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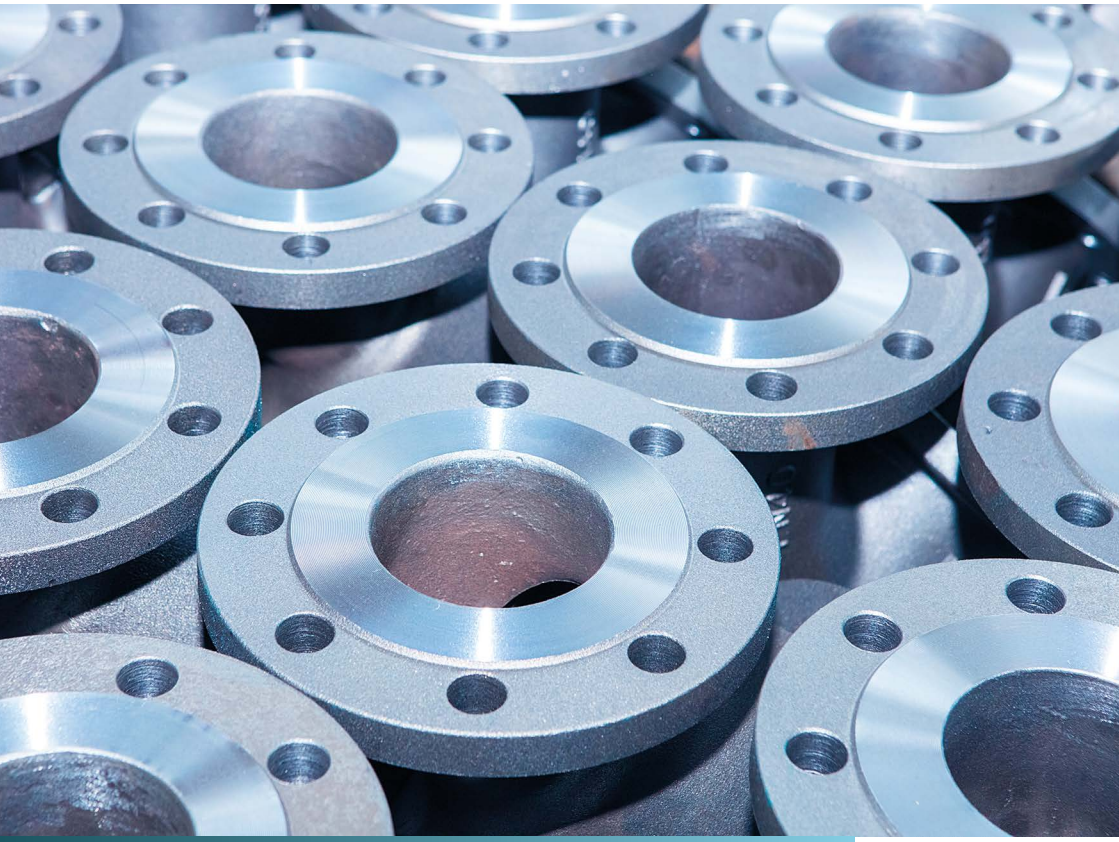


AUTOMATION GUIDE

For Pump and Compressor Manufacturers

Characteristics and challenges in fluid manufacturing

Lot of product variants within the same product family, need to shorten the lead times and to produce with as few clampings as possible – these are typical characteristics that determine the operating environment of fluid manufacturers producing components like pumps, compressors, directional valves and valves. The question of competitiveness is: who makes it the most economically in terms of production cost per piece, without tying capital to inventory and work-in-process (WIP)?

If you are under consideration on how to solve these challenges and whether or not automation could be suitable for you, this guide gives insight on how to optimize production with automation: what are the biggest production bottlenecks to tackle in pump and valve manufacturing, and how flexible automation can enable economical order-driven manufacturing down to a batch size of one.

Ability to deliver the right product variant with a short lead time is what most fluid manufacturers aim for.

Variables to get right

COST PER PIECE	TIED CAPITAL	LEAD TIMES	QUALITY	TRACEABILITY
↓	↓	↓	↑	↑

High mix of product variants and ever-increasing pace of business put pressure for fluid manufacturers to optimize their processes in order to shorten the lead times.

CHALLENGES

- Do you produce in batches to optimize production cost?
- Do you have large inventory and/or high WIP?
- Do you lose orders due to delivery problems?
- Do you have scrap or inconsistent capabilities?
- Is your process reproducible?

Status quo: Batch production

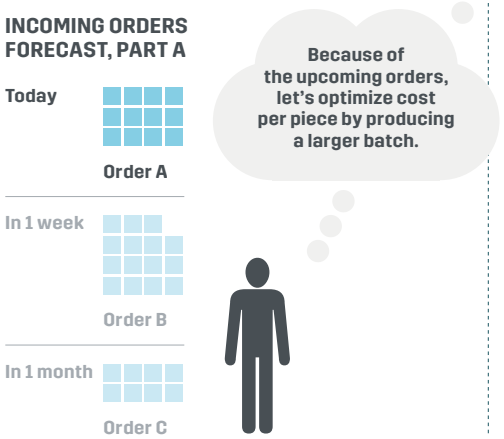
Lower cost per piece by making compromises?

Batch production – pros and cons

Batch driven production means producing larger batches of parts than the current order backlog consists of. The idea is that the larger the produced batch, the lower the cost per piece. In the fluid industries where parts are needed fast, batch production is a natural and its own way a cost efficient choice. That said, it requires making compromises that are showcased in this spread.

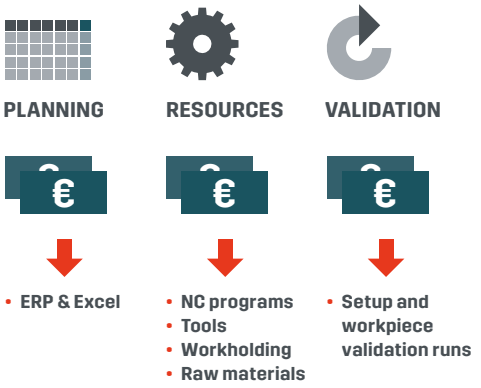
PROS
Lower start cost per part

CONS
1. Higher WIP
2. Longer lead time
3. Slower earnings



Pro: Lower start cost per part

The main reason to produce in batches is the high production start cost per part. This consists of production planning, start setup, and test drives to get the part and the quality right. These costs recur every time a new batch is started, regardless of whether the same part has been produced before or not – larger batches mean less production starts and less production start costs per part.

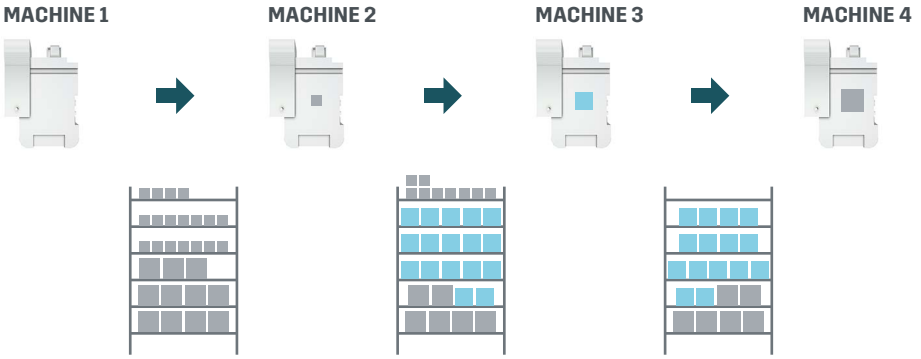


Con #3: Slower earnings

When producing more than what was ordered, extra capital is tied in inventory and revenue realization becomes slower. There is also a risk of some parts in the inventory becoming obsolete, which would mean a direct loss.

Con #1: Higher WIP

Larger batches naturally mean slower turnaround. Some process phases take more time than others, plus there are always surprises like missing tools and machine breakdowns on the way. This causes different batches piling up between the work phases, increasing WIP and tied capital. Here, production is more driven by available setups than the urgency of orders, and part of the machining capacity is wasted.



Con #2: Longer lead time

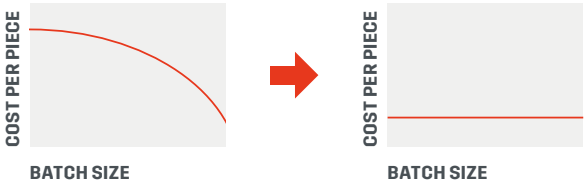
The slow turnaround caused by large batches results in longer lead times. When an urgent order comes in, getting it through fast enough can be challenging. The rapidly changing needs of customers require flexibility that batch production cannot offer.

Full optimization: Order-driven production

ORDER-DRIVEN PRODUCTION ECONOMICALLY

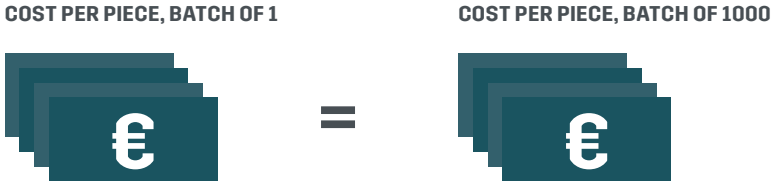
To lower the cost per piece, many manufacturers are used to producing in larger batches. This is because in the past small-batch production has not been economically feasible. Luckily, today's technologies offer a variety of possibilities to optimize production to be economical for batches of all sizes, meaning that **the unit cost of producing a single piece is the same as when producing a batch of 1000.** Not only is the unit cost lower, order-driven manufacturing also frees capital from WIP and inventory, and allows just-in-time deliveries with shorter lead times.

From batch production to order-driven production



Variables to get right

Economical order-driven production



WHAT DOES IT MEAN IN PRACTICE?

There are two steps that are needed to achieve order-driven and economical production: (1) **optimization of the key production bottlenecks**, and (2) **making the production process repeatable**. This requires looking at the whole production and identifying the exact process phases that could be further optimized. After that, the data and integration between all people, machines, data systems and resources is inspected and turned into one efficient and flowing process.

On the next page we introduce an example shop floor the most common bottlenecks that require optimization to achieve order-driven economical production. After that we dive deeper in each of these areas, introducing common challenges, benefits automation can bring, and the technical things to take into account when considering automation as a solution.

To achieve order-driven and economical production, key bottlenecks need to be optimized.

Manufacturing process: Common bottlenecks

Example shop floor

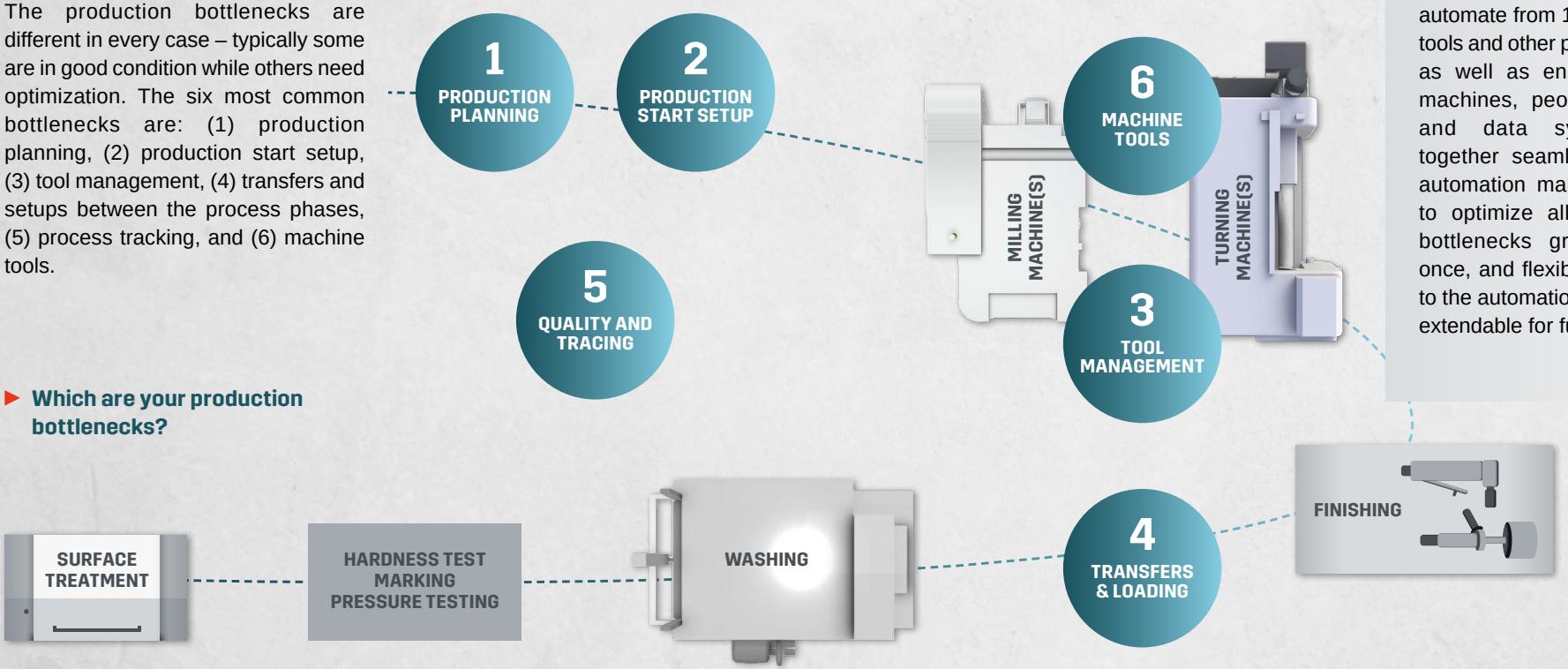
The production process can vary depending on what kind of a part or product is manufactured. The process has a couple to hundreds of different phases which all take different skills, times and resources.

Typically a single phase is somehow optimized but process-wide optimization might be lacking. Let's take a look at an example shopfloor. The production bottlenecks are different in every case – typically some are in good condition while others need optimization. The six most common bottlenecks are: (1) production planning, (2) production start setup, (3) tool management, (4) transfers and setups between the process phases, (5) process tracking, and (6) machine tools.

If these bottlenecks are tackled, one can truly manufacture:

- economically and order-based
- without tying capital to WIP and inventory
- just-in-time / with short lead times
- high-quality parts without scrap
- with full traceability

Each of the listed bottlenecks are presented more in detail in the following section of this guide. For each element we share the typical challenges; explain the benefits automation can bring; and finally list the things to be considered when planning to automate.



Which are your production bottlenecks?

2 KINDS AND 2 LEVELS OF AUTOMATION

There are two different kinds of automation: for low mix, high volume (the most known automation type) and for high mix, low volume (the focus of this guide).

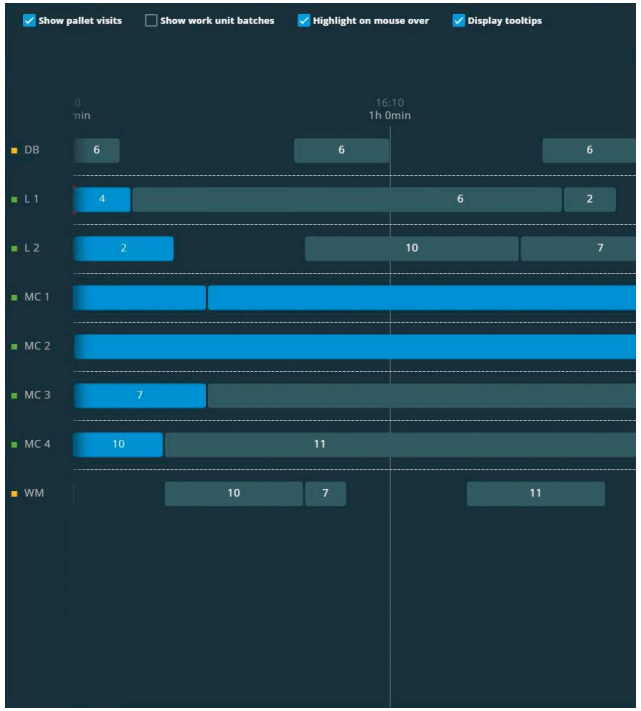
In the latter type, there are two levels of automation. The most basic one focuses on tending a single machine tool, mostly tackling the bottleneck of workpiece transfers and loading – this could be a pallet pool, for example. The second level is flexible automation, which means being able to automate from 1 to 20 machine tools and other process phases, as well as ensuring that all machines, people, resources and data systems work together seamlessly. Flexible automation makes it possible to optimize all of the listed bottlenecks gradually or at once, and flexibility also refers to the automation system being extendable for future needs.

1 Production planning

Challenges in manual production planning (ERP + Excel) are typically related to poor visibility and changes. The production plan is laborious to make manually, and even more laborious to keep up-to-date when new, high-priority orders come in or the unexpected happens in production. The unexpected meaning anything from missing raw material to a breaking tool, labor shortage, sudden maintenance break or previous orders taking longer than expected to produce.

In contrast, with flexible automation an intelligent production control software is integrated seamlessly to the different data systems and production equipment. Now, **production can be planned ahead based on real-time**:

- **Order information** with delivery dates from ERP
- **Information of available machinery and resources** (NC programs, workholding, tools, raw materials)



Intelligent production control software schedules the production based on ERP order due dates, and adapts to any changes in real time.

The intelligent production control fetches real-time information from different data systems and machinery, and calculates the optimal production schedule for incoming orders. It automatically updates the production plan when a new order comes in and warns in advance if a resource is missing and an order is about to get delayed.

After production, the intelligent control software reports the completed jobs back to ERP.

With flexible automation and the intelligent production control, resources can be shared between different machine tools, meaning that parts can be produced with any suitable machine tool that has free capacity – not only with a dedicated one. This can significantly reduce WIP, shorten lead times and increase capacity utilization.

The intelligent production control updates the production plan when a new order comes and warns in advance if a resource is missing.

TYPICAL CHALLENGES

- the production plan changes all the time due to incoming orders and priorities
- unexpected changes in production
- lead times are hard to estimate and promises made to the customer are difficult to keep

FLEXIBLE AUTOMATION BENEFITS

- the production plan automatically updates based on real-time information received from data systems and machinery
- flexible production: minimize the negative effects of machine breakdowns and resource shortages by removing machine dedication
- visibility over production and upcoming resource needs
- information of order completion available even months ahead

WHAT TO CONSIDER?

To achieve flexible production planning, make sure your automation has the following integrations:

- ERP
- machinery, regardless of machine brand(s)
- CAM
- Product Data Management (PDM)
- Tool Data Management System

2 Production Start Setup

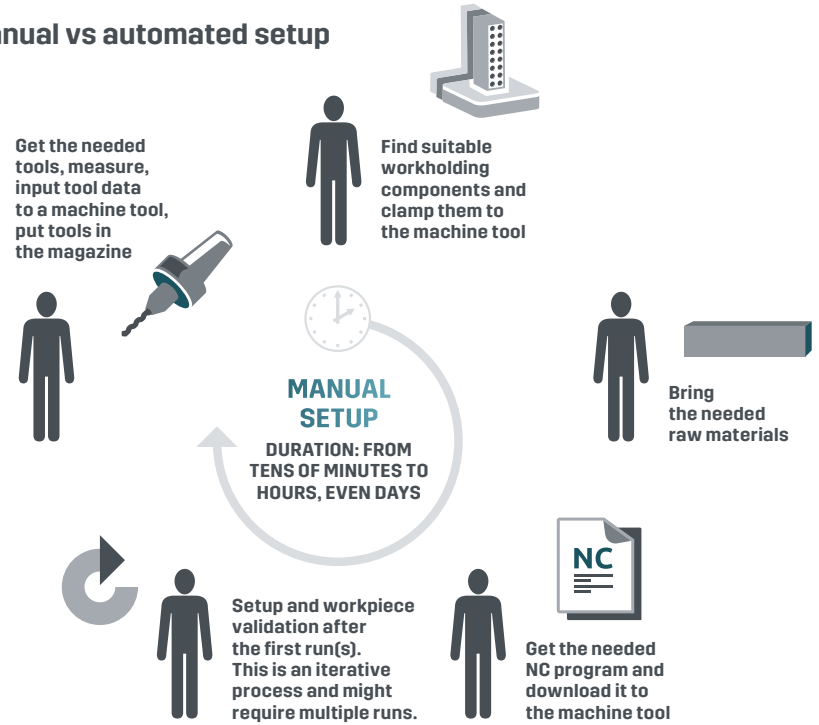
Manual workpiece set-up changes take a lot of time, even with automatic pallet changers (APC). The key problem is that the **manual setup work is difficult to restore** – in the worst cases setup work needs to be started from scratch every time, even when producing recurring parts. Even with the best possible documentation, it takes extra effort and time to start and complete manual setup work. Because of the labor-intensive nature of setup work, deciding which parts to manufacture next might be made based on the easiest available setup at the time, as opposed to choosing the order that is actually most critical to complete. **In a way, production might be being driven by setups instead of orders.**

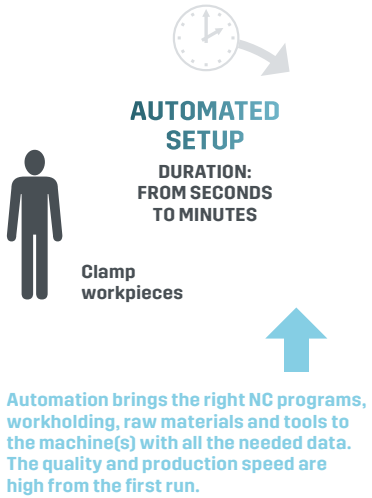
In case of recurring orders, flexible automation system has setups pre-configured with a systematic approach to manage all the information related to setups in production. This information consists of NC programs, cutting tools, workholding, work instructions and needed raw material. All these resources are easily available when needed. If some resources are missing, the system will inform about shortages in advance to avoid unnecessary production stops.

To reduce machine dependent jobs, the system can bring the same data and resources into any of the parallel machine tools on the shopfloor, no matter if the part has been previously machined with the same machine or not.

Pre-configured setups mean that every item, starting from the first, can be run at 100% speed with the same quality. The operator only needs to take care of the clamping of the parts. This usually means improved work ergonomics. Part clamping can also be robotized when annual production volumes get larger.

Manual vs automated setup





COMMON CHALLENGES

- production is driven by the easiest available setup instead of the importance of orders
- poor reproduceability sets challenges for standardizing part quality
- setup work decreases utilization and production output

FLEXIBLE AUTOMATION BENEFITS

- the system makes sure everything is in place before starting the production
- if a resource is missing, the operator will know in advance and have time to react
- setup time shortens significantly or goes down to zero
- setup is available for any suitable machine tool

WHAT TO CONSIDER

If you want to minimize setup times in your production, make sure your automation is capable of:

- fetching and sending information to machine tools (any brand on your shopfloor)
- fetching NC programs from CAM
- saving the workpiece instructions related to setup
- storing the list of needed tools and possibly tool offsets
- handling the raw material logistics
- having an interface with AGVs (in case they are in use)
- storing workholding hardware and all information related to it

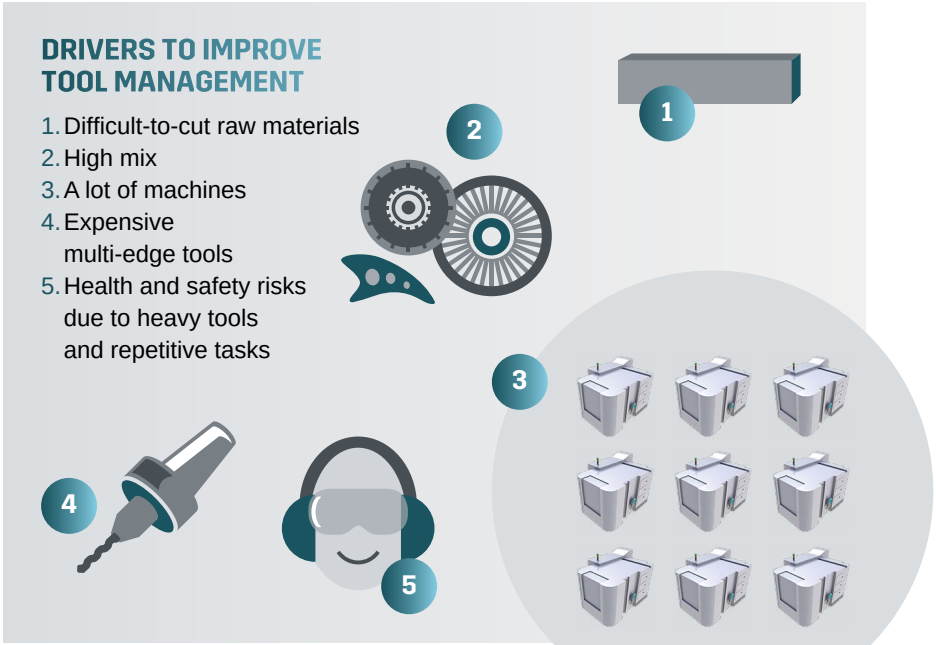
3 Tool Management

When the red light of a machine tool starts blinking, it is often because of a tool shortage. The required tool may be completely missing or it has run out of tool life. This is a daily situation on the shopfloor – **tool shortages are among the biggest time thieves in production**, constantly stopping spindles and requiring action.

Different software and/or hardware solutions can streamline tool management. The first step of tool automation is a production control software integrated to the machine tools, telling which tools are needed in which machine and when. By using and integrating a tool presetting device to the production control software and machine tools, the tool presetting process can be greatly streamlined. This also removes human errors in the tool presetting process.

In such manufacturing where the materials are challenging, tool lives short and the mix of machines and tools often high, tool maintenance plays an even more important role. With more flexible tool automation, tools can be shared with different machines and delivered automatically into machines based on real-time needs. When the tool life is about to end, the system automatically brings a replacement from a centralized tool storage. The reduced need for sister tooling, ability to share tools between machines and having a proactive way of maintaining tool life bring great utilization improvements while generating savings in tool investment. Removing manual tool movements also improves the working ergonomics of the operators.

If the tool lives are extremely short and demand for renewed tools is high, tool automation can be extended to optimize the tool setup process (insert changes and presetting).



TOOL AUTOMATION GRADUALLY

1. From reactive to proactive
In-advance reports on tool needs: which tool is needed, where and when

2. Remove errors from tool loading
Tool presetter and automatic input of tool presets to machine tools

3. Remove machine dedication and reduce need for sister tooling
Tools stored in a centralized tool magazine and robotically transferred to machines based on real-time needs (a tool can be shared between many machine tools)

4. Save time from tool setups
Automated tool setup process including insert changes, washing and presetting

CHALLENGES

- machine downtime because of tool shortages
- high manual intervention and planning to keep machines running and tools up-to-date
- risk for human errors in tool loading and offset writing to machines
- high tool and machine magazine investment

TOOL AUTOMATION BENEFITS

- know in advance which tool is needed, where and when
- save time in tool setups
- no machine crashes due to wrong tool loading
- tools can be shared between machines -> less tools needed, less machine tool dedicated work, longer lights-out manufacturing periods
- improved health and safety related to tool maintenance

WHAT TO CONSIDER

- integration with machine tools and/or presetters of any brand
- integration capability with different tool data management systems
- when adding a centralized tool storage, think about efficient floorspace usage, also vertically
- make sure your tool automation solution is extendable for future needs

4 Workpiece transfers and loading

A production process of a part can consist of tens of different phases. The transfers and loading between different phases play a huge role in process efficiency and production quality. It is a trade-off: focusing on handling the transfers and loading quickly increases the risk of quality problems (uneven quality, scrap). That said, focusing on careful transfers and loading might slow down the process. Another consideration is ergonomics - moving heavy workpieces can be time consuming and is a risk for injuries.

Flexible automation makes transfers and setups between process phases precise and fast. It knows exactly how the workpiece or pallet is positioned when the previous process phase ends, and handles the workpiece or pallet exactly the same way, every time. Transfers between different phases happen in seconds. The whole production process becomes reproducible, and in the best case, manual intervention from the process can be even completely eliminated.

Workholding plays a major role when automating the manufacturing process. Different kinds of machinery need different types of workholding – repeatibility and versatility should be the main drivers when making the investment in workholding equipment. The actual workpiece or pallet transfers can be carried out using a manipulator, AGV or an industrial robot. With automated transfers, time savings and quality improvements can be significant, especially when there are many process phases. In addition, the operator's daily work becomes more ergonomic without having to do heavy lifts.

EXAMPLES OF PROCESSES THAT CAN BE INTEGRATED WITH FLEXIBLE AUTOMATION

- Material management
- Milling machines (APC and no-APC)
- Turning machines
- Grinding machines
- Finishing
- Washing machines
- Surface treatments
- CMM
- Visual inspection

How many transfers between different phases are needed in your process?

CHALLENGES

- waiting time between process phases (WIP)
- careful loading work can slow down the overall production
- multiple manual interventions create higher quality risk
- poor situational awareness – what happens now and next

FLEXIBLE AUTOMATION BENEFITS

- parts can be made ready with a single clamp
- fast transfers enable high efficiency
- high precision enables high quality
- heavy mechanical work removed from operator
- up-to-date working documents available for all work phases

WHAT TO CONSIDER

If you want to make your transfers fast and precise, make sure your automation:

- integrates with different kinds of machinery, as well as manual and stand-alone process phases
- has a reliable and versatile workholding solution to work well together with automation
- is able to show work instructions to the operators

5 Quality, Traceability and Liability

In pump and valve manufacturing, constant part quality is very important. Typically the quality problems are caused by the irreproducibility of a process. In the worst case a quality problem could lead to a larger scale liability issue. Flexible automation can help in enabling constantly high quality and reduce the paperwork related to traceability reporting.

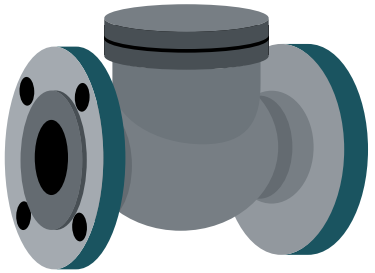
QUALITY

A reproducible process is key to having constant high quality that meets the industry standards. Collecting and storing all the correct data on tooling, NC programs, setups and work instructions automatically (introduced in sections 2 and 4) saves significant time and helps in producing high quality, starting from the very first part.

TRACEABILITY

Traceability is not only a matter of security or liability – it also allows companies to improve their processes. The main challenge in traceability reporting is that it requires a lot of manual work and has a risk for mistakes. A high amount of paperwork is needed on the factory floor to generate the needed documents, and typos or missing information can make the report incomplete.

Flexible automation with an intelligent control software has built-in traceability reporting, freeing the operator from having to put extra effort into tracing and ensuring that the documentation is correct. The report is gathered together automatically by collecting all the needed data from the process, and can be easily exported to other systems like QMS.



WOULD AUTOMATIC TRACEABILITY REPORTS BENEFIT YOU?

- the part identification through the whole part/product life
- ability to trace all the parts from the same batch
- ability to trace all the components of an assembly
- a part production record, including: what has been done, by whom, when, which machines, NC programs and tools used, and quality control / inspection reports

PART: XYZ

- Serial no: 25455448
- Operation: 10 - Milling
- Machine used: MC3
- Program: 3445
- Machining time: 3h 12 min 50 s
- Status: Machining completed

CHALLENGES

- demand for high quality
- traceability reports cause a lot of paperwork
- quality assurance and traceability can make ~15–30% of the total production costs
- price of failure – the cost of when not achieving the first time right
- liability issues

AUTOMATION BENEFITS

- a reproducible process enables high part quality and first time right
- easy and reliable traceability reporting

WHAT TO ENSURE

- make sure the system can store all the manufacturing data for later use
- ability to collect all the traceability data without causing extra work for the operators
- easy data exporting to other systems such as QMS

6 Machine tools

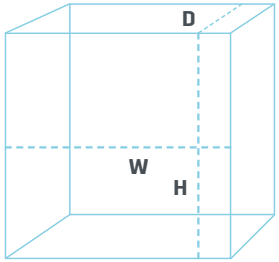
The machine selection process starts from the parts or part families that are produced. Oftentimes previous machine investments have been made based on the machining needs at the time, as opposed to also planning ahead. In the future, this can then result in a situation where machines are not suitable for new parts, and the need for new machines arises yet again. There are many shopfloors that are full of different machine types, each producing dedicated parts and having specialised operators. Sometimes it is the best way to go, especially with different raw materials and variable part sizes, but oftentimes one machine could produce many more different parts than it is used for.

When planning a machine tool investment, the future business possibilities and resource-efficient production should be also considered. The range of part sizes, the "envelope" in which all produced parts fit into, need to be thought out before hand. In addition, in the ideal world you would want to make sure that all machines are able to produce any of the parts. Benefits of purchasing similar machines that are able to run as many parts as possible give flexibility in job resourcing by removing the dedicated machines, in operator resourcing by making sure everyone can use any machine, and reduces the maintenance and sparepart costs. Also the amount of clampings need to be thought out: in general, 5-axis machines give greater flexibility with a reduced need for reclamping.

Hard materials cause a large consumption of cutting tools. This should be considered when deciding the tool magazine capacity of each machine tool. A big enough magazine allows for sister tools that enable longer lights-out manufacturing periods. However, if tool life is short and there are many machine tools, tool automation with one centralized storage for thousands of tools and the ability to share and bring tools to machines can be a profitable investment (presented in section 3).

Similar machines that are able to run as many parts as possible give flexibility in resourcing and reduce maintenance costs.

In which size of an envelope would all of your parts fit? Do you need many envelopes?



THINK ABOUT YOUR MACHINE TOOL RESOURCING

- do you need dedicated machines or could you utilize the "envelope" model to improve machine utilization?
- when a machine breaks or an operator is on vacation, do you have similar machines or people with the right skills to substitute?
- is it better to save on machine costs and increase the amount (and time) of clampings or the other way around?
- what is your tool and sister tool need – should you purchase larger tool magazines or a centralized one?

SHORT-VIEWED MACHINE INVESTMENT MAY LEAD TO

- dedicated machines – what happens when a machine breaks?
- an increased investment need for machine tools
- increased floorspace needs
- tool setup challenges when sister tools are in use

WITH GOOD INVESTMENT PLANNING

- the long-term investment for machine tools and the maintenance costs reduce
- operator resourcing becomes more flexible because more people have skills to run the same machine
- the floorspace is better utilized with less tools that are all capable of performing as many jobs as possible

WHAT TO CONSIDER

- similar machines to increase flexibility and reduce maintenance costs
- 3-, 4- or 5-axis machine, what is suitable for your current and future needs?
- large enough tool magazines to also enable the utilization of sister tools / tool automation to share the tools for different machines
- machine interfaces for integration with different production data systems
- operator skillsets on machine control technologies

Summary

In this guide we presented common challenges in the field of fluid manufacturing, the variables to get right to ensure successful business, and typical bottlenecks. As demonstrated, all of this can be tackled with automation to make production processes flexible, economical and reproducible.

A comprehensive automation project definitely takes a lot of evaluation and preparation work but when done well, the results for fluid manufacturers have been remarkable:

- >90% spindle utilization
- cycle time down by 58%
- ability to produce the whole weekend lights out, even batch sizes of 1
- yield rates of 99.5%
- improved employee retention

To read more on how your peer companies have solved their productivity challenges with automation, go to fastems.com/fluid

When done well, the results of flexible automation for business can be remarkable.

What are your production bottlenecks? How to find and measure them? Could they be solved with automation? We at Fastems are happy to help solve any productivity challenges: fastems.com/contact

CHECKLIST – REQUIREMENTS TO CONSIDER WHEN PLANNING TO AUTOMATE

Production planning

- [ ] integrates with ERP, machinery (regardless of brand), CAM, PDM and Tool Data Management Software
- [ ] predictive scheduling and adapting to changes based on real-time data
- [ ] visibility over production and accurate order completion forecast

Production start setup

- [ ] integration with machinery and data systems with production documents
- [ ] save the setup-related information: workpiece instructions, the list of needed tools and their offsets, and workholding hardware with the data
- [ ] handle raw material logistics and integrate with AGVs (in case they are in use)

Tool management

- [ ] integration with machine tools and different tool data management systems
- [ ] tool presetter and integration to it
- [ ] when considering tool magazines or one centralized tool magazine, efficient use of floorspace, also vertically

Workpiece transfers and loading

- [ ] integration with different kinds of machinery and extendability for futher needs
- [ ] ability to also add also manual work cells and stand-alone machines, and give instructions to the operators
- [ ] reliable and versatile workholding solution to work well together with automation

Quality, traceability and liability

- [ ] ability to store all the manufacturing data for later use
- [ ] ability to generate traceability reports automatically
- [ ] integration to QMS

Machine tools

- [ ] similar machines to increase flexibility and reduce maintenance costs
- [ ] 3-, 4- or 5-axis machines, what are the most suitable for your current and future needs?
- [ ] tool magazines large enough to also enable utilization of sister tools/ tool automation to share the tools for different machines

Read how other pump and compressor manufacturers have solved their productivity challenges with automation:

fastems.com/fluid