Good morning everybody.

My name is Mike Corbett and I am the Applications Manager here at XYZ Machine Tools and my talk this morning is about how machine tools fit into the world of lean manufacturing.

Since the introduction of the Lean manufacturing ideals brought about by Toyota in the 1950’s, the manufacturing world has been trying to make themselves leaner and meaner by developing and modifying the concepts than lean defines and applying them to each individual manufacturing plants needs and requirements.

This sometimes proves to be quite a challenge and here at XYZ our machine assembly has incorporated many of the concepts that lean manufacturing advocates but not everything that Toyota have in their TPS (Toyota Production System) has been taken on board.
One thing that we at XYZ found when introducing the lean concept was that a lot of the fundamentals regarding lean revolved around assembly of a product rather than the machining of individual parts. Because of this, machine tools themselves stood a little isolated within a company that embraced the lean manufacturing concept.

Of course a company can still employ the things that lean stand for in the machine shop as a whole and ensure that they reduce waste, use flow and value stream mapping to show the production path of a part is it is produced and employ Kaizen to make sure that the production of parts is as efficient as possible and ensure they only add value that a customer really wants and to make sure that the parts are right first time.

But if we drill down into an individual machine tool installation, does a machine tool and its CNC control have the facilities to help with lean?

Up until recently we at XYZ don’t believe they did and so have brought to the market 2 products that help companies get nearer to the lean machine. These 2 products are the LPM (lean production machine) and the 2-OP.

Both of these machines have been designed and built from the floor upwards to incorporate features which will help to bring lean to the machine tool itself.
3 years ago we launched the LPM machine. Although from the outside it looked like a standard VMC (vertical machining centre) with 787mm X axis travel, 469mm in Y and 533 mm in Z with a 8000 RPM, 15 HP spindle and a 16 station toolchanger, it has a number of major advantages over a traditional VMC for customers trying to reach lean nirvana.
The first was a different design to the machine table. As well as having Tee slots machined into the table for clamping of vices and fixtures, the table has located into it a Jergens ball lock system. This allows fixture and vice plates to be clamped to the table with a repeatable locking system. By using 3 ball bearings being pushed against a housing in the table the locator creates 2200 Lbs of pressure and tests show that the plates can relocate to within 2 microns.

This ensures that on remounting a fixture or location plate the operator does not have to ensure the parts are set up correctly reducing set up time and speeding up the changeover when changing from the manufacture of one component to another.

This capability used in conjunction with controls ability to save the datum position of the part relative to the ball lock position selected in the program means that when a program is reloaded to the control from the storage system the datum position on the part or fixture plate is already set and there is no need for the setter / operator to have to reset X,Y and Z datums which
happens to be one of the most time consuming things to do when starting production of a part.

These 2 features the ball lock locations and recalling of a datum location fitted as standard to the LPM ensure this machine eliminates at least 4 items of the 7 forms of waste that lean highlights have been addressed. The items addressed are:-

Overproduction
This is carried out by many machine shops for the very reason that it takes time to set up a machine to produce a part. Because this set up time is unbalanced against the production time especially when a small batch size is required many machine shops think “well now it is set up I might as well make more parts than I need lets say 100 instead of 50 and we will keep the extras for later.” But of course lean states you should only make the required number of parts when you need them and so by reducing your set up time using the ball lock system the you can make the number you require when you require them not over produce.

Inventory.
Inventory of course is another form of waste. Holding the extra number of parts produced costs in terms of warehouse / stores facilities along with the fact that you have already bought the raw martial at your cost, used up tools to manufacture the parts and taken the biggest risk of all which is that the design may change so the 50 extra you made may now be obsolete.

Extra processing
The extra work involved packing the over produced number of parts or applying special protective coatings may also be required especially in the aerospace arena.

Reducing Defects
By using a proven datum setting system such as the Jergen’s ball locks the parts produced should be right first time rather than an incorrect position being set by an operator / setter and a defective part being made.

But these 2 features of ball locks and pre set datums in the program are not the only things that make the LPM stand out as a machine designed for lean manufacture.

One of the important parts of lean is the function of Poka yoke, the ability to mistake proof the operations being undertaken on the machine.

![Image of check list](image)

The LPM does this with its unique check list page., When the operator / programmer has written the program this is only half the story as far as part manufacture is concerned and so the control has a screen which ensures that the machine is set up correctly before the program will run.

With its traffic light system for all the items that must be carried out before the cycle start can be pressed and so the operator / setter has complete confidence that he has not missed anything and the job is ready to go.
In the traffic light system red indicates that the function is not completed and must be done.

Amber informs the operator that values are set in the control but it is worth checking them.

Green is the indicator for the operator that the feature has been done and the next step of setting the machine can be carried out.

As each procedure is arrived at the control even guides the user to the relevant screen so selection of the wrong screen is eliminated and speeds up the procedure of getting the part machined.

The final part of the LPM’s lean set up is to reduce the waiting between finishing one part and the setting up of the next part. Waiting is classed as another form of waste. Whilst the machine is cutting a part, the operator could be stood around and becoming what we call at XYZ Mr. Google man. Mobile phone in hand surfing the net, texting their friends and family or just googling the world.

In the PMX control there is a feature called stage programming, the ability to create a program for the next part that needs to be manufactured. But it is not only background editing is also lets the user access the check list to enter tool lengths, set datum’s, and allocate tools to the carousel positions that are needed. The operator’s time is the most expensive thing in a machine shop as we will see later and so the making Mr Google man as efficient as possible is an important part of any business.

The waiting can be further reduced by using a software feature where the control can merge up to 3 programs and allow parts to be programmed as individual items but when an assembly to link 2 or even 3 programs together the control creates what is called a Master program. This allows greater flexibility by mixing different elements or parts into one program.

To allow these features to be digested lets see it all work together.

So laden with Lean features as you saw in the video, I forgot to mention the ability to store notes with a program and pictures of the set ups etc so again the Poke Yoke has been used to reduce errors when calling jobs back from weeks or even months before by reminding users of how the job was clamped, a reminder of the tools used with even a list of the inserts required, the feeds
and speeds the cutters need to run at in fact any relevant data that the operator needs.

Image of Metalworking award

So ground breaking was the LPM when it was brought to the market the Metalworking Production magazine judging panel awarded the LPM the Best entry level machine winner at their awards ceremony in 2012, an award we were proud to receive.
Image of 2-OP

Having developed a machine with so many lean manufacturing principles fitted to the control and the machine being accepted by users, attention turn to development of a product that would solve another problem faced by many machine shops, utilisation of operators and looking further at the reduction of waste in terms of part production.

The product that does this is the newly introduced 2_OP.

Taking some of the lean features introduced on the LPM, such as the ball lock part / fixture locating system the major feature of this machine is its portability.

The machine is supplied with its own pallet truck to help it achieve its aim of making production shops more productive by increasing operator utilisation.

The problem faced by many machine shops producing small batch sizes is that is that it is not worth investing the time and money in creating a machining cell due to the fact that the ideal shop layout would not suit every type of job.

The knock on effect of this problem is that very often operators spend some of their time watching the machine or as we mentioned earlier becoming Mr. Google man. This is because the cycle time for the part they are producing may only be 5 minutes. Not long enough to leave the machine before loading the next part but just long enough to type in the next big thing into a search engine.

So the 2-OP has been developed to reduce this waste by being portable and having the ability to take the machine to the area in the workshop where it is most needed.
For example a typical shopfloor could be laid out as shown on the screen. The company with this layout have 100 parts to produce and they are delivered to the shop on a stillage for the 1st operation to be carried out. Due to the fact that the machine required for the 2nd operation is located down the other end of the factory all the parts have the 1st operation completed and parts placed into another stillage. Let us say that the cycle time for the 1st operation on one part is 8 minutes.

Now we have another form of waste to combat due to the shopfloor layout, Transportation. The stillage needs to be taken down to the other section for the parts to have the 2nd operation performed. This means the operator having to take the part from the stillage and place it into the machine, carry out the 2nd operation and then remove the part and place it in the stillage again. If the 2nd operation takes 5 minutes this gives a total machining time of 13 minutes per part a total of 21.66 hours and a labour cost of £1079.00 if the cost of running the shop is £50.00 / hour.
Now the company introduces a XYZ 2-OP. The machine can be placed right next to the turning machine and part are now taken out of the stillage and the 1st operation carried out and the operator takes it from the 2-OP and places the component into the 2nd operation or primary machine and starts the machine running. They can now turn their attention back to placing a part into the 2-OP and hence there are now 2 machines running in parallel. This means
that the total cycle time for one part is now only that of the primary or longest running machine.

In this case that would be 8 minutes and so the total time for the batch would be 13.33 hours. This is a reduction of nearly 40 % in the takt time for the part and a cost reduction on labour expenditure of £400.00

Workshop layout with 2-OP
100 Parts to be produced
1st operation Milling
Cycle time for milling 5 Minutes
Transfer part straight from mill to lathe without placing on the floor
2nd operation Turning whilst new part is being milled in 2-OP
Cycle time for turning 8 minutes
The cycle time for one part complete from cell = 8 minutes
Total series machining time = 800 minutes
= 13.33 Hours

Cost comparison

<table>
<thead>
<tr>
<th>Serial Production</th>
<th>parallel Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.33 hours for production</td>
<td>13.33 hours for production</td>
</tr>
<tr>
<td>Shop rate = £ 50.00 / hour</td>
<td>Shop rate = £ 50.00 / hour</td>
</tr>
<tr>
<td>Cost for production = £ 1066.50</td>
<td>Cost for production = £ 666.50</td>
</tr>
</tbody>
</table>

Cost reduction due to serial production of 100 parts = £ 400.00
But to the lean Sesei (the lean master / teacher) the 2-OP offers a more than just cost savings on the production of parts, like the LPM helps companies achieve their lean objectives.

As mentioned earlier its biggest waste reducer is the reduction in transportation of parts. By placing the 2-OP next to the primary machine or machines, the movement of parts around the factory is greatly reduced. The less you move a product around the factory the less likelihood of damage to the part.

The operators will have less waiting to do, another form of waste. Many years ago the machines were more expensive than the operators but today this is not the case. A Vertical machining centre that we sell will be typically 40 – 50 thousand pounds and given a life span of approx. 10 years works out at a yearly costing of £5000 / year. An operator can cost in the region of £ 30,000 per year when all the costings are taken into account. Operators are an expensive item to be kept waiting and the 2-OP will help to make sure your operators are kept busy and be more productive.

The motion of moving parts from one stillage to another in this sample case 4 times is another form of waste that is addressed by using a 2–OP. Letting an operator lift and move the parts more than is necessary just adds cost to the part production and so by moving the part directly from one machine to another without putting it down improves the workflow through the factory.

Within the world of lean manufacturing many workshops find it difficult to create value stream maps that are efficient because the machines are located in the factory from the moment they are installed and so the path of production is very often dictated to by the machine shop layout which may well have evolved over a number of years.

Today with the introduction of the 2-OP machine with its 8 station tool changer, 6000 RPM spindle and the portability of the machine, companies can
now look at seriously at reducing some of the waste that occurs during their production. Transportation, waiting, inventory, motion and overproduction are many of the things addresses by a XYZ 2-OP. They may be also able to adjust Takt time quicker and easier and be able to react to customer demand by having a machine that can be moved next to the primary machines easily.

Lets see it working in a real life case study.

So hopefully you can see here at XYZ we are not only trying to offer value for money machines that are state of the art for both small production runs but also larger batch sizes but we are also looking for ways to make better use of the machine tools in which you have installed in by being innovative, thinking about being lean but also offering these solutions with a cost effective price so you can also be mean.

If you have any questions about the products I have shown here please feel free to shout up or they are both on display in our showroom area where lunch will be served so please talk to any of the XYZ representatives if you would like to know anything else or any other machines in our range.