

Successful Planning and Scheduling

in the Tool and Die Industry

2017

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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, Production Metrology and Production Quality as well as Manufacturing Technology.



WBA Aachener Werkzeugbau Akademie GmbH

The WBA Aachener Werkzeugbau Akademie develops industry-specific solutions for the sustainable competitiveness of the tool and die 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 tool shop 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.

Imprint

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Spotlight



Proactive planning and scheduling in the tool and die industry addresses the target figures reliability, cost optimization and transparency. It has a consistent planning structure that is individually adapted for each company as well as a binding planning process. The planning system is optimally supported with efficient procedures and systematically ties in external suppliers. Ultimately, the right planning and scheduling can sustainably strengthen the competitiveness of tool shops.

78%

Share of companies that use milestone plans

Tool shops with a successful planning and scheduling system have a defined milestone plan that is carried out.

7 days

Planning horizon in detailed planning

Tool shops with a successful planning system define the suitable planning horizon according to their product spectrum and possess a defined planning system, both in rough and detailed planning.

1 hour

Degree of detail in detailed planning

88%

Share of companies with prioritization rules

Tool shops with a successful planning system strictly set prioritization rules and abide by them.

Initial Situation



830,000 km

**There are over
830,000 km of traffic
jams in Germany
annually.**

Traffic jam! A total of more than 830,000 km or 265,000 h worth occur in Germany every year. Around accidents or construction sites, congestion is not unexpected. However, everybody knows the feeling when the traffic unexpectedly lightens and leaves the driver behind wondering: why was there a traffic jam?

Congestion “out of nowhere” is created through inefficient reactions of drivers when a vehicle ahead brakes. This inefficiency is natural. Time lag due to reaction time and the resulting braking maneuver, which is often stronger than needed, propagate the effect from vehicle to vehicle. The congestion then moves backwards from 15 km/h until it is standing still. Although sufficient capacity is available for an undisturbed flow, it appears as if the highway is full. According to traffic researchers, the solution is simple: firstly, prohibit drivers from overtaking other vehicles during peak times as the constant reprioritization of individual vehicles requires braking maneuvers. Secondly, introduce different maximum and minimum speed limits in different lanes since not everyone can or wants to drive equally fast. Thirdly, create synchronous and autonomous braking and accelerating processes through automation because people are generally unsuitable for such maneuvers. It can be the ideal “traffic preventer” by transferring these three maxims to your company’s enterprise planning system.

The systematic analysis of planning in production is part of industrial practice since the beginning of industrialization at the start of the 20th century. Numerous publications, studies, research projects and results as well as dissertations about production planning and work organization can also be found at the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University. Already since the 1930s and continually up to today, the examination of production planning has been a fixed component of all technical apprenticeships and degree

programs for decades. The success of over 100 years of effort can be evaluated with respect to their intended application or industrial sectors.

For series production, which has always been the focus of a majority of research activities and system support expenditure, the implementation of reliable production planning does not pose a large challenge anymore. Digital planning systems have completely asserted themselves here. On the other end, tool shops are still unable to cope with planning tasks despite also having various digital support systems available. The challenges posed by a “lot size of 1” does not seem to have an unfailing system, in the shape of a method or even a purchasable software system. Few to no repetitions in the product or process lead to the failure of classical mechanisms of ERP systems. Additionally, short-term rush orders and repair orders as well as many late customer changes often lead to highly dynamic general conditions. Tool shops often cannot systematically consider this complexity and implement them into reliable planning results. Instead they are dependent on the improvisation of individual employees. Despite high planning efforts for project management and work planning in some cases, frequent and individual reprioritization and rescheduling by the foremen or tool makers is common in tool manufacturing and assembly.

The effects of an unsystematic and reactive planning and scheduling that trusts in individual employee instructions are mirrored in the target figures for planning and scheduling in the tool and die industry as well as a low level of efficiency for the planning efforts. High throughput times, a low delivery date reliability as well as an insufficient productivity and cost efficiency due to low capacity utilization are the signs of dysfunctional planning and scheduling.

The lack of success of planning and scheduling in the tool and die industry can usually be reduced to a few deficits. These are, first of all, the lack of systematization for the relationship between degree of detail and completeness on the one hand and benefits and expenses on the other. Furthermore, tool shops are currently inadequate in evaluating the use of different planning and scheduling activities as well as the corresponding support systems. In addition, a number of tool shops do not have a uniformly defined planning structure or a binding, documented planning process. Lastly, the possibilities of networking with suppliers for a deliberate increase in flexibility and capacity utilization are only used to an extent.

The present study shows recommendations for action with which the named deficits can be addressed. It is based on an understanding of production planning in the tool and die industry, which inherits the target indicators of reliability, cost optimization and transparency. The statements made are based on the data of the benchmarking database of the Laboratory for Machine Tools and Production Engineering (WZL) and Fraunhofer Institute for Production Technology IPT, which is comprised of over 1000 tool shop data sets that are no older than five years. Further, anonymized data about planning and scheduling from the WBA from bilateral consortial projects with tool shops was used. The study "Successful Planning and Scheduling in the Tool and Die Industry" gives an impetus for a sustainable increase in competitiveness with the help of proactive enterprise planning.

Initial Situation



**265,000
hours**

**Traffic jams result in
265,000 hours of
waiting time annually in
Germany.**



Successful Planning and Scheduling in the Tool and Die Industry

[Tool shops with a successful planning and scheduling boast a high degree of standardization.]

Planning and scheduling is a core element of industrialized tool shops and can increase competitiveness by addressing three target figures. Firstly, successful planning and scheduling has a large effect on process reliability. Process reliability is characterized by the adherence to milestones along the entire order processing of tools, so that the continual adherence to delivery dates to the customer is guaranteed. Furthermore, planning and scheduling has a considerable influence on the cost structure of order processing. Accordingly, an early and continuous plan leads to an increase of used capacity in tool shops and hence ensures a higher cost effectiveness of machines.

a proactive planning and scheduling is required. Single and small batch production results in numerous different extents of processing for tool shops, which causes a rise in the dynamism and complexity along the entire process chain. Therefore, a successful planning and scheduling necessitates the fulfillment of fundamental requirements and additionally needs individualized design elements to map the heterogeneity of processing amounts. Four major requirements for successful planning and scheduling in the tool and die industry can be identified (see figure "Requirements"). Modern tool shops realize their tool production along a value-creation chain with numerous interfaces.

Requirements for successful planning and scheduling in the tool and die industry

Independent networking	Standardization	Reference architecture	Technology basis
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Furthermore, the transparency in a tool shop depends on early and continuous planning. Transparency along the entire process chain guarantees a better milestone compliance and cost structure of orders since knowledge about the work list and the progress of orders is available at all times. Also, the individual responsibility of employees is increased as the rendered performance can be transparently called up. In order to reach the three target figures of reliability, cost optimization and transparency,

A successful planning and scheduling for industrialized tool shops needs the integration of many departments within the company. Thus, the first requirement for a successful planning and scheduling is the existence of functional departments with well-connected networks within the tool shop. Consequently, it must be guaranteed, on an organizational level, that all departments that exist in the company occupy clearly defined functional roles. A department forms a functioning unit in itself and be

Requirements



85 %

Tool shops with a successful planning and scheduling realize up to 85 % of their quotes.

Requirements



€ 7,750

Tool shops with a successful planning and scheduling have invested € 7,750 into further planning training for employees within the last three years.

able to organize itself and communicate its utilized and unused capacities at all times. This information is necessary for the processing, planning and scheduling of all orders on the company level.

In this context, all value-creation partners have to be integrated into the planning and scheduling via synchronized interfaces. This requires defined standards in order to prevent interface losses and completely depict the complexity of the value-creation network during planning. Due to the application of different technologies and the related machine variety, tool shops need continuous CAx chains and unified systems to minimize losses at interfaces.

Apart from standardization, a uniform concept for the description and implementation of interfaces and systems should be created. The reference architecture is a general framework in which a common basis for the functionality of all the systems that are relevant for manufacturing is created. As a result, the structuring and development of technical systems take place in the reference architecture so that they can be integrated and operated on a common basis. For this purpose, the reference architecture needs to bring the different value creation structures of the company together to a collective, unified structure.

Efficient controlling in the tool and die industry requires a high forecast quality within production planning. However, the forecast quality often is negatively influenced by fluctuating incoming orders, unforeseeable downtimes of machines or employees as well as the interface towards value creation partners. The longer the beforehand selected planning time is, the more inexact the forecast is for manufacturing controlling. These circumstances often result in rescheduling of order processing and create a higher control effort on the shop floor. Considering this, planning and scheduling requires a consistent and current data stream from machi-

nes in order to have transparency about available capacities at all machines at all times. Therefore, a successful planning in the tool and die industry requires utilization of modern technologies and an appropriate feedback system on the shop floor. The machines must be able to communicate with the planning system and pass on necessary information via defined interfaces.

[Tool shops with a successful planning and scheduling believe in the validity of their plan and do not carry out any reprioritizations.]

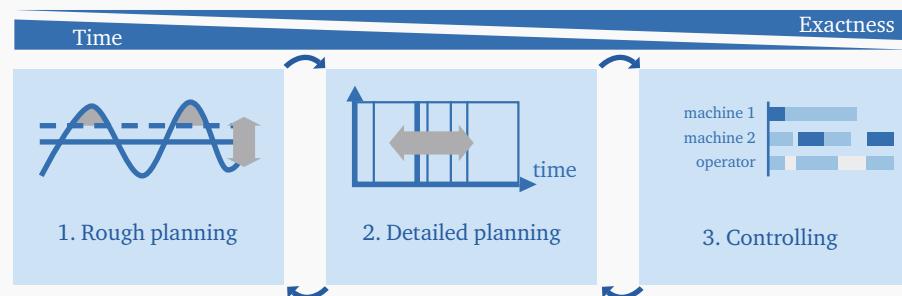
Planning structure

For the tool and die industry, every new customer order means a new product that needs to be developed, with almost no repetition effect that can be realized. This requires a systematic planning approach that models the complexity and dynamics of the process landscape. For an efficient planning and scheduling in the tool and die industry, the opportunity presents itself to make use of a 3-phase model adapted for the demands of the industry (see figure “3-Phase Model”).

capacity. Instead they take into account potential future orders in their plan above a certain probability of occurrence.

Finally, a milestone plan for the project is made in rough planning (see figure “Milestone plan”). In the tool and die industry, the process chain is functionally characterized by the respective departments. The handovers of orders are the main milestones of the processes.

3-Phase Model for successful planning and scheduling in the tool and die industry



In rough planning, the capacities for a tool project are reserved on a monthly basis at first, in which the work hours along the process chain as well as the necessary technology hours are calculated based on past values. Thus, in rough planning, standardized capacity demands are iteratively coordinated with existing capacity and orders terminated in accordance with capacity planning. A success factor in rough planning is a planning horizon of more than three months. It should be noted that successful tool shops do not plan against unlimited

A connection with the contents of the assignment and the responsible departments is illustrated in the figure for typical process chains of the industry.

A defined milestone plan for internal delivery dates in individual process steps of the value-creation process increases the reliability of the entire tool shop for a customer. The definition of milestones for the respective process steps creates in internal customer-supplier relationship between departments. Thus, it is ensured that clearly defined

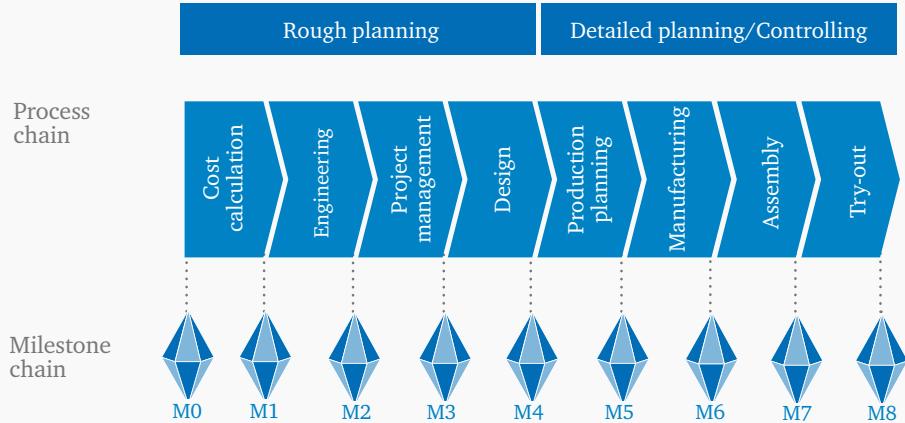


3 months

Tool shops with a successful planning and scheduling have a scheduled planning horizon of 3 months in rough planning.

Planning Structure

Milestone plan along the process chain of a tool shop



21 pp

The average due date adherence in design is 21 pp lower than in manufacturing.

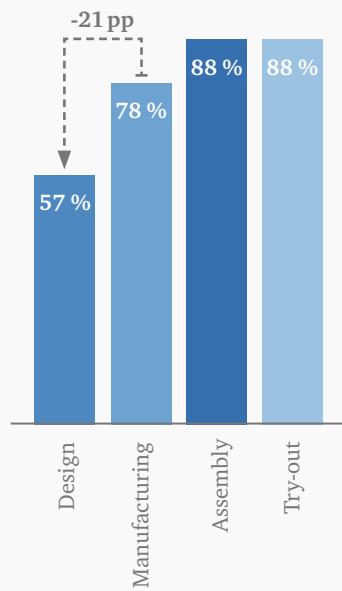
delivery dates allow for milestone adherence with customers. It is noteworthy that design engineering is not considered in the milestone plan. This shows that the average internal milestone adherence is weakest for design (see figure “Due date adherence”).

In comparison to manufacturing, the due date adherence within design is 21 pp less. This confirms the result that the complexity of tool design in single and small batch production requires a creative process and is only plannable to an extent. However, successful tool shops also implement measures to increase the predictability of design. They systematically introduce tool standards and increase the degree of standardization in the tool development process in order to force repetition frequency and learning effects. Furthermore, design reports the work progress in defined time intervals to continually guarantee transparency with respect to the production planning. The systematic inclusion of upstream process steps into planning lowers the deadline pressure on later process steps. These often have to recover the accrued backlog in order processing in order to still adhere to the customer due date.

After rough planning, detailed planning takes place for a tool project. It is often carried out on a weekly basis. After the tool is

designed, production planning creates a detailed work plan that includes the amount to be manufactured for each order, the machines that need to be allocated as well as the required starting materials. Successful tool shops engage a majority of their employees from the production planning department for detailed planning. Also, it has been shown that a planning horizon of more than

Due date adherence in the process steps of the order processing



a week as well as a degree of detail down to the hour are success factors for detailed planning. In controlling, the planning and prioritization of individual orders is made for the respective machines. In the tool and die industry, there are numerous control principles. However, the First-In-First-Out (FIFO) principle is the dominant prioritization rule. Implementing and holding on to a control principle is a success factor for tool shops. Thus, no reprioritizations are made for rush orders or orders deviating from their original milestone plan (see figure "Prioritization rules").

Additionally, the shown figure illustrates that successful tool shops compensate due date deviations through external capacities from partners. In this manner, the waiting times of individual orders are reduced and the predictability of the order processing is

increased in manufacturing and assembly. A lot of findings and data are generated during the order processing, which can increase the success of future orders if utilized properly. For example, data about the actual induced costs or the time-critical path in the process can be recorded. The recording and, in particular, the feedback of this information presents a valuable input for the following orders since the use of this knowledge gain increases the quality of the preliminary cost calculation as well as the milestone adherence for the customer.

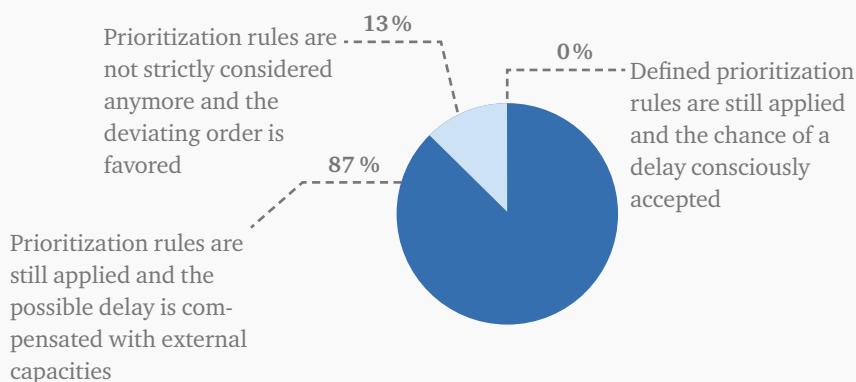
Planning Structure



**7 days
1 hour**

Tool shops with a successful production planning have a planning horizon of over 7 days and a degree of detail down to the hour in detailed planning.

Prioritization Use for schedule deviations from the original milestone plan



System Support



€ 30,000

Tool shops with a successful planning and scheduling have invested over € 30,000 in planning and scheduling software on average in the past three years.



5 %

Tool shops with a successful planning and scheduling employ 5 % of their workers permanently for planning and scheduling tasks.

[A successful tool shop typically employs half a position exclusively for the upgrading of its system support.]

Many tool shops misjudge the importance of systematic production planning as it does not directly create value and results in additional costs. In contrast, successful tool shops employ 5 % of their employees permanently for planning and scheduling tasks and continually invest in their further training. A successful planning and scheduling for small tool shops with under 100 employees can already be formulated with inexpensive analog systems, such as planning boards. For larger tool shops, these systems are only suitable as an additional visualization for rough planning on the shop floor. Larger tool shops have to increase the efficiency of production planning through the use of digital systems. With this in mind, successful tool shops on average have invested over € 30,000 in planning software in the past three years. The tasks of digital systems are, firstly, visualization and, secondly, decision support for the order processing. Therefore, digital systems create a higher transparency for employees along the entire process chain and enable uniform project cycles, which is the basis for milestone adherence as well as planning reliability for orders. Further, this increases individual responsibility of employees as their order status is transparent and can be called up at any time. Digital systems effectively support the decision-making process as the constant monitoring as well as the availability of data increases the ability to respond in the tool and die industry. By bundling information, predictions and risk estimates can be made for future orders, which aids in achieving the targets of planning and scheduling. Due to the heterogeneity of the tool shops as well as the diversity of production planning system (PPS) available on the market, the choice of a suitable system is a core success factor for successful planning and scheduling. However, the identification of a suitable PPS system presents a large challenge to tool shops due to their special demands from single and

small batch production. A systematic approach that maps the dynamics and complexity of the process landscape in the tool and die industry is necessary. In the future, an ideal IT system for successful planning and scheduling for a tool shop has to fulfill a variety of requirements. These systems can be an autonomous planning system both for the centralized or decentralized dynamic planning and scheduling of orders. Hence, the system is able to present decision options on the basis of near real-time production information, to prioritize as well as to evaluate. It has an interface to interact with employees, which is tailored to the needs of a planner as well as the employee on the shop floor. In this manner, the production planning of a tool shop can be adapted dynamically and in near real-time. Based on this, the production process can be directly adapted via the control. In addition, a comparison of the processing sequence with respect to throughput times and costs offers a decision-making support. Furthermore, tool shops need to continually invest in suitable IT systems after their original selection to adjust their planning and scheduling in the dynamically changing industry. The full potential of a successful planning and scheduling can only be achieved through the involvement of employees. Thus, it is imperative to train employees in using the planning systems and motivate them to continue developing the planning system through their own optimization approaches. On average, successful tool shops have invested € 7,750 in the last three years into the training of employees for planning and scheduling. The result of an optimized planning and scheduling with a suitable system support is resource efficient as throughput times are shortened and bad planning and scheduling is avoided. Additionally, the employee that stands in the focus of the system can concentrate on value-creating activities with the help of suitable user interfaces.



Outlook

[Successful tool shops plan and commission their suppliers as early as possible in the order processing.]



37 %

Successful tool shops realize 37 % of value-creation via external partners – with a rising trend.

Similar to the developments in other industrial sectors, value-creation has changed in today's tool shops. The toolmaking process is realized beyond company borders with numerous external partners and the achievement of internal depends largely on the services of those partners. As the enabler for series production, milestone adherence is a deciding success factor in the tool and die industry. Therefore, suppliers will have to be increasingly considered in a successful production planning for a tool shop. The delivery dates of all partners have to be considered in the internal plan and then realize a defined process for planning and scheduling that anticipates supplier delays. Thus, the plan guarantees that the tool shop does not propagate the supplier delay to the customer. For this reason, it is important for tool shops to build up a strategic outsourcing process with selected partners. This process can be implemented with framework contracts along the entire value-creation chain, which stipulate defined scopes of supply and supply quality at all times.

Apart from networking with value-creation partners, the tool and die industry is closely linked to the customer due to its position between product development and series production. In the future, the order processing will have to increasingly enable customer changes to their orders and still guarantee that these are doable with the internal resources and available capacities. For this purpose, planning and scheduling has to be flexible and consistent, so that value-creation steps are generally synchronized with planning and scheduling.

Due to frequent reprioritizations and inefficiencies of drivers, there are over 830,000 km or 265,000 h of traffic jams annually on German highways. However, the effect of "traffic jams" in German tool shops as a consequence of insufficient planning and scheduling is barely measurable. Nevertheless, it is indubitably noticeable all areas of a company. As a result, in order to sustainably secure competitiveness, the success factors presented in this study should be implemented:

■ **Planning Structure:** An individually adapted planning and scheduling structure of rough and detailed planning as well as controlling is necessary.

■ **System Support:** Continuous investments into system infrastructure shall be budgeted for and is necessary to handle the degree of complexity of planning and scheduling in tool shops.

■ **Planning Process:** The rules defined in the planning structure have to be consistently followed – internal and external milestones have to be defined, adhered to and prioritization rules must be consistently followed.



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