Feel the force of flexible manpower

FLEXIBLE MANPOWER LINES CAN PROVIDE THE ANSWER FOR COMPANIES STRUGGLING TO MAINTAIN PRODUCTIVITY WITH FLUCTUATING DEMAND

By Freddy Ballé & Michael Ballé

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As many industries brace for the difficult times ahead, with a looming oil shock and vigorous competition from low-cost countries in sluggish European economies, several companies go for lean as the key to turn difficult market conditions into competitive advantage. Indeed, historically, lean companies have often thrived in economic downturns, just as, originally, Toyota gained notice by its unexpected weathering of the 1974 oil crisis. Currently, Toyota is expanding aggressively worldwide and continues to gain market share, vying to become the world's number one automotive manufacturer.

Lean programme managers tend to complain that lean is difficult in periods of volume decrease because factory productivity gains are hard to get in plants set up to produce at high levels of demand: not so. In fact, the very definition of productivity gains in the Toyota Production System is to be able to remain equally productive at different levels of demand. For instance, most people would think of a production line where 10 workers make 100 parts a day which, as a result of improvement, now makes 120 as a 20% productivity improvement. Not in lean! This is an actual improvement if, and only if, customer demand has increased by the same 20%. If not, this increase of production is nothing more than overproduction, the number one waste, and main crime in lean production.

Lean seeks the total elimination of waste, as a way to improve the response to customer needs in terms of lead-time, quality and cost. In the lean perspective, profits can be found in the way manufacturers make things: every customer matters, every part counts. The reduction of man-hours in every operation is done by eliminating the now famous seven wastes: waste of overproduction – producing too much or too soon; waste of waiting for parts to arrive or for a machine to finish a cycle; waste of conveyance – any conveyance is essentially waste and should be kept to a minimum; waste in processing – when processing does not go smoothly and requires extra work; waste of inventory – any more than the minimum to get the job done; waste of motion – any motion which does not contribute directly to value-added; waste of correction – any repair is waste.

The most blatant waste in most factories is the first one, the waste of overproduction. Most industrial operations are designed to function at optimal speed, in the mistaken belief that this guarantees the return on investment of the capital expended in the equipment. Obviously, the more parts a machine produces, the quicker it pays for itself, right? Possibly, but only if the parts are needed by the next process, and ultimately by the customer. Unfortunately, this is rarely the case. In the automotive industry, for instance, most of the equipment is designed according to the wildly optimistic predictions of automotive manufacturers, who believe that their latest creation will take the entire market, and are systematically optimistic in their marketing outlook. Consequently, many industrial machines are able to function at an optimal speed, which is largely greater than real demand.

> **“Faced with the upcoming cost crush, flexible manpower lines are a way to service customers while remaining cost competitive”**

This creates all sorts of further wastes. Imagine that an automotive line is planned for 1000 parts a day, but the real demand is less than two-thirds of that, say, 600 parts. In many plants, we'll find a semi-automatic line with a few operators running it, designed for 1000 a day. It will work it at maximum capacity for the day, overproducing by 400 parts, which will then need to be stored as inventory, handled, conveyed, checked, and so on, before they're needed – many of the other wastes rise from the first one. Furthermore, should the line not perform perfectly, and, because of a variety of minor problems, should it only really produce 800 parts in the shift, it doesn't matter too much, because real demand is still covered. This, in practice, is a serious waste of man-hours, and one that occurs routinely in most plants, but not one which is easily perceived, because it is still felt that the machines are thus fully utilised. To be sure,

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> “For industrial operations flexible manpower lines are a key to survival in turbulent times”

as soon as the lean specialists set up an hourly production analysis board to track hourly production within target, it appears that as much as 20% of production time can be lost due to a variety of causes.

TAKT YOUR TIME

To break away from the kind of waste created by such automatic lines, lean practitioners think in terms of takt time: should we rigorously stick to customer demand? What should be our target cycle time? For instance, if the shift's operating time is of 450 minutes, and we need to produce 300 parts per shift (600 a two-shift day), the 'takt', or rhythm of the line, should be 450/300 = 1.5 minutes, which is 90 seconds. To produce at customer demand, no more, no less, we need to produce a part every 90 seconds. If we go quicker than this, we're overproducing, and generating waste; if we go slower than this, we're wasting precious time and getting behind on our production needs. Unfortunately, the semi-automatic line has been designed with, say, five operators to run at 500 parts per shift (1000 a day), which means a cycle time of 0.9 minutes, or 54 seconds. Each operator's cycle and robot has been conceived for cycles of 54 seconds, if we actually produce at takt time to stick to real customer demand, both operators and machines will be waiting 36 seconds every cycle – what a waste, you'll say!

In fact, if you look closely at the line, you're likely to see that most of the automation is about moving the parts along between actual value-added operations, and then testing. Placing parts in a machine is usually quite tricky (whereas ejecting them is much simpler), so quite sophisticated automatic devices are needed just to place parts correctly. Testing is also a concern, because experience shows that it's hard to know whether the automatic testing actually spots the real quality issues. Operators are still needed to action key machines, and are usually set far apart from each other between much automated conveyance. In other terms, precious capital expenditure is used to automate conveyance – waste! What would 'lean' flexible manpower lines look like? Let's consider basic cases of assembly lines with manual or machine operation or straightforward machining lines. We can look at four levels of automation: a completely automatic line; a semi-automatic line; a manual line; or a manual line with automatic unloading.

In most cases completely automatic lines are expensive because the loading of each machine, as well as parts feeding, has to be very precise. This type of machine will be optimised for a set level of volume and the amortisation of the cost of the investment is a large part of the total cost. Consequently, even should the machine be able to work at different speeds, if volume decreases, the cost of production of each part increases due to the fact that the total amount to amortise is fixed.

The general principle of semi-automatic lines is similar to automatic lines but with operations especially difficult to automate handled by operators. Usually these manual operations have no reason to be one after the other in the graph of machine operations and the operators are placed far apart on the line. As a result, the number of operators is independent of the cycle time when the line runs. To run the line with lower volumes without losing direct labour productivity, operators need to be placed close to each other, to be able to handle several processes in case of high takt time. Not only is this the only way to reduce operators if volume goes down, it's also the key to realising productivity gains through kaizen. Unless operators work together, there is no point reducing each operator's workload by half, because none could be pulled out of the process – so they'd still have to stand there for the entire cycle, even if with less motion.

In the case of operations either completely manual or manual loading and unloading of elementary machines of assembly or machining, a U-shape permits the adjustment of the number of operators to the required volume for real customer demand. At different levels of volume, the total investment of the line still needs to be amortised, but the manpower cost could be maintained constant by unit produced. Clearly, the investment cost is much lower than in automatic or semi-automatic lines and if the unit cost would be slightly higher at the maximum volume, the cost gap will increase when the production volume decreases.

Manual lines with automatic unloading is a variant of the manual line in which the unloading operation has been automated when a cheap investment solution can be found. Unloading operations are far easier to automate than loading operations, and only need facilitate the handling of the part by the operator. In this case the operators can load the machine before unloading (as the part has self-ejected), which allows more efficient movements. In this case the unit cost should always be lower than for the manual line because the increase of efficiency of the operator pays for the unloading investment.

Altogether it is difficult to improve the efficiency of an automatic line. Each operation cannot be easily changed even if improvement ideas can be generated. Generally, the OEE (Overall Equipment Efficiency) of automatic lines is not good at the beginning, mainly because of reliability issues for each complex operation: the line needs time to stabilise and reach the objective cost. U-shape manual lines are far better suited to constant improvement actions on each operation, given that the machines are simpler and that manual operations are easier to improve: motion kaizen before equipment kaizen. When an improvement has been made, manpower cost can be reduced by adjusting the number of operators on the line. For instance, the line can be designed to work at n or n-1 operators according to the takt time.

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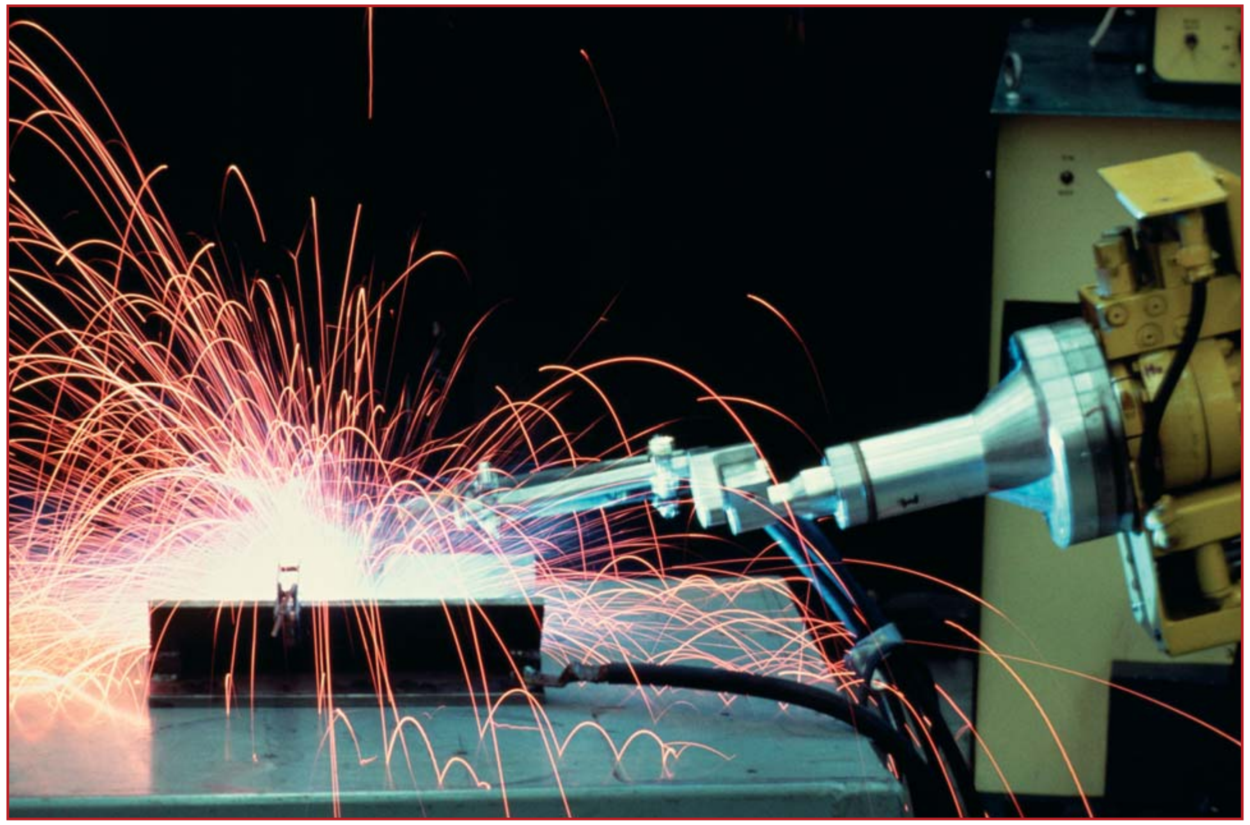

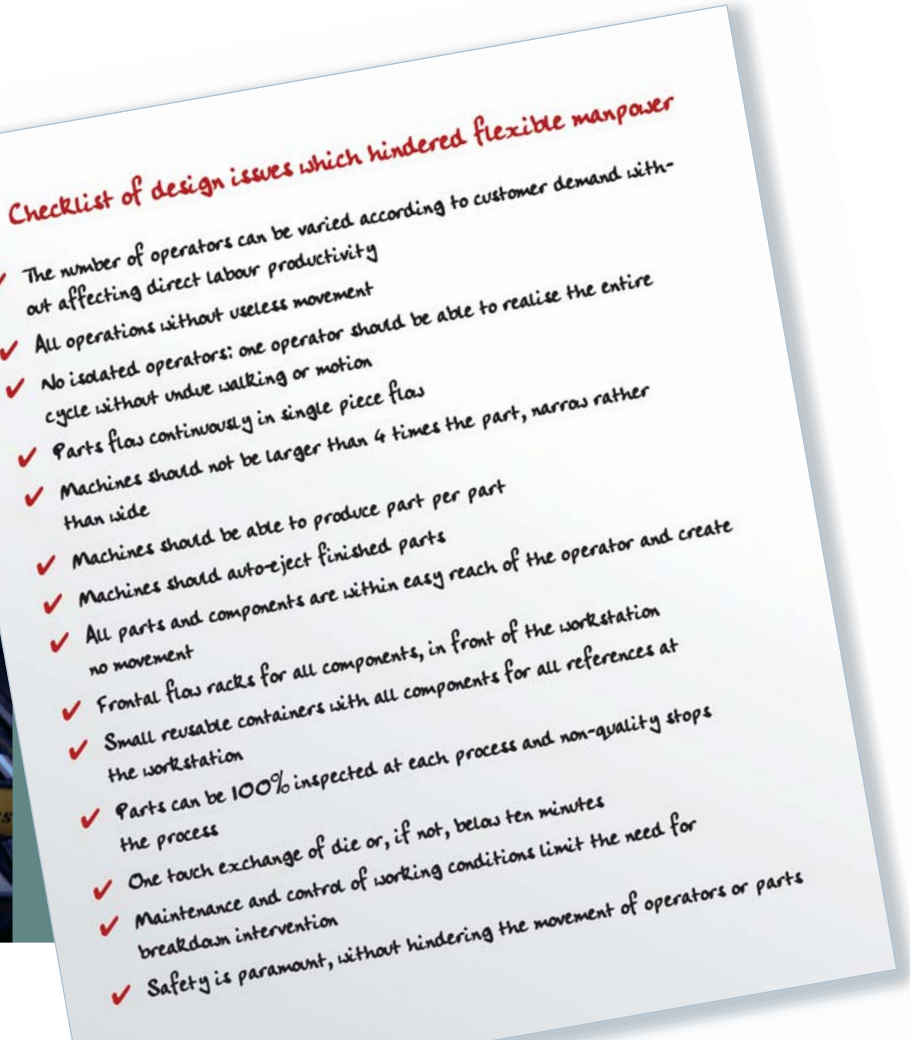

Checklist of design issues which hindered flexible manpower

- ✓ The number of operators can be varied according to customer demand without affecting direct labour productivity
- ✓ All operations without useless movement
- ✓ No isolated operators: one operator should be able to realise the entire cycle without undue walking or motion
- ✓ Parts flow continuously in single piece flow
- ✓ Machines should not be larger than 4 times the part, narrow rather than wide
- ✓ Machines should be able to produce part per part
- ✓ Machines should auto-eject finished parts
- ✓ All parts and components are within easy reach of the operator and create no movement
- ✓ Frontal flow racks for all components, in front of the workstation
- ✓ Small reusable containers with all components for all references at the workstation
- ✓ Parts can be 100% inspected at each process and non-quality stops the process
- ✓ One touch exchange of die or, if not, below ten minutes
- ✓ Maintenance and control of working conditions limit the need for breakdown intervention
- ✓ Safety is paramount, without hindering the movement of operators or parts

Fig 1: Checklist of design issues drawn up by the engineer

Such lean designs are a radical departure from the way lines are traditionally conceived. How can manufacturing engineers be persuaded to challenge their own thinking about equipment design and go lean? The same way that we convinced production managers: take them for a walk at the Gemba. In one plant's case, a manufacturing engineer managed to increase dramatically the parts per person per hour of a cell after six or seven redesigns. By getting the line working to takt time when volume went down from 1440 parts a day to about 700, he improved productivity by 40%. He certainly got the lean bug, and is now trying to convince his colleagues to do the same. How did he come to see the light? Through the seven wastes, of course.

In this case, the lean experts working in the production side of this company spent some time with this engineer on the cell, detailing the wastes, and helped him to draw a checklist of design issues that hindered flexible manpower on the cell.

As engineers learn to work closely with the plants to design flexible manpower lines, these checklists extend. They can draw from a wealth of practical tricks to ensure that all of these points are achieved with the lightest systems possible, using "your head, not your money", as Taiichi Ohno would have put it. Fundamentally, behind the development of such light, flexible systems, lies a completely different concept of the engineering of assembly: a focus on the value-adding part of the operation, and a creative avoidance of conveyance or any other non-value adding manipulation of parts. This also requires moving away from the unfortunate traditional design of parts manufacture as a robot, with a workstation created around it and operators appended for the few operations the robot cannot handle, to a vision of assembly where the operators perform the most flexible tasks as a production team, helping each other, and machines are confined to their narrow machining role, a more human-based approach to production. In too many plants, production is still organised around isolated robot cells with operators loading, waiting, and then unloading parts. Once the plant has been set up that way, it is very hard to change – what needs to be transformed is the very thinking behind this vision. In practice, this means developing engineers by asking them to spend time on the shop floor, talking to operators and resolving problems with existing lines. As they work at reducing the ergonomic burden of workstations and increase flexibility, they'll progressively move to leaner cell original designs.

Professor Kazuo Koike of Tokai Gakuen University reminds us that Toyota's impressive ability to deal with changing market demand requires rigorous preparation. As an example, if a production line needs to reduce production volume by 20%, it will use 20% fewer workers and increase the takt time by 20% by giving each worker additional tasks so it takes longer to complete a cycle. This involves managing five factors: selection of equipment; determining equipment position, distance and safety; reorganisation of jobs; teaching standardised tasks; and experience of each worker with preceding and following jobs on the line.

> **"In too many plants production is still organised around isolated robot cells with operators waiting"**

A flexible manpower line is designed to maintain the same productivity (in parts per hour per person) whatever the volume produced. The practice of flexible manpower lines developed at Toyota as a means to grow on limited resources: as an old line's volume fell, the most experienced operators were pulled from the line to help and start new product lines, in a cycle of constant renewal and learning, thus avoiding the wastes of more production starts. This practice is also a main driver for relentless kaizen. At the present time, for industrial operations, flexible manpower lines are a key to survival in turbulent times when volumes can free fall unexpectedly as world events exacerbate business cycles. Faced with the upcoming cost crush, flexible manpower lines are a way to continue to service customers while remaining cost competitive on variable volumes. Furthermore, the efforts needed to create such lines, from the conception of frontal loading for operators to single-piece flow of parts are, in themselves, conducive to rigorous analysis of operations and eliminating waste. As lean is progressing in the factory it is more essential than ever to bring engineering on board, both to reduce the material costs of parts, and to design equipment better adapted to today's increasingly demanding competitive environments. ■

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