolmaker. Business models incorporating industrial product-service-systems consist of five sub-models:

- Value proposition model: Which value is offered to the customer?
- Marketing model: How can appropriate customers be attracted?
- Benefit model: How is the profit mechanism to be designed?
- Production model: How shall the output be generated?
- Service delivery: How does the toolmaker integrate himself into the value-adding chain of his customer?

The results of the survey presented in this paper address the *value proposition* and the *benefit model*. The findings indicate which services have the potential to offer added value for the customer. As shown in the graphs, there is indeed a relevant need for services increasing the technical availability of a tool, which leads to more stable productions processes. Furthermore the results show the customers' willingness to pay for a selection of possible services to be offered by the toolmaker, giving input for possible pricing strategies.

The cost side of the *benefit model*, meaning the cost incurred by establishing and maintaining an industrial product-service-system, depends on the individual services offered and will be analyzed within the research project with respect to the *production* and the *service delivery model.* The aforementioned smart tools are the backbone for the generation of tool related services. Within TIPSS, a prototype industrial product-service-system will be created, including tools equipped with the "mould jini" sensor technology. These tools will be tested and evaluated in the actual production process of a project partner. Part of the research is the development of algorithms that allow the interpretation of the collected process data. In combination with the service portfolio established on the basis of the survey results, the operational service provision process will be developed *(production model*). Regarding the *service delivery model*, an internet based cooperation platform will be created. The platform is needed to exchange collected data and facilitate communication between customer, toolmaker and further entities within the customer-partner network. The cooperation platform ultimately has the goal of establishing the toolmaker as the network manager that coordinates all elements of industrial product-service-system, acting as the single point of contact towards the customer.

The final outcome of the TIPSS project consists of a business model combining newly developed smart tools, a portfolio of services to be offered within the industrial product-service-system as well as a cooperation platform for global partner and customer networks. With all elements put together, toolmakers will posses suitable methods, techniques and technologies to improve their local and global performance and strengthen their competitive position.

5 References

Ansoff, H.I., P. A. Sullivan. 1993. *Optimizing profitability in turbulent environments: a formula for strategic success.* In: Long Range Planning 26 (5) 11–24.

Bauernhansl, T. 2004. *Veränderungsmanagement im Werkzeugbau: Strategien zum Leben erwecken*. In: Proceedings of the 4th International Colloquium "Tool and die making for the future", September 28–29, Aachen.

Benchmark. 2004. *Benchmark – Lernen von den Besten*, Teil 8: Öffnung nach außen. In: werkzeug&formenbau 2004 (6) 74–76.

Copani, G., L. M. Tosatti, S. Marvulli, R. Groothedde, D. Palethorpe. 2007. *New Financial Approaches for the Economic Sustainability in Manufacturing Industry*. In: Procceding CIRP Tokyo, 183-188.

Cleveland, M. 2002. *A Competitive Assessment of the Die and Mould Building Sector*. Grand Rapids, Mi.: www.mbs-2003.org. Retrieved August 1, 2005.

DuPont. 2007. DuPont Materialdaten für die Konstruktion – Modul II. http://plastics.dupont.com. Retrieved November 12, 2007.

Holmes, J., T. Rutherford, S. Fitzgibbon. 2005. *Innovation in the Automotive Tool, Die and Mould Industry*. In: Wolfe, D., M. Lucas (eds.). *Network Structure of an Industrial Cluster.* Queens University, Toronto. 119–154.

IRN. 2002. *A Competitive Assessment of the Die and Mold Building Sector*. IRN, Inc., Grand Rapids, MI.

Kortmann, D. 2007. *Dienstleistungsgestaltung innerhalb hybrider Leistungsbündel.* Shaker, Aachen.

Lifset, R. 2000. *Moving from product to services*. Journal of Industrial Ecology. Vol 4 No 1, 1-2.

Lindahl, M., G. Ölundh. 2001. *The meaning of functional sales.* Proceedings of he 8th international seminar on life cycle engineering, June 18-20, Varna, Bulgaria, 211–220.

McKinsey & Company, Inc., WZL der RWTH Aachen. 2002. *Profitable Wachstumsstrategien für den Maschinenbau.* VDMA, Frankfurt/ Main.

Meier, H., E. Uhlmann, D. Kortmann. 2005. *Hybride Leistungsbündel*. In: wt Werkstattstechnik online, 2005/7–8:528–532.

Menezes, J. 2004. *European Mould Making: Towards a New Competitive Positioning*. In: Proceedings of the 4th International Colloquium Tool and Die Making for the Future, September 28–29, Aachen.

Mintzberg, H., J. Lampel. 1999. *Reflecting on the strategy process*. In: Sloan Management Review 40 (3), 21–30.

Müller-Stewens, G., C. Lechner. 2005. *Strategisches Management*. 3rd Edition. Schaeffer-Poeschel, Stuttgart, 409–411

Roy, R. 2008. *Evaluating PSS Business Models for Machine Tool Industry*. In: Proceedings of the Transregio 29 International Seminar on PSS, January 21–22, Bochum.

Salminen, V., P. Kalliokoski. 2007. *Challenges of Industrial Service Business Development*. In: Taisch, M., Thoben, K.-D., Montorio, M. (eds.), 2007, Advanced Manufacturing, Taylor & Francis, London.

Schuh, G., F. Zohm, A. Sauer. 2003. *Werkzeugbau der Zukunft: Von den Besten lernen*. In: Schmiede-Journal, 2003/9:36–37.

Schuh, G., C. Klotzbach, F. Gaus. 2007. *Business models for technology-supported, production-related services of the tool and die industry.* In: Takata, S.; Umeda, Y. (eds.): Advances in Life Cycle Engineering for Sustainable Manufacturing Businesses – Proceedings of the 14th CIRP Conference on Life Cycle Engineering, Springer, London:207–211.

Schuh, G., F. Gaus. 2007. *Service im Werkzeugbau - Cash-Cow oder Fass ohne Boden*. In: Klocke, F.; Schuh, G. (eds.), Proceedings of the 7th International Colloquium “Tool and die making for the future”, December 4, Wiesbaden.

Schuh, G., C. Klotzbach., F. Gaus. 2008. *Service provision as a sub-model of modern business models for tool and die companies*. In: Proceedings of the 15th CIRP Conference on Life Cycle Engineering, March 17–19, Sydney:570–574.

Schuh, G., F. Gaus. 2008. *Neue Geschäftsmodelle im Werkzeugbau*. In: Spritzgießen 2008 – Innovation und Produktivität, VDI-Verlag, Düsseldorf:159–173.

Schuh, G., W. Boos, F. Gaus, H. Ziskoven, 2009. *New business models for tool and die companies based on intelligent injection molds*.

Truch, E., D. Bridger. 2004. *The Importance of Strategic Fit*. In: Truch E (ed.) Leveraging Corporate Knowledge. Gower Publishing, Aldershot.