APPLICATION OF LEAN TECHNIQUES IN A DISCRETE MANUFACTURING ENVIRONMENT

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ABSTRACT

This article describes how Lean manufacturing techniques were applied to a mature product, in a mature industry; it follows a previous article *"Application of Finite Capacity Techniques in an ERP Environment"* by the same author, published in *'Control'*, July/August 2002.

PRODUCT BACKGROUND

Capacitors have been manufactured for around 100 years, and very little has changed to the design. Basically the capacitor is a series of 'elements' encased in a steel box and impregnated with special oil as in Figure 1. The elements are wound from reels of polythene film and aluminium foil between 5 and 16 micron thick. The manufacturing process is shown in Figure 2.

Each capacitor can have between 10 to 60 elements. Each capacitor element is wound from one foil roll and up to 4 film rolls. The wound length of element, and the film and foil thickness will be different for each capacitor and customised for each customer order. The batch sizes will vary from 1 to 600. A truly, customised environment. The winding speed is constant at 40 elements per hour. However, as the number of elements for each customer order is different and the soldering time changes with the size and complexity of the capacitor, capacity planning and SFC (Shop Floor Control) are complex.

The site has approx 100 employees working on the HV capacitors, many of whom are long serving with a wealth of experience and knowledge. The site was organised functionally by department with little cross-skilling or labour flexibility.

Figure 1

Capacitor Cross Section

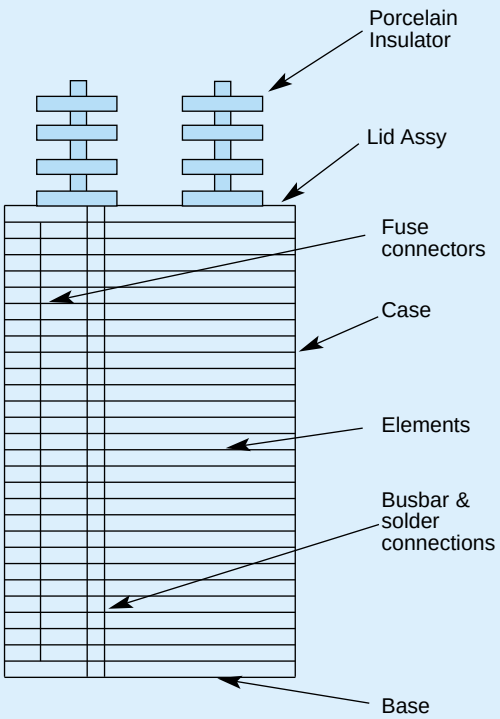
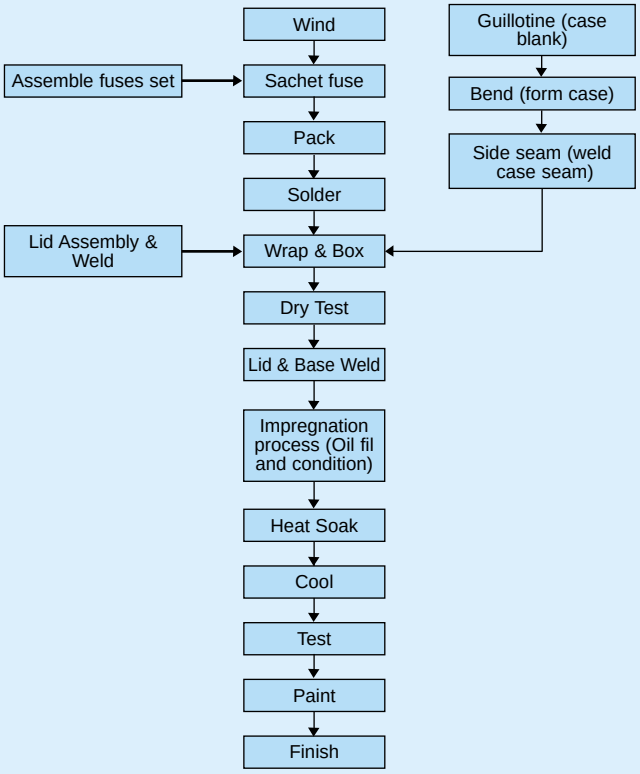


Figure 2

Capacitor Manufacturing Process



VALUE STREAM ANALYSIS AND DIAGNOSIS

Value stream mapping is a simple technique, now described in readily available lean texts, which helps make an objective assessment or baseline of the environment to be studied. The value stream map for this product line is shown in Figure 3. Most obvious is the 'push' production system with production being motivated by individual work centre efficiency, which regularly was greater than 80%, based on clocked and planned hours. Lead-time exceeded 20 days with high levels of variability; work in progress was greater than 1000 units at any one time. Little evidence of work based continuous improvement. The FIFO sequence of production orders was not maintained with production personnel selecting their jobs based on optimisation of their work centres rather than actual customer requirements. The rolled throughput yields through the whole chain was less than 70% and there was a general acceptance of failures and a 'repair' culture.

Additionally, to complete the analysis, the following background is useful. Material and labour shortages were commonplace with at least 2 line stoppers per week. Market demands had increasingly eroded margins since the de-regulation on the electricity supply in the 1980's. Production labour shortages were regularly causing employment of costly temporary labour and overtime. On-time delivery was between 0 and 15% and business was being lost due to poor service, and a blame culture prevailed.

Figure 3

Current State

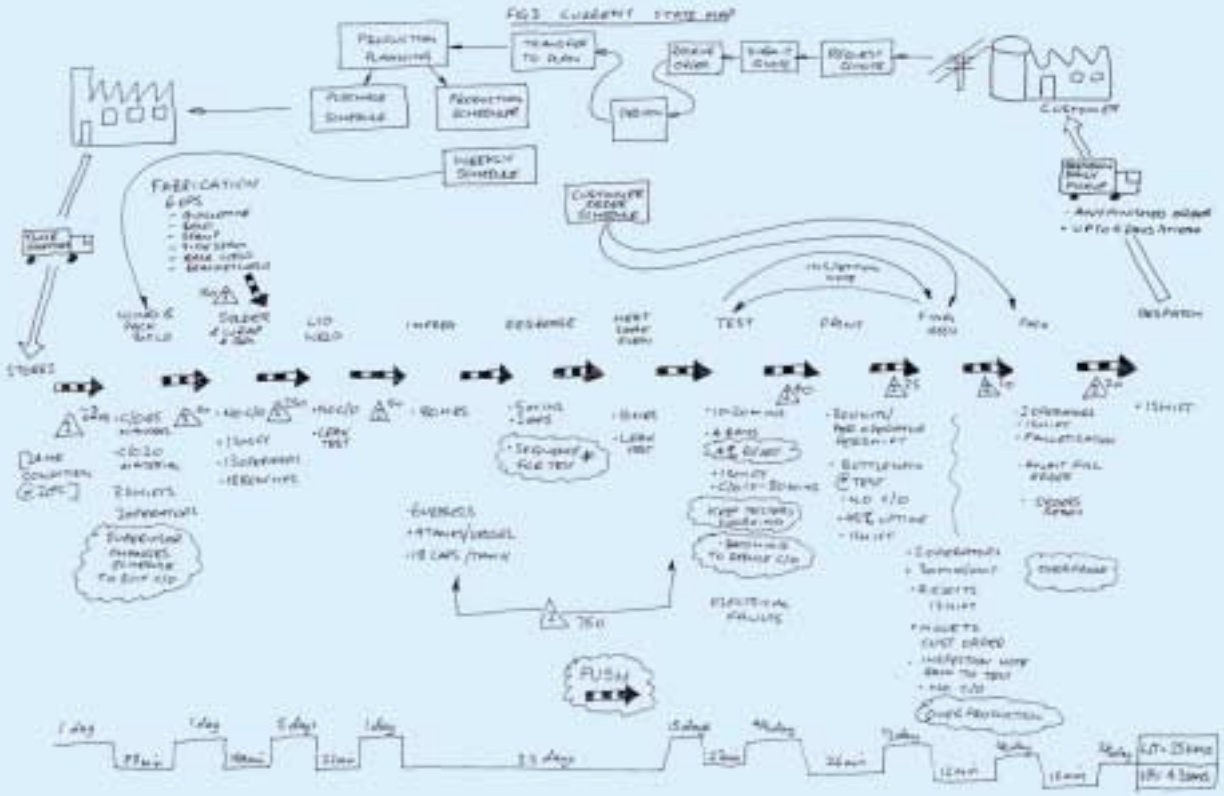
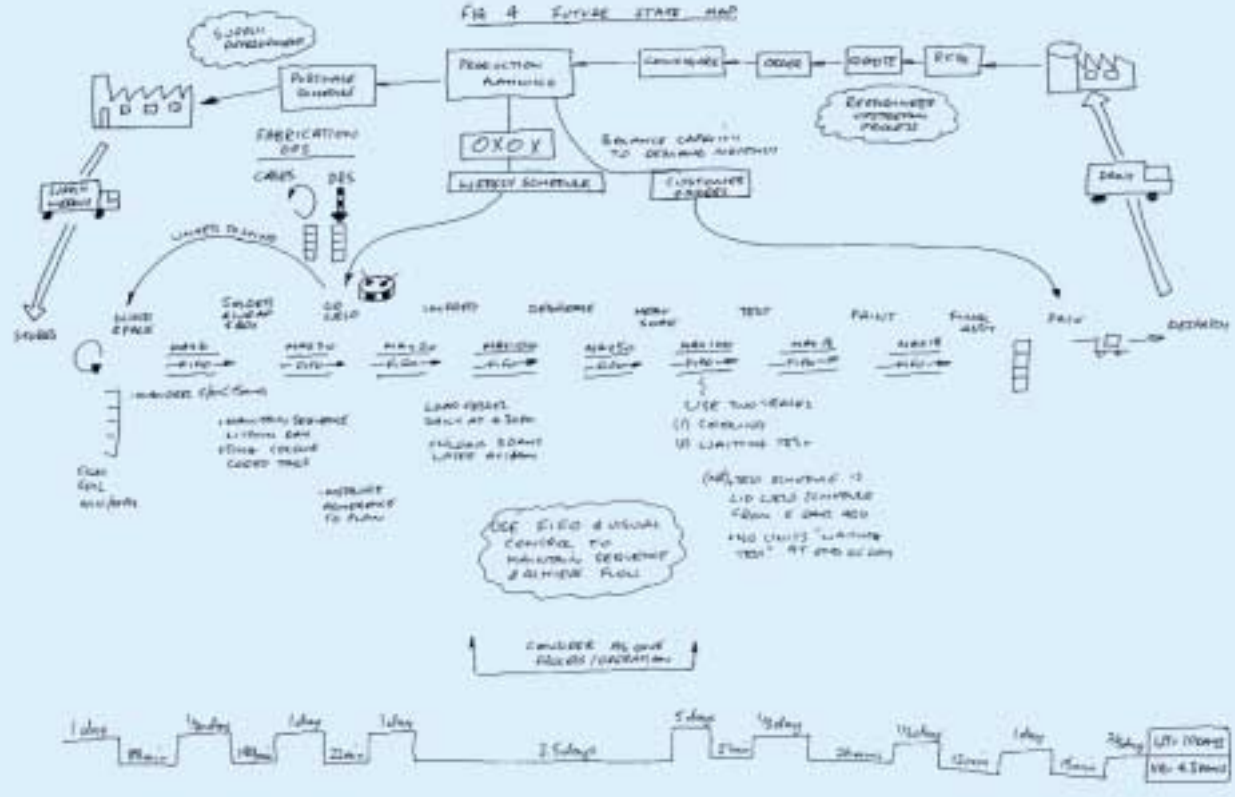


Figure 4

Future State



A FOUR-PHASE CHANGE MANAGEMENT PLAN

Phase 1: Previous to the value stream analysis exercise and following a management shake up, a team building and people skills programme had been rolled out to change organisational behaviours and devolve some responsibilities to the shop floor.

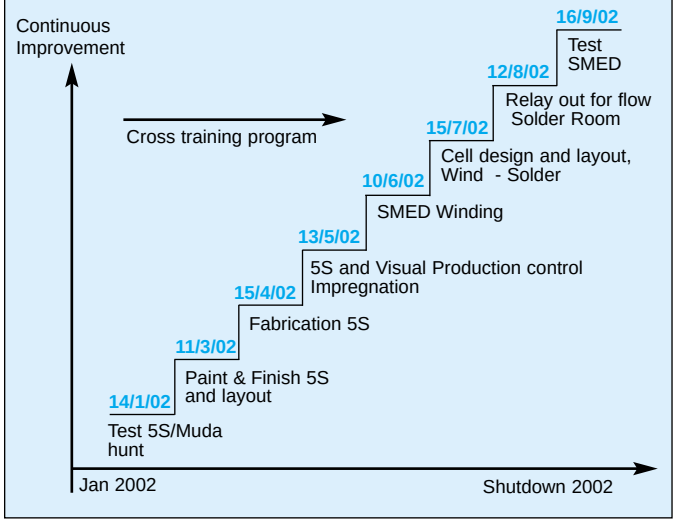
Phase 2: Following diagnosis and value stream analysis, a methodology was developed to move away from a 'push' production control system to a simple 'drum buffer rope' system between winding and lid weld. The idea here was to set the pace of the whole plant based on customer demand (or drum beat) and apply that pace at lid weld. Lid weld was chosen as the fictitious bottleneck because several operations synchronise at this operation. The 'rope' is the schedule at winding which is the true plant bottleneck. Further a materials control system was developed to prevent stock outs and maintain production continuity. This has been described in an earlier article *"Application of Finite Capacity Techniques in an ERP Environment"*

Additionally, maintaining the FIFO sequence of the schedule through the whole plant a system of colour coding was developed in the workshops (Phase 3) described later.

Phase 3: Following value stream analysis, a future state map was developed, Figure 4, and subsequently a programme of interactive workshops was planned to facilitate the transition from 'push' to 'flow' with the corresponding increase of the overall process efficiency rather than work centre efficiency and the effect being to reduce lead-time to 10 days (theoretically 4.3 days possible), reduce cost (4% per unit) and improve delivery reliability (OTIF to >80%). See Figure 5.

Figure 5

Workshop Programme. Series of Week Long Interactive Workshops, which make Step Changes to the Process



The continuous improvements techniques of 5S, SMED, OEE, 7 Wastes and root cause analysis were appropriately planned into a series of Kaizen workshops for each area.

Phase 4: Process Re-engineering of the information flow from 'request for quote' to 'raising production order'. This will be described in a future article.

GAINING COMMITMENT

The next step on the programme was to sell the concept and the ideas to management, for without their commitment to the project; there would be little point proceeding. This was achieved by giving a short presentation to the senior management team outlining the issues, a short description of the lean techniques to be used to tackle the issues and a cost benefit analysis. The cost benefit analysis assumed a full order book, which was forecasted by the sales team. Further by opening up the bottleneck machines, by reducing set up time and working breaks, it was calculated that the factory could handle another 14% output without adding costs, excepting the additional variable material costs. This equated to a cost saving of 4% per unit on average. In return a small budget was requested for Kaizen workshop consumables such as tool boards, paint, some services and machine moves.

Once management were engaged, the next step was to outline the programme to the shop floor team leaders, including the local Union Rep. This was done by holding a $1^1/_2$ day seminar, which explained in a two-way dialogue the concept of JIT manufacturing and the steps involved in achieving JIT in the workplace namely workplace organisation (5S), flow, line balancing, bottleneck concepts and set-up reduction. This event concluded with the team leaders drawing up a relay out plan for the capacitor line, and an agreement that they would support the programme.

Following that step, a short presentation was given to the whole workforce and staff explaining that the programme of change was being implemented, the benefits to them and the company and the likely impact of the changes on working practice.

WORKSHOP EVENTS

A workshop is a pre-planned change event, involving a team of people directly involved in the day-to-day operation of the area, the team leader and a facilitator. The event usually lasting between 1 and 5 days dependant upon the scale of the changes planned. The objectives will be very carefully thought out in advance and will be specific, measurable and timed, for example - identify and created specific locations for all tools and parts' or 'reduce floor area by 25%'. Careful consideration of the objectives will ensure the workshop maintains it's focus during execution and is not distracted by other issues. All the preparation to achieve these objectives is then worked out from anticipating what the team may want to do to achieve these objectives. For example availability of work services support, purchase of suitable storage bins and shelving. Once this has been agreed a briefing will be held explaining to the participants the need for change, the objectives, the tools and techniques, our expectations of them and some idea of the likely outcomes. This is important for two reasons, firstly it helps remove some of the anxiety from the change, and secondly gives people the chance to have their say or address any concerns about the process before it happens. Both actions contribute to the probability of ensuing sustainability of the workshop. In any case the changes are executed during the workshop event.

EXECUTING THE PLAN

The first workshop to be delivered was workplace organisation (5S) in test. There were three reasons for this. Firstly it is a high profile area frequently visited by customers, secondly the 4 operators are well educated and likely to be willing disciples of the change process, and thirdly the improvements and positive benefits made during the workshop would be visibly obvious to the whole workforce as test is a natural focal point of the workforce.

Thereafter each workshop was executed in the same way to the agreed plan, Figure 5. The basic steps to run a workshop are

- ✓ Detailed assessment of the area
- ✓ Preparation plan including
  - Likely materials to be needed
  - Book meeting rooms

- Plan how to minimise impact on production continuity
- Advise team of event
- Brief team
- Other appropriate preparations
- Request Senior Managers & Team Leaders attend wrap up session.

✓ Run workshop (Generally 5 days)

- 15% Learning slides, eg 5S, SMED etc as appropriate
- 80% Making the changes
- 5% Preparation, delivering wrap up presentation, questions
- Action plan to deal with unexpected improvement actions or action that are outside of remit of workshop.

RESULTS

Metric	Before	After	Change
Lead-time	>20 days	13 days	-35%
WIP	>1000	250	
Changeover time (on bottleneck)	32min	13min	59%
Adherence to daily plan	No plan	>75%	75%
Production control	None	Visual	
Core skills	86	109	37%
Area released	0	126m^2	126m^2
No employees involved in continuous improvement	<10	>50	400%
Process efficiency	16.0%	30.7%	91.8%
On Time Delivery	<15%	>80%	
Unplanned cost savings as % revenue	0	0.15%	+0.15%
Bottleneck output (theoretical)			+14%
Cost of implementation	N/a	£6,000	£6,000, 1 off

The planned cost per unit reduction of 4% was unfortunately not realised because the previously planned sales forecast was not enough to drive the additional output from the bottleneck machines.

DISCUSSION

Several learning points were made during this campaign. Firstly be very clear about the validity of sales forecasts, the old adage applies, 'the only thing you can be sure of about a forecast is that it will change'. As seen in the section above, if increasing output is the basis of reducing cost then be sure that this is going to happen. Fortunately in this case study, the benefits of the programme had other key competitive benefits and so the programme was successful. Secondly, it is very important to pitch the pace and level of understanding to the level of development of the workforce. It is better to go a little on the slow side, not to seek perfection, than to try and achieve too much in one event. What you will loose in progress you will gain many times over in sustainability and buy in. Thirdly, let people make mistakes, allow them to experiment, but also give them the time to get it right next time. Fourthly give people an idea of what to expect, they won't be able to see the end point in their minds eye, the more you can help them see this during the briefing the easier it will be for them to see it during the workshop.

This programme of change is now in its eighteenth month from conception. Although the planned workshop events have been completed, the journey of continuous improvement has just started. It has become clear to everyone, the greatest challenge they face is solving the problem of 4% failures at test and the re-work loop caused by leaking welds.

CONCLUSION

The implementation of simple low cost improvement techniques has been able to significantly improve performance. Additionally the use of interactive workshops where participants are encouraged to take action and 'learn by doing' has demonstrated sustainability and developed an interest in the workforce to maintain the momentum of continuous improvement activities.

GLOSSARY

5S, Kaizen technique for achieving and maintaining an organised workplace

OEE, Overall Equipment Effectiveness, Kaizen technique of measuring the actual good output versus the total time available

SMED, Single Minute Exchange of Die, Kaizen technique for reducing changeover time

Line balancing, matching labour to the rate of customer demand, often involving multi-machine working

7 Wastes, categorisation of non-value added activities

Drum buffer rope, scheduling methodology which attempts to optimise the whole manufacturing system by balancing the flow through a manufacturing system rather than the traditional approach of optimising each individual workstation to balance their various capacities. The outcome is resources only produce what is needed when it is needed, rather than creating unnecessary work in progress.

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