item

Lean production building kits The second generation

Guidelines and practical tips for using and building cost-effective factory equipment

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How this guide can help

The principles of lean production have changed industry forever, improving both performance and flexibility in many different areas of production. However, that is no reason to settle for the status quo – as the name suggests, continuous improvement never stops.

As methods are honed, production systems are also taken to the next level. Experience with lean production building kit systems has been fed into technical advances, which in turn have helped companies to complete many tasks faster, more efficiently and more cost-effectively than in the past. Today, thanks to cutting-edge fastening technology, production staff can build transport trolleys, racks and shelving units that are much more robust and yet can still be modified quickly and with relatively little effort.

This White Paper summarizes the basic principles of lean production and explains which methods have proven useful in practice. Despite increased demands, second-generation solutions can still deliver progress in the fight to eradicate inefficiency in production. State-of-the-art lean production building kit systems are an extremely effective tool when seeking to achieve continuous improvement.

1.0 Benefiting from second-generation lean production building kits

In the mid-1980s, lean production was uncovered as the secret of success in the Japanese economy. After raising the bar in terms of flexibility, cost-efficiency and quality, the Toyota Production System was taken as the prime example of lean production in action. The obvious benefits of this system spurred on companies and researchers around the world to analyse, adapt and enhance the principles on which it was based. The consequences were far-reaching – so much so that the basic tenets of modern quality management and continuous improvement can be traced back to the lean production concepts developed at Toyota. Today, the boundaries between conventional and lean production are no longer clear-cut.

The widespread use of lean production has not only helped refine the associated methods, it has also ensured the continued development of the tools and equipment used to put it into action in the workplace. Experience with shortcomings, additional application areas and a whole range of individual improvement measures have ensured that the second generation of lean production building kit systems is much more efficient and robust than their predecessors.

This White Paper shows how companies can benefit from the technical advances in lean production building kit systems. The special system solutions that support the on-site construction of shelving units, racks, transport trolleys and conveyor lines enable personnel to improve their working environment independently, without the need for centralised planning arrangements. Production equipment and facilities can now be built faster, with more elegant results and more economical material usage than can be achieved with first-generation systems. What's more, reusing and modifying existing frames is usually a more straightforward affair.

The second-generation lean production building kit systems are proof that continuous improvement and consistent optimisation can help lower the consumption of resources. Companies also need to be willing to move away from the attitude that tried-and-tested working methods ought to be preserved forever. All methods need to be continuously scrutinised and replaced with more efficient alternatives as and when necessary. For example, using a cutting-edge lean production building kit system instead of a first-generation solution can halve the amount of time needed to build a transport trolley. What's more, work that previously had to be done by two members of staff can often be done by just one.

The first section of this White Paper explains the principles of lean production and the role that building kit systems play when it comes to putting these principles into action. The second section focuses on the practical side of how companies that make consistent use of lean production technologies can save time and money without compromising on quality and durability.

Any customer can have a car painted any color that he wants so long as it is black.

Henry Ford (1863-1947)

2. How it all began – the origins of lean production

Improvement, increased efficiency and innovation are what keep the wheels of the economy turning. Success means satisfying customer demands while using your own resources as economically as possible – balancing costs and benefits is simply good business sense. When it comes to production operations, costs need to be kept as low as possible, and the best way of doing this is to use new processes and technologies and organise processes logically. At the end of the 19th century, pioneers such as Frederick Taylor and Frank Gilbreth developed efficient production as a separate branch of research. At a time when most companies were reliant solely on the inventiveness of their entrepreneurs, Taylor and Gilbreth developed the concept of scientific management, which optimises each individual activity and integrates the work capacity of each employee into the overall process.

In 1913, Henry Ford kick-started the most intense phase of the second industrial revolution when he introduced the concept of focussing consistently on processes. The conveyor belt became a symbol of the industrial age. Conveyor-belt production, standardised mass-market products and specialised machinery were seen as the best ways to drive down costs even further and make products affordable for more and more people.

However, some ten years after conveyor belts had revolutionised production forever, the first problems started to appear. While customers were increasingly demanding cars that were different, Henry Ford insisted in his book “My Life and Work” that: “Any customer can have a car painted any color that he wants so long as it is black”1.

The manufacture of variants and ever shorter product cycles posed major challenges for the system of centrally planned mass production. When everything runs as planned, goods can be produced with maximum efficiency, but each change causes costs to increase.

In the 1950s, Taiichi Ohno and Shigeo Shingo developed a different approach at Toyota. They moved process planning from the top of the hierarchy to the place where the work was actually being done. To reduce capital lockup, they integrated suppliers closely into in-house production planning, which operated on the pull principle - in other words the flow of materials was not determined by the speed of the production line but by sales volumes. Production adapted to demand and was optimised so that it could respond to changes flexibly. Ohno and Shingo also rolled out a continuous improvement system to ensure production methods could be refined on an ongoing basis instead of in stages.

The "Toyota Production System" (TPS) is the nucleus of lean production. It enables companies to respond faster to changes and therefore be more agile on the market.

Since the 1980s, the Toyota Production System has also been modified outside Japan. It took around 30 years for the benefits of lean production to become so compelling that companies across the entire world started to study and adopt the approach. Another 30 years later, principles such as continuous improvement and consistent quality management have become standard for cutting-edge production.

However, lean production is still being developed. Numerous companies and universities are working to refine methods and practical experience is being fed into the next generation of lean production. And, since continuous development is a key feature of this attitude and approach to work, that is precisely how it should be.

1 Henry Ford, "My Life and Work", 1923, from Chapter IV "The secret of manufacturing and serving"

Pioneers of process orientation

Frank Gilbreth (born 1868) and Frederick Taylor (the architect of Taylorism, born 1858) were pioneers of research into industrial efficiency. They rejected the idea that rationalisation was solely the job of an individual entrepreneur and applied scientific standards as they researched individual work processes and the role that people played in them. Breaking down processes into individual stages that could then be individually optimised helped deliver further progress in manufacturing. Factors that had often existed previously only as a rule of thumb were measured and analysed with scientific accuracy, such as how long it took to unload coal from a ship or how quickly a worker could move a workpiece from the ground to a shelf.

Gilbreth and Taylor incorporated everything into the process. They believed that maximum efficiency could be achieved when there were as few deviations from the process as possible, and their approach boosted productivity enormously. All the same, Taylorism focussed on the supply side and neglected the demand side of business.

2.1 Continuous improvement – never being satisfied with the status quo

When he published his book "Kaizen: The Key to Japan's Competitive Success" in 1986, Masaaki Imai put a relatively little known topic firmly centre stage – continuous improvement. Kaizen is made up of the Japanese words for "change" (Kai) and "for good" (Zen). Imai defined change as a continuous process that incorporates all areas and all stages of work. Kaizen is the attitude that sees improvement as a never-ending process because it is not possible to be satisfied with the status quo. No area is unimportant or impossible to improve – you just need to look closely enough. Swedish manager Jan Carlzon later summed up the principle with these words: "You cannot improve one thing by 1000 percent but you can improve 1000 little things by 1 percent."

Today, the continuous improvement process (CIP) is part and parcel of every state-of-the-art production system, where bringing together skills and responsibility is essential to delivering ongoing improvements in small steps. While Taylorism regards the worker as a small cog in a big machine, CIP gives the specialists on site the freedom to introduce changes on their own initiative. That means giving workers the tools and the authority they need to deliver gradual improvements in a step-by-step process. Lean production building kits are system solutions that make it easy for users to build shelving units, racks, transport trolleys and other factory equipment. Ideally, a CIP workshop will be incorporated into a company's production system so that teams of workers can use it as and when they see fit.

The cumulative improvements this workshop helps to deliver are not cost-intensive and enable the teams to try out new methods, even if they turn out to be flawed. Investing in small steps like these is important and, far from being wasteful (see page 9), this approach counts as essential research into new methods.

However, continuous on-site improvement is always just one of several measures. CIP is tied into quality management to ISO 9001 and is ranked alongside ideas management and suggestion schemes.

2.2 Rapid response – the role of the lean production building kit system

One of the recipes for success in lean production lies in maintaining a consistent focus on the value-added chain and processes. This ensures maximum transparency. All processes are regularly reviewed to identify opportunities for improvement, which in the ideal scenario helps keep changeover times short whenever processes need to be modified. This flexibility is decisive when it comes to responding quickly to changes.

Companies that can rapidly integrate new products, improved versions or additional variants into the production process have an edge on the competition. However, whether large or small, changes require alterations to factory equipment. Lean production building kit systems give companies the option of building the frames or trolleys they need on site, without having to first work through a tedious planning process that drains manpower. The continuous improvement process is based on the belief that the teams who know the products and processes should be able to develop solutions independently and put them into action directly in the CIP workshop.

The first generation of lean production building kit systems satisfied the basic requirements. They were predominantly based on plastic coated steel tubes that were simply cut to size and connected together with fasteners to build the desired equipment.

As the principles of lean production started to take hold, though, the requirements on lean production building kit systems started to increase. As the systems were put to greater use, three key problems often came to light:

1) Poor durability: The combination of plastic and steel results in creep behaviour, which means fasteners have to be retightened on a frequent basis. Continuous maintenance work is required when equipment is being used over long periods.

2) Complex assembly: Fasteners usually form intersection points for 2 to 5 tubes. All the individual parts need to be held in position and screwed tightly in place at the same time, which often requires two people.

3) Laborious modifications: Because specialised fasteners are used at intersection points, structures cannot be reconfigured – e.g. by subsequently repositioning a tube or disconnecting it from an intersection point – without having to undertake complex rebuilding work. With the mistakes of the past now learned, the second generation of lean production building kit systems has come onto the market, ready to meet increased demand. These systems are usually based on aluminium, do not feature a plastic coating and enable long-lasting, stable connections. One-man assembly is also possible, as are subsequent modifications. All this helps companies develop the improved speed and flexibility that lean production demands.

In practice, state-of-the-art lean production building kit systems save a great deal of time and help meet the need to actively support continuous improvement. They therefore offer the ideal tools for eradicating all types of waste in production. Alongside an unrestrained focus on the customer that is achieved through maximising quality and ensuring rapid adjustment to market requirements, the fight against waste is central to lean production.

3.0 Lean production – the seven principles against waste

Customers pay for the added value generated during production – not for unnecessary activities. Lean production focuses on identifying and tackling the sources of waste, which reduces costs without compromising on quality. Indeed, the only processes that are eliminated are those that use up resources without contributing to the value of the product.

Seven different types of waste have been identified in production and these are often referred to collectively as "muda", a Japanese term that describes an activity that is pointless or lacks purpose or sense. Although the fight against waste, which can often be difficult to identify, is more tangible than the somewhat more abstract concept of efficiency, it is an activity that nonetheless aims to boost the cost efficiency of production systems. All the same, the relationship between a company's outlay and return doesn't offer any really clear indications of where waste can be eliminated. Lean production focuses on a company's outlay and sets out to counter all types of waste.

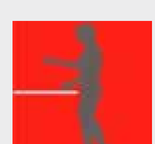
The seven principles against waste relate to:

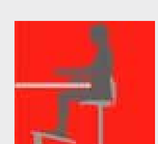
1. The movement of materials
2. Stock levels
3. Movement
4. Waiting times
5. Processing
6. Overproduction
7. Rectifications and errors

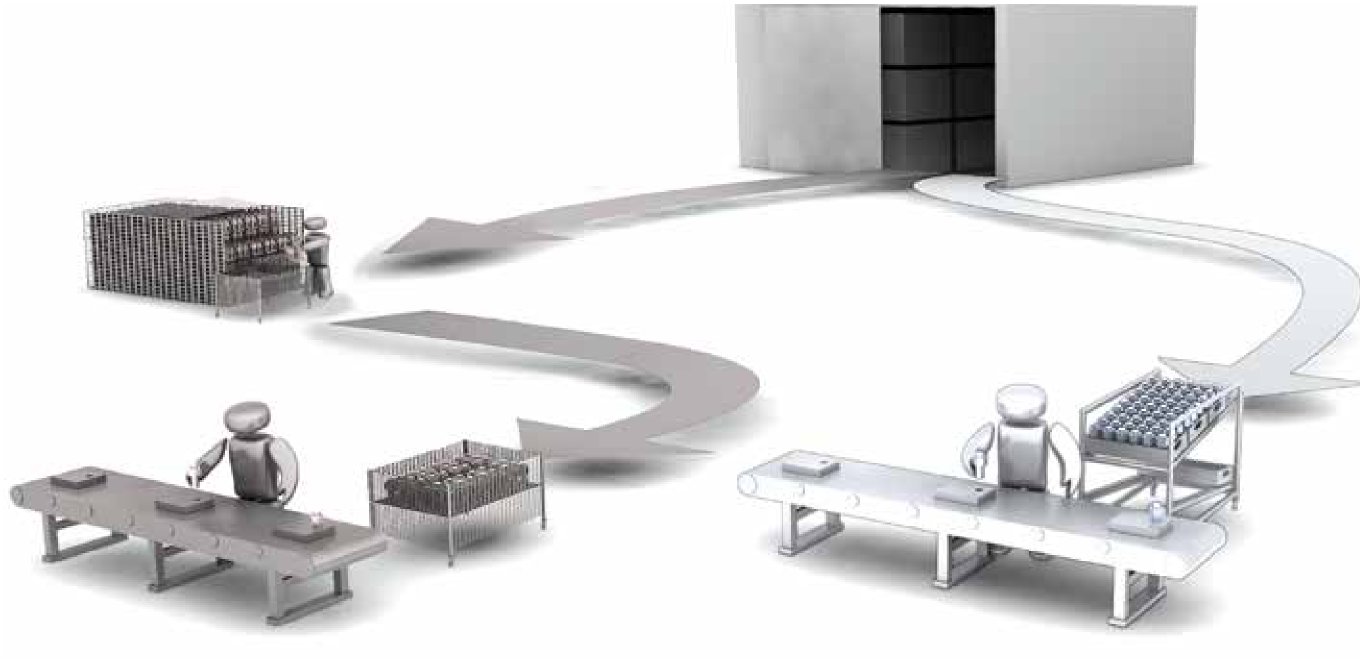
The following pages of this White Paper explore the detail behind the principles of lean production and how a lean production building kit system can help companies put in place the necessary methods.

Seven classics and two new additions

Recent research on lean production has resulted in two new additions to the seven classic muda identified by Toyota in the 1950s and 1960s – a lack of ergonomics and untapped employee talent.







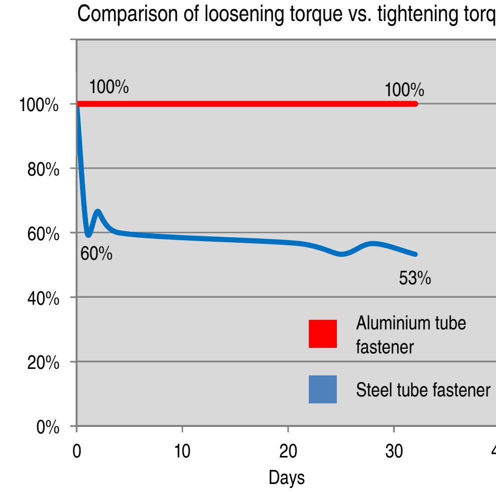
3.1 Avoiding unnecessary movement of materials

Important resources are used every time a workpiece is moved from one place to another. However, instead of generating added value, time spent on transport simply increases costs by extending capital lockup and demanding more outlay in terms of energy and personnel. What's more, each time something is moved, it is put at greater risk of being damaged or suffering quality impairments. The potential for waste exists in every single aspect of an internal logistics system. Or, to put it in a more positive light – internal logistics offers huge potential savings!

A lot of waste can be prevented by carefully planning the individual steps in a workflow, and that includes arranging the various locations where work is carried out so that they are closer together. At the same time, the individual processes themselves need to be coordinated with each other. The aim of value-stream mapping (VSM) is to optimise throughput times and to time the individual stages in a workflow as accurately as possible. This includes taking into account set-up times when different products are being made on the same machinery or at the same work benches. Following an optimum material flow produces important indications for how to cut waiting times (see muda 4, page 13) and shorten transport routes. One of the aims of lean production is to reduce the movement of materials and manage this movement in a more efficient way by using intelligent interlinking systems between workstations and customised transport solutions, for example. Second-generation lean production building kit systems therefore offer a single system for intralogistics and frames that ensures a smooth transition between work stages and transport stages. Using aluminium tubes with stable aluminium fasteners results in strong holding forces that are not impacted by dynamic loads and therefore have a positive impact on durability. Furthermore, stable constructions can be built with less material, while state-of-the-art fastening technology can withstand several thousand load changes without screws having to be retightened.

Transport trolleys made from welded steel frames are usually very heavy. A cutting-edge lean production building kit system can be used to build stable yet lightweight aluminium frames, meaning that internal logistics teams can save energy.

Comparison of loosening torque vs. tightening torque [%]



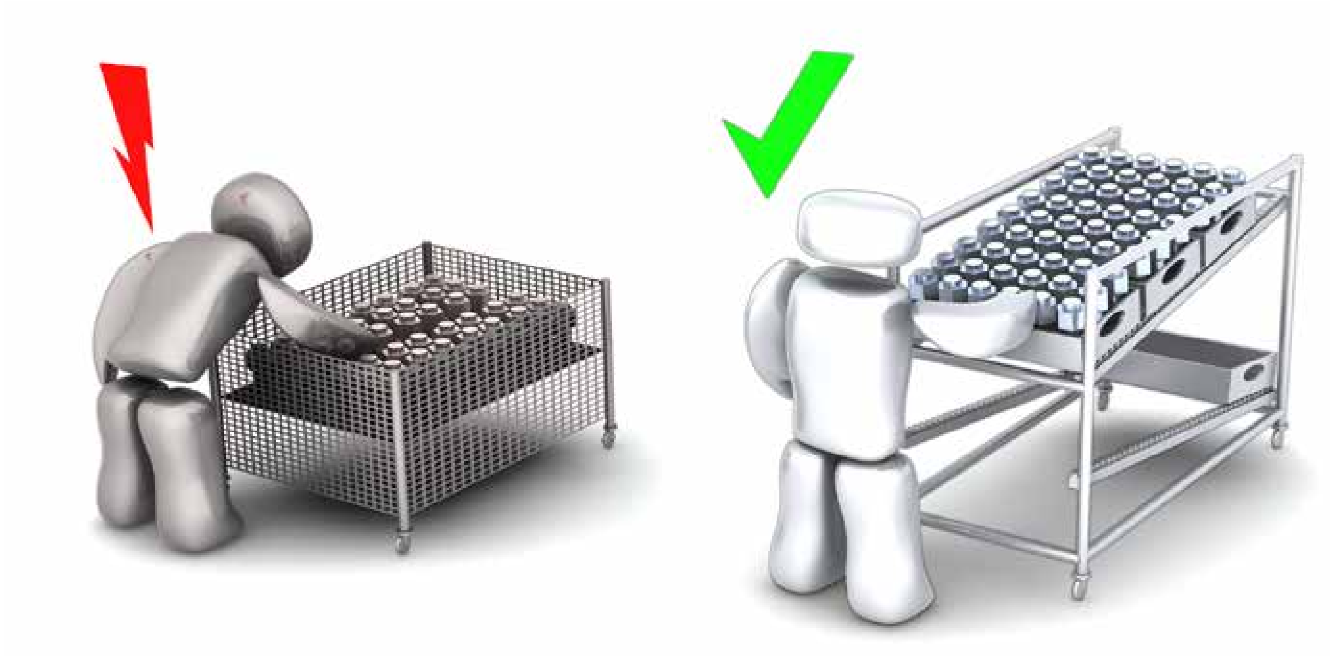
3.2 Minimising stock levels and warehousing

High stock levels are always a warning sign for problems with production planning. They can have many causes such as overproduction (see page 15), waiting times (see page 13) and unnecessary movement of materials (see page 10). These need to be subjected to thorough analysis. To ensure reductions in stock levels don't lead to problems in the workflow, all the culprits need to be tackled in parallel. The aim is to stabilise production processes so that stocks of preliminary and intermediate products can be reduced.

However, even if the stated goal is to achieve a "one-piece flow", there still needs to be a certain volume of stock to protect against fluctuations. The art lies in getting that volume just right and continuously monitoring the actual flow of materials based on feedback.

The Kanban principle is often used as a means of managing sequences. Kanban is a Japanese word meaning "signboard" or "billboard" and describes a simple method for ordering materials based on actual consumption. Kanban systems use cards to provide information on which locations are running low on stock. Included with every delivery, these order cards clarify the current flow of goods in line with the pull principle, which helps companies to minimise stock levels of the preliminary products required at the production site. One of the typical applications of lean production building kit systems is the construction of Kanban carriages or trolleys that enable operators to quickly resupply workstations.

The second generation of these building kit systems also applies the principles of lean production to themselves. Experience has shown that the "one fastener for all" principle helps to keep warehousing requirements low. Instead of having to stock a whole range of specialist fasteners for various scenarios (connecting together 2, 3 or 4 tubes), companies can complete all their engineering tasks using just one standard product for 90° connections. Only a few of these fasteners need to be held in the CIP workshop, since modern logistics systems can deliver additional supplies quickly. Suppliers with excellent global supply availability help their customers to reduce these costs. A good supplier will even be able to deliver specialised components in the desired quantity in just 24 to 48 hours.



3.3 Preventing superfluous movement

"Only the last turn of a bolt tightens it – the rest is just movement." This quote from Shigeo Shingo, one of the driving forces behind the Toyota Production System, neatly sums up this type of waste. If a company wishes to cut out waste, it has to focus on the movement in the production sequence that actually generates added value.

Employees having to repeatedly lean over or bend down to reach consumables, fastening points that are difficult to reach, and workpieces located at an unergonomic working height – all of these require unnecessary movement. The additional time taken up by each individual reaching movement adds up to a significant wastage of working time. The same applies to time spent looking for working materials. Arranging material crates so that they are in easy reach and ensuring workpieces are at the correct working height saves time.

Preventing superfluous movements usually also improves the ergonomics of a work bench. Unnatural postures and reaching distances that are too high or too low put strain on an employee's muscles and bones. By contrast, an ergonomic work bench can be customised to suit the optimum handling area for each individual operator, which eliminates fatigue and prevents uneven strain, thereby also improving safety levels.

Second-generation lean production building kit systems make the construction of factory equipment as straightforward as possible, even ensuring that assembly work can be completed by a single person. Every strut is inherently stable because it is fastened individually. This is a clear advantage over previous systems, which fastened numerous tubes together in special intersection point fasteners.

3.4 Reducing waiting times

A successful production system is based on carefully planned sequences. Valuable working time is lost if a workstation has to wait for workpieces or even an individual screw, and you can't expect people to wait for a machine . The same applies to machine downtimes and other technical problems. Although the principle of keeping waiting times down is in direct conflict with the need to keep stock levels as low as possible (see page 11), oversupplying materials and spare parts is no way to improve overall productivity.

To reduce waiting times, companies need to obtain the right mix of standardised processes, clear lines of communication and flexibility based on independent organisation. After all, it is not possible to plan for all eventualities, and centralised planning usually takes too long and incurs excessive costs.

That is why, in lean production, solutions are put into action on-site at the work bench or workshop, which is often referred to as the "gemba". Employees know best what tools and equipment they need and can develop these solutions themselves using a lean production building kit system. Cutting out waiting times also improves efficiency.

Fasteners that are supplied preassembled speed up work as they simply need to be put in place and tightened, thereby eliminating the need to fit together numerous individual components and saving time. In the past, when subsequent modifications had to be made at complex intersection points, the entire connection would have to be disassembled, even if just a single strut had to be moved. When using state-of-the-art solutions, users can add reinforcements virtually anywhere they like, whenever they need to. This means that companies don't need to stock too much material as a precaution and cuts waiting time for planning and making modifications. Because fasteners create a stable, rigid connection, cantilever arms can be added in a matter of seconds so that tools and similar elements can be suspended in the handling area. The work can even be carried out in situ if the user has sufficient experience with the system. Eliminating a whole range of different profile fasteners makes on-site warehousing and reordering much easier.

3.5 Eliminating complex processing

Heavy lifting, difficult-to-reach materials, unnecessary worksteps – these are just some of the many different ways that time and money are wasted in production processes. This type of wastage can usually be traced back to superfluous processes or excessively complex sequences. The tools have to be right for the job.

When applying lean production methods, companies should first plan for the minimum and improve the existing infrastructure gradually. This prevents over-engineering and retains flexibility. If the design allows, a basic frame can always be modified later on so that it can be extended. It is not uncommon in lean production for plants to be used over a long period of time, being gradually modernised with add-ons and extensions.

Second-generation lean production building kit systems are therefore based on a small number of basic elements that can be adapted and extended as necessary using highly specialised elements. This safeguards flexibility. Planning for the minimum means users can subsequently improve designs to suit their application. For example, a frame or transport trolley can be modified for specific requirements with relative ease and does not therefore have to be built larger or stronger than strictly necessary in the first instance.

Experience has shown that the plastic coating on steel tubes, which is typical of first-generation systems, exhibited less resistance against displacement forces. This meant that frames had to be built with more material than necessary so as to ensure long-lasting stability. What's more the creep behaviour associated with plastic-coated steel tubes meant that screws had to be retightened on a very frequent basis. Any damage to the plastic coating exacerbated this effect, while the exposure of sharp edges also represented a significant risk of injury.

Second-generation solutions include stable aluminium fasteners, use flexible-foam tube protectors that are fitted separately and produce constructions that are exceptionally durable.

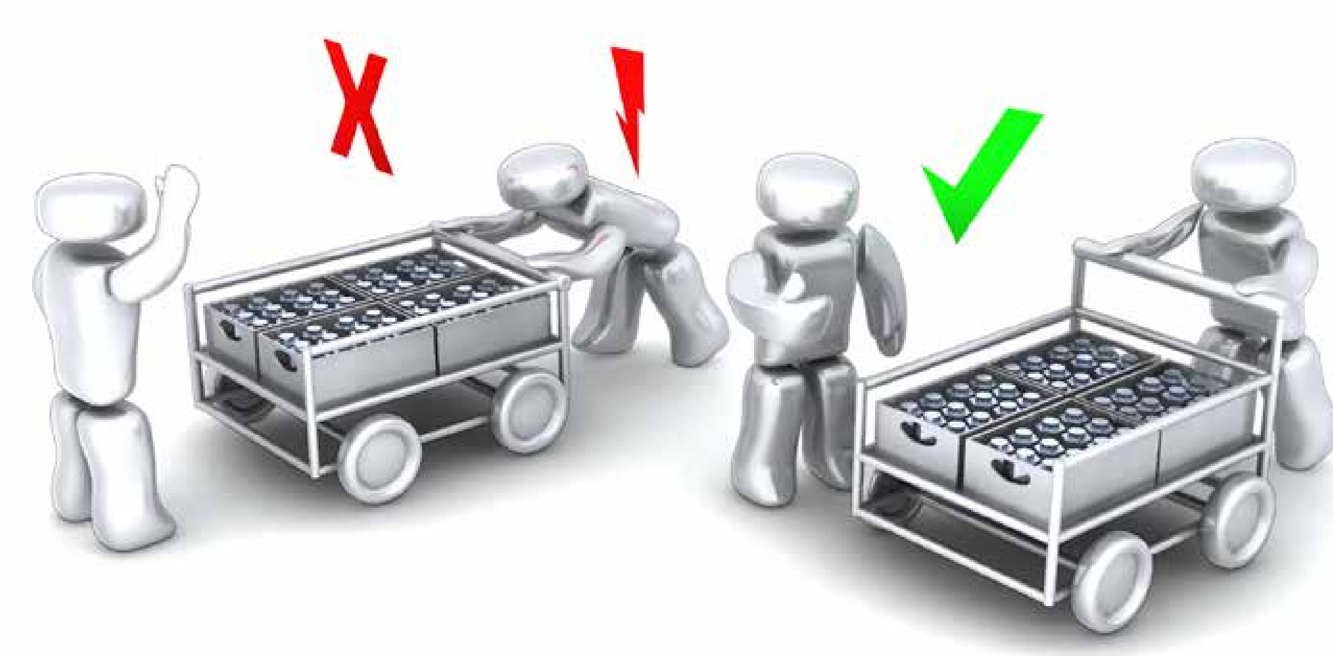
3.6 Preventing overproduction

Overproduction goes hand in hand with the waste caused by excessive stock levels (see muda 2, page 11), the difference being that, instead of having too many preliminary products, the company produces too many end products. Manufacturing things before they are needed ties up capital and drives up warehousing costs. It also wastes time and money on transport and management, while storing products for long periods of time can also have a detrimental impact on their quality.

In the ideal material flow, production gets accurate feedback about how much output is currently required and the timing of sequences is not too rigid (see muda 1, page 10). All in all, production has to be flexible enough that it can adapt to the actual take-up of products (pull principle). Being able to restrict, increase or convert production systems is one of the main aims of lean production and this is usually easier to achieve with small, flexible units than with monolithic systems, which are only efficient when producing high unit numbers all the time.

By ensuring users can easily convert workstations and reconfigure them as required, a lean production building kit system supports this essential flexibility at the production site. An adaptable system that grows with a company's needs is open to change and extension – the key to success lies in being able to reuse systems without limiting their functionality.

When using state-of-the-art lean production building kit systems, constructions don't need to be completely disassembled before additions can be incorporated at intersection points – add-on components can be integrated as and when required. It is the second-generation fastener that makes this possible, as it can be added at any position on a structure. The "one fastener for all" principle ensures that existing constructions never fall out of use, because they can be extended and reconfigured to suit requirements. For example, the incline on a roller conveyor can be adjusted to suit the dead weight of workpieces in a few simple stages and, since assembly work is straightforward and can be completed by a single person, frames and carriages can be built and modified in next to no time.



3.7 The right way to handle rectifications and errors

In classic production systems, rectifications and errors are frowned upon and need to be avoided at all costs, since every error impacts on quality and profitability. By contrast, lean production boasts a fault culture that strives for perfection by hoping to learn from mistakes, something companies can only do when they actively engage in the process. Every error that is discovered is valuable because it represents an opportunity for long-term improvement. Nothing could be worse than declaring production problems completely taboo and thereby encouraging everyone to overlook and ignore them.

The approach that is used most often is the continuous improvement process. CIP is one of the fundamental principles at the heart of quality management to ISO 9001. As a methodology, it demands that companies keep a close eye on all work stages, ensuring continuous monitoring and feedback. It also places particularly high requirements on production systems – the more specialised and complex they are, the more difficult it usually is to adapt them.

The first generation of lean production building kit systems responded to these specifications with simple system solutions that could be applied without the need for centralised planning. They made it possible for staff to build additional tools and factory equipment on site. However, when put into widespread use, a number of weaknesses in these systems began to emerge, such as the fact that structures often had to be completely rebuilt just to make minor modifications at the intersection points of tubes. When a component encompasses a tube by more than 180° to create a fastening, it is impossible to fit additional components at the same section of tube.

The second generation of lean production building kit systems is compatible with continuous modification at all stages in the production process. These systems are based on a small number of basic elements that can be repeatedly recombined and added at any point with exceptional flexibility. Furthermore, additional struts can be incorporated to strengthen a structure and can be fitted at any angle, while a forgiving design principle provides additional support by compensating for tolerances in the lengths of profiles and tubes.

4. Summary

State-of-the-art lean production building kits have been optimised for continuous improvement in the workplace and use system solutions to create tools and factory equipment without requiring major planning input or material usage. The second generation combines maximum stability with minimum planning and assembly work, thereby ensuring users can build and improve frames on site with no need for complex drawings. As a result, these systems embody the principles of lean production, which strive for flexibility, economical use of resources and maximum quality.

All this is made possible by intelligent fastening technology that guarantees exceptional durability. Cutting-edge fasteners do not need to be retightened and exhibit no settlement, because second-generation solutions are usually based on aluminium tubes and fasteners that ensure optimum strength, unlike systems that feature plastic coatings.

To avoid the complex intersection points that previously had to be implemented with specialised fasteners, modern solutions prefer to use a single type of fastener for all needs. Individual struts can be fitted to intersection points with inherent stability and can even be subsequently repositioned, which makes it easier to adapt existing constructions so that, for example, the incline of a roller conveyor can be modified at a later point in time.

Lean production building kit systems make it possible for staff to build transport trolleys, shelving units, racks, conveyor lines and other factory equipment on site, as their needs dictate. These building kit systems are also ideally suited to needs-based material picking and provisioning.

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