8760 Fastems

CNC Milling Machines

The best practices for automation

Contents

1. Introduction

With the ever-increasing complexity of products, the current speed and fluctuation of business, and challenges in finding talented workforce, identifying ways in which manufacturing companies can increase productivity is becoming more important than ever.

Automation is one of the key strategies to improve productivity and this guide aims to pave the path to achieving a successful, first-time automation investment when it comes to CNC milling machines.

Based on decades of experience with top metalworking manufacturers of all sizes, we have found that the road to a successful automation of production with milling machines is based on two cornerstones:

1. Selection of fewer high quality multi-purpose machining centers
2. Implementing intelligent automation that is capable of much more than just moving pallets in numerical order.

2. Striving for a LEAN Machine Shop

Every production process should be designed with productivity in mind. There are multiple production philosophies and methods that focus on productivity, but of these LEAN* is most well-known. **LEAN is a production method and a collection of practices that aims to minimize everything that doesn't add value to the end product (that it calls waste*).*** One of the key principles of LEAN is to focus on 'flow' which means that all production steps should be continuous and always value-adding.

One can identify multiple kinds of flows in metal cutting such as:

1. The flow of raw material
2. The flow of work-in-process (WIP)
3. The flow of finished goods
4. The flow of operators
5. The flow of machines
6. The flow of information
7. The flow of engineering.

So, to improve the flow within these processes, we need to identify what kind of barriers hinder them and subsequently overcome them. The three main barriers in terms of metal-cutting are **distance, set up times** and **quality**.

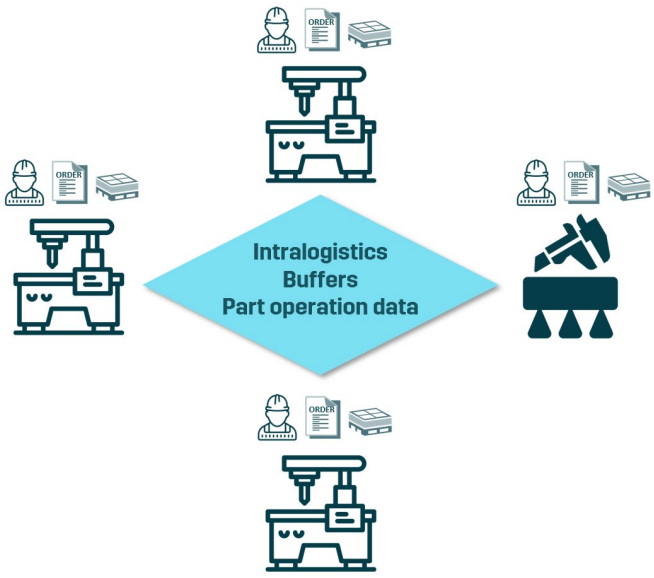
Distance refers to all transports between manufacturing operations and storages that are not adding value to the product.

Setup times*:* If setup changes between machined batches take a long time, it creates a natural temptation to produce larger batches than ordered, creating WIP and inventory. Furthermore, the production equipment might not be available for another, more urgent production order at the time of the over-sized batch production.

Quality*:* When scrap rates are high, manufacturers tend to produce extra workpieces, which again builds up unnecessary inventory.

**See e.g. https://en.wikipedia.org/wiki/Lean_manufacturing.*

The list of barriers goes on and on. The crucial question therefore becomes: What methods and solutions are there to overcome these barriers?



1 When striving towards a LEAN machine shop, manufacturers should focus on reducing working intralogistics, buffers and making part operation data easily available.

Rethinking the Process Flows

When looking at shop floor manufacturing equipment, one way to improve workflow is to critically evaluate the current philosophy concerning machine tools. Focusing solely on metal removal rates and machine tool utilization rates will indeed help produce a large amount of chips, but at the same time it will build up inventories, tie up floor space and create an increased need for intralogistics.

Instead of this, **investing in multifunctional machining centers is one of the key aspects to increase agility in milling applications**. Here, we strive for a situation in which as many machining operations as possible are be combined to be machined with the same machining center. This increases the readiness to react to changes and eliminate waste. The next chapter will focus on the many benefits of multifunctional machining center investments.

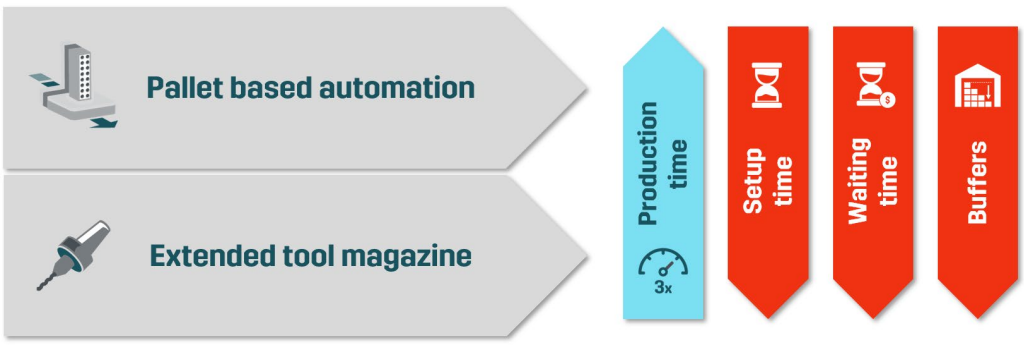
2 Investing in one multifunctional machining center instead of multiple 3-axis machine tools increases agility and removes barriers in milling manufacturing.

3. Investing in Multifunctional Machining Centers

Multifunctional, highly productive 4- or 5-axis machining centers have a lot higher of a price tag than traditional 3-axis machines. **That said, one 4-axis machine with the right automation can produce at the same rate as three 3-axis machines**. However, to justify the investment, the machine must be kept fed. These machines can withstand high workloads and feed rates for an extended period of time, which translates to following benefits:

1. Increased production time
2. Reduction of the setup times required for changing workpieces
3. Reduction of overall waiting times
4. Reduction of buffers while also maintaining service levels.

However, even 4- or 5-axis machining centers can't achieve these goals themselves. Proper automation solutions are needed, along with large enough tool magazines for the machine tools to enable high workpiece variability and extend lights-out production. The graph below illustrates the total picture:

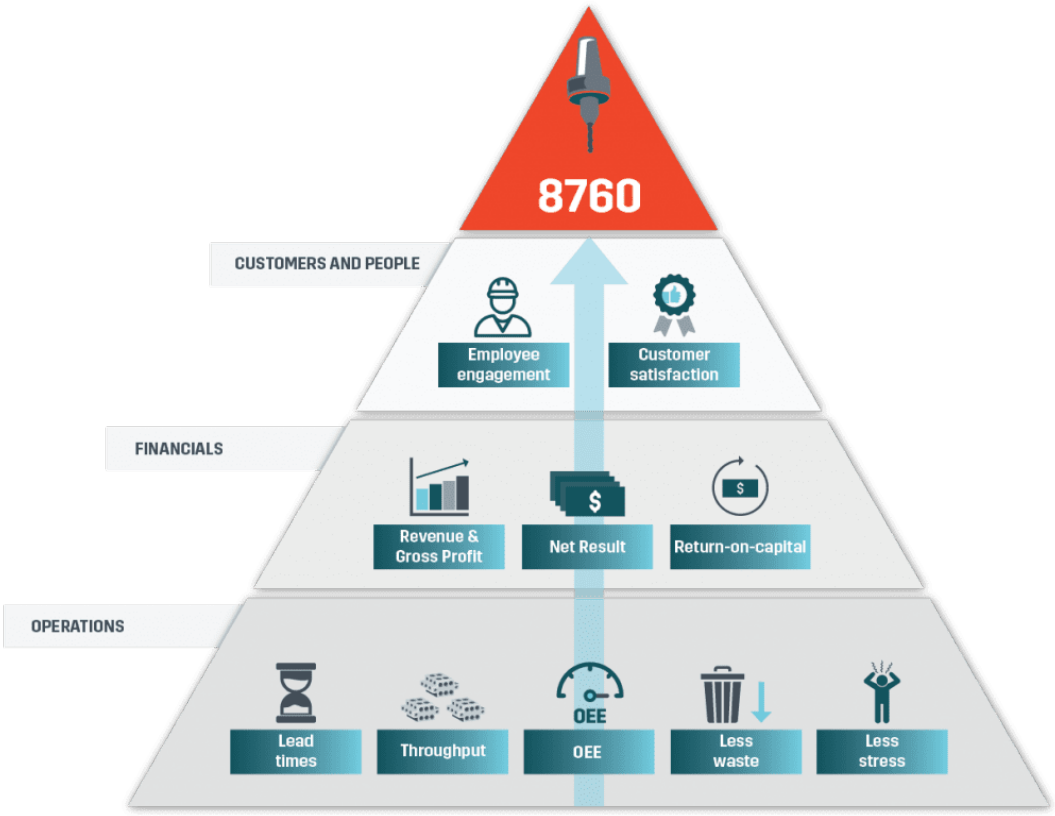


3 Multifunctional machining centers with pallet automation increase manufacturing productivity by reducing setup times, waiting times and buffers, while also enabling lights-out production.

By combining a multifunctional machining center with flexible automation, one can achieve machine tool utilization of up to 85%. This is because pallet-based automation creates the necessary flexibility between set-ups and enables unmanned production. **In a nutshell: the more the setups are completed in parallel with ongoing production, the better the machine tool utilization. In turn, this also results in less waiting times and WIP.**

4. Why Automate?

The four automation benefits discussed in the last chapter are only part of the big picture when it comes to the reasons and benefits around automation. The graph below explains how the benefits beginning from the renewed operations are linked to financial outcomes. Finally, the two most important stakeholders to any business, namely it's customers and personnel, are reaping the benefits. In short, everyone wins – a lot.



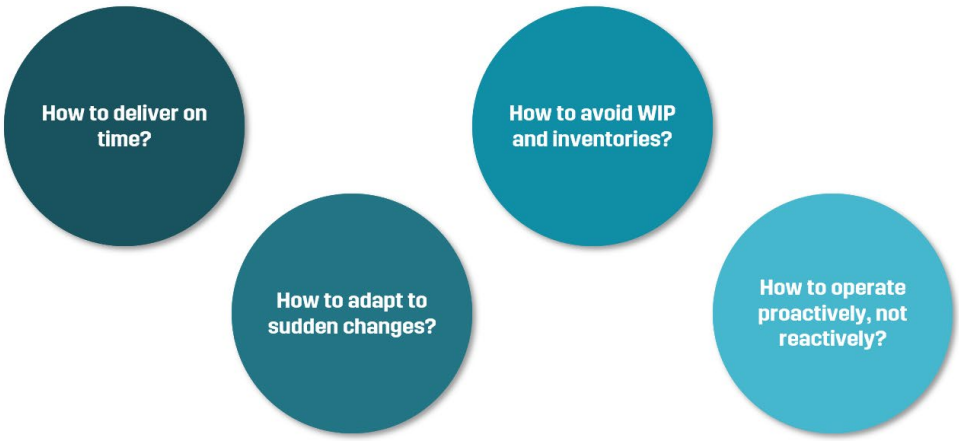
4 Flexible automation benefits manufacturers in three levels: customers and people, financially, and on operational level.

The idea behind automation is ensuring that production can do the right things, at the right time – all the time. After all, the ultimate goal for manufacturers is to make the most out of the time they have. In numbers, that's exactly 8,760 hours each year. To summarize, the benefits of CNC automation are:

- Higher output and revenues
- Stronger gross profit and net result
- Higher return-on-capital
- Improved customer satisfaction
- Better employee engagement
- Faster and more reliable lead times
- Higher machinery utilization and OEE
- Better and more consistent quality
- Less stress for production managers
- Smaller inventories.

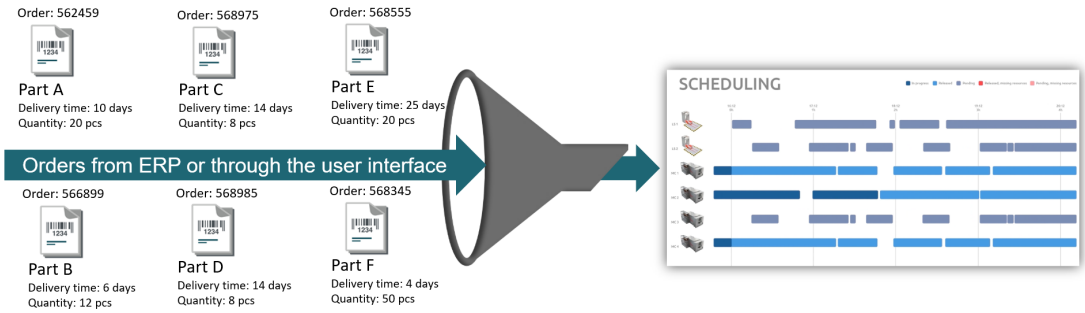
5. The Fine Art of Production Planning

In variable batch production physical automation alone – that is, the replacement of operators with robots – isn't enough. In addition, one needs **efficient and automated production planning and production resource management**. The main questions hinting us towards this direction are quite classical: How to deliver on time? How to adapt to sudden changes? How to avoid WIP and inventories? How to operate proactively, not reactively?



5 Intelligent production planning and control software can reduce the daily hassle on the shop floor.

When faced with such questions, it quickly becomes clear that production can no longer be organized and planned with Excel spreadsheets, let alone with pen and paper. Instead, automatic production planning should be considered, and specifically intelligent production control software which is available for this purpose.



6 Fastems' MMS is one example of an intelligent production control software with the ability to export production orders from an ERP and automatically schedule them for just-in-time deliveries and maximum capacity utilization.

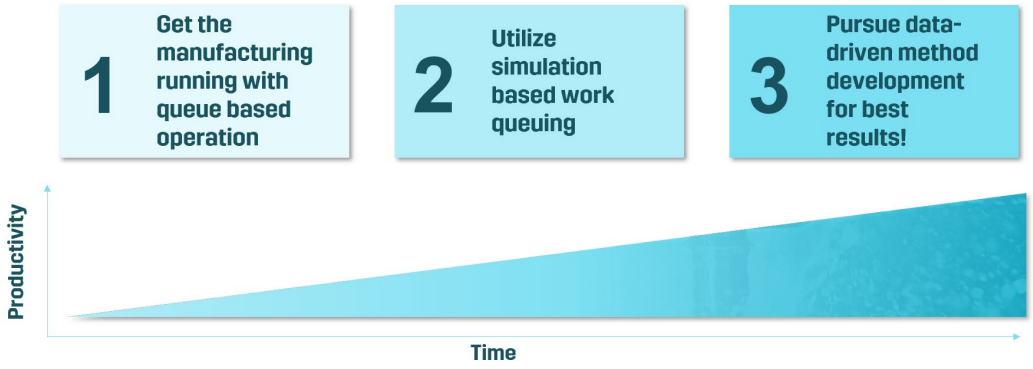
One example of such a software is Fastems Manufacturing Management Software (MMS). With MMS, production orders are either transferred from the ERP or inputted manually to the system. Based on the due dates for the orders and available production resources*, MMS then automatically plans production. If unexpected events occur, e.g. a machine breaks down or an urgent order comes in, the system automatically reschedules the entire production, considering all the necessary resources and due dates. The system also notifies operators well in advance if production is about to stop due to missing resources, like tools, for example.

The software also provides real-time production data and shows forecasts on upcoming production order completion. A well working automation system creates transparency in production and makes sure everyone is informed about what is happening and what is about to happen, at all times. The key performance indicators (KPIs) provided by the system, which are of particular interest to the plant management, can be used to identify further potential for targeted process optimization, among other things.

**Production resources = NC programs, raw materials, tools, machines, operators, and fixtures.*

6. Automating Step by Step

Transforming a production set-up to be (more) automated is a journey and for the best results, should usually be done in steps. Next, we'll go through the so-called 'automation ladder' which illustrates exactly how to do so.



7 Often, a step-by-step approach into automation brings the greatest benefits in the long term.

The first step involves running production as a work-queue based operation per work station or machine. Instead of planning the production batch by batch, it will be scheduled for a longer period in a queue, helping operators to prepare for the coming batches in advance and extending the unmanned production times.

Typically, queue-based operation does not differ too much from unautomated production philosophies, making the automation ramp-up quick and effortless. However, flexible automation has much more to offer, and requires a lot less effort from the operator. Through this, efficiency moves to a whole new level.

To maximize benefits from the automation technology, effort must be put in data management and tuning of various processes. This means entering production data (NC programs, tools, fixturing, raw materials) into a master computer and make processes reproducible to cut down the setup times close to zero.

With more automated approach the system can schedule production based on the end customer orders and available production resources, even when sudden changes occur. After this, it is time to start following production data and finetune production based on the findings. For instance: are some NC programs often slower

than they should; are certain tools often breaking with specific workpieces; is the capacity utilized in a meaningful way? How can we improve? Data-based decisions leave no room for excuses or second-guessing, and the results are easy to track.

The end goal of this combination is high utilization of equipment combined with fast and constantly value adding flow for every single workpiece.

7. Types of Pallet Automation

Pallet pools, pallet towers and linear flexible manufacturing systems are similar in terms of investment size – but that's pretty much the only commonality. Here is a comparison highlighting the main differences between the typical automation solutions for horizontal milling machines:

	Traditional pallet pool > 1000kg	Traditional pallet tower < 1000kg	Flexible Manufacturing System
Pallets per machine tool	6	12	12+
Unmanned production capacity (pallets)	6	12	Up to 36
Machine tool utilization	65%	75%	85%
Cost of extension	Buy a new system	Buy a new system	Low cost
Real-time automatic KPI reports	No	No	Yes
Machine tools per operator	1	1	3

8 Table comparing different automation solutions for milling CNC machines.

Pallet pools are limited in terms of the possible number of pallets. In combination with queue-based work management, this leads to less flexibility in terms of workpiece processing and unmanned manufacturing. Achieving elevated levels of productivity can be difficult.

Multi-level pallet towers offer significantly higher pallet capacity compared to pallet pools. However, the disadvantage of pallet towers is that they usually restrict the working area of the machine tool and are designed for lower payloads. Work management is queue-based, similar to pallet pools. Both pool and tower based solutions often offer poor work ergonomics – this should be considered in advance.

Linear solutions allow for less consuming work here due to the ergonomic loading stations. Furthermore, flexible manufacturing systems offer higher pallet capacity per machine, enable higher machine tool utilization (up to 85%) and can be easily extended for multiple machine tools with comparatively low investment costs.

9 Ergonomic loading stations for raw materials and machining pallets enable less consuming work for operators.

10 Linear pallet automation system consists of a production control panel, ergonomic loading station, machine tool(s), pallet storage and a crane that moves pallets in the system. This example is Fastems' Flexible Pallet Container FPC.

8. Practical Examples

Here are some practical examples of successful flexible automation system implementations:

Mach Machine: Permanent palletized setups increase efficiency and reduce cycle times from 24 minutes per piece to only 10
fastems.com/case/horizontal-machining-mach-machine/

Sant Hydraulic Technology: Proudly standing behind machine utilization rates of 98.6 percent and world class machining efficiency
fastems.com/case/sant-hydraulic-technology

Kytola Instruments: Productivity increased through automation of existing machinery
fastems.com/case/kytola-instruments

Zwick: The variety of individual components produced with automation ranges between 14,000 and 15,000 parts annually with about 4,000 new parts added each year
fastems.com/case/zwick-gmbh-co

KP Components: Improving productivity by automating several processes to reach the goal of zero set-up times and take full advantage of the 8,760 hours
fastems.com/case/kpcomponents

9. Summary and Conclusion

Automation is one of the key strategies to improve productivity and this guide describes how to make a successful first-time automation investment when it comes to CNC milling machines. With planning and rethinking of machine tool strategy and processes, a whole new level of productivity can be achieved in metal cutting manufacturing.

Investing in a high-performance horizontal machining center is a decisive key to increased agility in milling applications. Furthermore, with the right setup, an automated 4-axis machining center can do the work of three 3-axis machines, reducing both initial investment and the operating costs.

However, even 4- or 5-axis machining centers can’t achieve these goals without large enough tool magazines and proper automation solutions to enable high workpiece variability and extend lights-out production. Pallet-based automation can improve utilization of a machining center massively, whereby "flexible" does not only refer to the production itself, but also to the possibility to expand the automation for additional machines.

However, automated production can only be as good as the production planning method behind it. The higher the part variance and smaller the quantities per order, the more is needed from the production control. Therefore, intelligent software for automated planning, control and monitoring of production is required. This kind of software can act autonomously even in the case of unplanned events and is able to reschedule production according to the given order priorities and available production resources.

Transforming a production set-up to be automated is a journey and for the best results, should usually be done in steps. After all, an entire range of crucial processes with a multitude of different influencing factors must be considered. To fully benefit from flexible automation, efforts in data management and process reproducibility are necessary.

With the right machine tool and automation strategies enabling reproducible processes, the entry into automated production is crowned with success.