Product Group Report: Machine tools

A report on the remanufacture of manual and CNC tooling machinery in the UK.

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1 Overview

Machine tools are an essential element of modern production facilities. They are employed in a wide range of industries, adding value directly or indirectly to products. Investment in machine tools requires confidence in the capital goods market, thus the global machine tool market is highly dependant on global economic and political trends. The downturn in global trade after 2001 saw the machine tool market decline sharply and, despite the massive growth of manufacturing seen in China and India, the sector is only just beginning to recover. The continued migration of production operations to lower wage economies, coupled with the greater productivity of single machines, has reduced the home market for machine tools in the UK. Since 2000, the UK stock of machine tools has steadily decreased by 6% per annum (Benchmark Report, 2006).

Over half the turnover from UK machine tool producers is due to export, although the UK also imports a similar value of equipment. The UK is believed to be the 12th largest producer of machine tools in the world, with the 15th largest market (Gardner Publications Inc). It has historically been a strong exporter of high quality machine tools. Although budget Asian alternatives have made inroads into the cheaper end of the market, European, Japanese, and American products are still seen as superior in terms of quality. Developing markets in China and India have been slow to take advantage of the more expensive European machines, although the UK is now beginning to see more exports to Asia. There is also a strong export demand for used machinery that is no longer required in the UK.

In terms of production, there are few large UK owned machine tool manufacturers remaining, with a number of foreign companies such as Yamazaki Mazak and Hardinge (Bridgeport) operating manufacturing facilities in the UK. Whilst most large OEMs offer a comprehensive support and parts service, very few offer full refurbishment or remanufacture. Smaller OEMs on the other hand are far more likely to offer some form of remanufacture or reengineering. These firms usually produce a limited range of products, aimed at a particular manufacturing operation, and will work on machines from other manufacturers as well as their own.

With the many OEMs ignoring the demand for second hand and reconditioned machines, a number of third party operators have emerged, offering repair and remanufacture. Some of these firms specialise in particular components such as CNC monitors or spindles, whilst others remanufacture entire machines. Some of these organisations form alliances with well known OEMs such as Jones and Shipman, who manufacture grinding machines. With OEM parts commanding a high price, this is an attractive option for users of machine tools; large and small alike. There is also a thriving market for retrofitting of CNC systems to aging machines to boost their productivity to a level comparable to modern units. There has been a shift in the aerospace industry over the last 3 – 4 years towards opting to purchase re-engineered and remanufactured equipment rather than new, and this has boosted the UK remanufacturing industry significantly in some areas.
Due to the extensive skill and knowledge base that the UK possesses in the machine tool sector, older British machines are regularly shipped back to the UK from developing economies for remanufacture. These machines will then be returned to their owner in “as new” condition, but at far less cost than a new unit. Some firms also offer an on-site remanufacturing service. This practice is particular popular for large lathes, mills and vertical borers. Smaller machines are normally replaced with cheaper imports from Asia and the Middle East.

2 The product

The overwhelming majority of machine tools are used to work metal, although they can of course be used on other materials. The Manufacturing Technologies Association, which represents the machine tool sector in the UK, defines a machine tool as: “a power driven machine, not portable by hand when in operation, which works material by cutting, forming, physiochemical (or non-contact) machining, or a combination of these techniques”. Modern machine tools often incorporate a complex computer control system, known as CNC (computer numerical control).

Vibrations are a source of error when machining and so must be avoided at all costs. To counter this, machine tools often have substantial cast iron structures to absorb vibration and provide stiffness to prevent the machine flexing under load. Modern machines may also have real-time feedback control systems that alter the tool path to take into account machine movement, vibration or tool wear. For extremely accurate operations, a temperature controlled environment may also be required. Operator safety is of course a paramount consideration, and all machines must be fitted with appropriate guards and safety cut-off devices. These must be retro-fitted to older machines to comply with current regulations, and owners who fail to do so may face prosecution.

By the nature of their working environment, machine tools must be extremely rugged and reliable, as downtime is expensive. Many machines run 24hrs a day for years on end, needing very little manual intervention.

3 Evolution rate

The products created using machine tools are becoming ever more complex and demanding, and so today’s machine tools are becoming more accurate and reliable than ever before. New materials and computer modelling techniques are helping to optimise machine structure, whilst increased computer processing
power and networked communication is allowing for improved monitoring and feedback systems on CNC units. The introduction of high speed machining techniques allows for lower tool forces to be applied to the work piece, thus reducing machine and work piece distortion. There is also a move to reduce or eliminate the need for coolant, historically both bad for the environment and a non-value adding expense (up to 15% of total cost).

In the drive for improved productivity, so called lights-out (unmanned) machining operations are becoming more popular, with machines being able to perform a multitude of tasks without human intervention. This has seen the introduction of 6 and 7 axis machines that rely on advanced feedback control rather than a traditional heavy-weight chassis for stability.

For many applications however, this new technology is simply not required. The ability to retro-fit CNC technology to twenty or thirty year old machines means that for all but the most high tech, demanding operations, quality used machinery can still compete, particularly in lower wage economies where there is not such an emphasis on removing manual labour from the production process.

In terms of energy efficiency, the deciding factor for machine tools is the electric motors that are used to provide the motive force. As more efficient motor technology emerges, older tools can be adapted to accept these newer designs. A new generation of permanent magnet rotor devices are beginning to be developed which offer improved efficiency and reduced size. Although these have not been incorporated into current machines, it is likely that machines in the future will all employ this technology. Linear motors are becoming widely used in higher end applications because of the improved accuracy and repeatability they offer. The rate and method by which coolant is applied will also affect the efficiency of an operation to a lesser extent, and again, this system can be upgraded on older machines as technology moves forward.

4 Value

Machine tools represent a significant capital investment for companies. Some modern CNC machine centres can cost hundreds of thousands of pounds to purchase and install. Older tools therefore retain a residual value as a second hand or remanufactured item; they are attractive to companies who wish to reduce their required capital outlay. Large firms may also wish to buy used equipment for lower volume or backup production. Further more, lead-time on a remanufactured machine may be substantially less than a new one; some manufacturers have a delay of 12 months or more for production of some bespoke models.

The heavy iron castings used in machine tool chassis and beds retains a significant value, even if all other components of the machine are replaced. They also represent a substantial amount of embodied energy. Some industry sources believe that 20 year old cutting beds are superior to modern items as the designs were more substantial and the quality of cast iron better. These castings are
extremely robust and repair is simple; they can easily facilitate several cycles of reuse. Modern castings are generally lighter to reduce cost, and rely more on lower tool forces and intelligent control feedback to maintain accuracy.

Due to the rapid advancement of CNC technology, it is unlikely that a remanufactured machine tool would retain its original control unit. Although many tools do not require the very latest in CNC, it is likely that the controller would be replaced with a more up to date system. The CRT display unit could be retained if still working, although a remanufactured unit may be fitted to reduce the risk of warranty claims. There are companies who specialise in the remanufacture and repair of machine tool display units, so even damaged units may hold some residual value. OEM replacements are expensive, and may not be available for older models.

To ensure remanufactured machines can produce the required accuracy, any wearing components such as bearings, channels and spindles should be either replaced or remanufactured. Channels and spindles may be re-coated with materials such as Turcite® before grinding to their original tolerances, and so retain some of their value. Bearings will usually be replaced with new.

Motors and cooling pumps represent the most significant energy consumers on machine tools and as such should be replaced with newer, more efficient items. As with all other components discarded during the remanufacturing process, these will retain a value as scrap and should be recycled in a responsible manner.

5 Potential

The UK has a strong remanufacturing industry base, with extensive skill and knowledge of the sector. However, owing mainly to the migration of industry to lower wage economies and the introduction of cheaper alternative products into the UK market, demand for machine remanufacture is falling. Niche sectors such as aerospace and steel are remaining healthy, with specialised re-engineering firms taking advantage of the current market stability. General engineering and automotive are on the decline however, which is having a negative impact on the internal UK machine tool industry as a whole. This is not to say that the market is beyond hope. Far from it; despite the highly publicised failures of car companies such as MG Rover, the automotive sector still accounts for around 40% of machine tool sales in the UK (MTA, 2006). Heavy industry is still a large consumer of new and remanufactured machines.

Machines of value below £25,000 are no longer economical to remanufacture when compared to cheap alternatives from the Far East. Re-engineering of larger, high value machines is more popular than ever, but many are destined for overseas customers; there is a net flow of large machines out of the UK. The industry will find it increasingly difficult to acquire cores, with many firms are already experiencing a rising price for used machines, and sourcing cores from abroad as non are available in the UK. Well reputed, specialised firms can
continue to operate in this environment as their expertise in the field justifies the extra cost of UK labour and transporting cores from overseas. Smaller firms however, who existed mainly to serve the UK market will find it increasingly difficult to compete. Offering remanufacture is no longer adequate to compete in the global market. Firms must display a capability to re-engineer machines, i.e. give them capability above that for which they were originally designed. Remanufacture can be carried out anywhere in the world, whereas the skill and knowledge required to design and fabricate a new machine or add CNC, based around an existing core, takes time to develop. This is what UK firms must aim to capitalise on in order to compete with firms operating closer to the eastern marketplace, with lower costs. Manufacturing is a global force, and firms who choose to target only one marketplace will find themselves at a distinct disadvantage.

As machine tools become more complex, and firms demand more performance from their tools at low cost, there will be an increasing market for re-engineered machine tools of excellent quality. The global demand for machine tools is expanding, and looks set to for the foreseeable future. If the UK wishes to capture this market, it must nurture firms that are able to offer complete engineering solutions, not just remanufacture. Many machines currently being remanufactured in the UK are benefitting from the addition of CNC control. When these machines reach the end of their second lifetime in 10 or 20 years, the UK needs to be prepared to enhance them with the next generation of technology, and be at the forefront of that technology.

6 Policy options

- **Fiscal measures** – Include remanufactured machine tools in the governments ECA scheme to encourage firms to use remanufactured machines rather then purchase new lower value imports.

- **Product design** – Stimulate academic and industrial research into machining so that the UK will retain its current position as an innovative force in the machining sector.

- **Market Development** – Help smaller British machine tool firms expand their market place to Europe and Asia by providing them with advice and information on doing business with foreign companies, and the benefits that it can bring to their operation.
7 Model

Many firms interviewed stated that the number of orders they received varied quite dramatically from year to year, particularly for larger machines. The vast majority of firms are also relatively small, and thus there was no one firm or group of firms that could be seen as dominating the industry as in other sectors such as aerospace. The industry size has therefore been estimated from data collected from interviews and data from the MTA. Approximately 450 machines are remanufactured every year in the UK, with some of these being destined for overseas customers. This equates to an industry turnover of £45 million, although it should be noted that individual contracts can have multi million pound costs, thus this turnover could be affected significantly by relatively few orders. Further complicating the issue is the enormous range of machine tools that are remanufactured. It is impossible to specify an “average” machine tool, with machines weighing from under a tonne to over 100 tonnes. For this model, a mass of 4 tonnes has been selected, which would represent a mid sized machining centre.

**Assumptions:**

- A total industry turnover of £45 million
- A total output of 450 machines per annum
- The cost of a remanufactured machine is £100,000
- A machine mass of 4,000kg
- The CO\textsubscript{2E} produced during the manufacture of a machine is 3.3kg CO\textsubscript{2E} / kg machine.
- The CO\textsubscript{2E} that could be saved by recycling a typical machine is 2.1kg CO\textsubscript{2E} / kg of machine.
### Table 1: Scenario assumptions

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Overall output and assumptions</th>
<th>Possible policy interventions</th>
<th>Units Saved From Waste Stream</th>
<th>Tonnes diverted From Waste Stream (kt)</th>
<th>CO$_2$E Saved (kt)</th>
<th>£mil Spent On Reman Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref</td>
<td>The proportional level of remanufacture remains constant at 2006 levels, with a decrease of 6% in line with UK machine stocks.</td>
<td>None</td>
<td>4713</td>
<td>19</td>
<td>23</td>
<td>471</td>
</tr>
<tr>
<td>A1</td>
<td>The proportional level of remanufacture increases at a rate of 0.2% pa in line with predicted UK machine tool production growth.</td>
<td>Encourage remanufactures to be proactive in seeking Foreign trade</td>
<td>7420</td>
<td>30</td>
<td>36</td>
<td>742</td>
</tr>
<tr>
<td>A2</td>
<td>The proportional level of remanufacture increases at a rate of 2% pa which represents the predicted growth of the European machine tool industry.</td>
<td>Same as A1 together with greater emphasis on R&amp;D</td>
<td>8388</td>
<td>34</td>
<td>40</td>
<td>839</td>
</tr>
</tbody>
</table>

### Figure 1: Scenario outcomes

![Remanufacture of Machine Tools](image-url)
**Scenario Ref**

In this scenario, the UK has failed to capitalise on its knowledge and skill base. Remanufacture is only used to supply UK based customers. As the UK steadily reduces its stock of machine tools, so too does the work for remanufactures. By 2020, only 190 machine tools are remanufactured each year, a fall of 260 machines on 2006 figures. This represents 757 tonnes of material being diverted from the waste stream and a CO$_{2E}$ saving of 854 tonnes each year, under half the current figures.

**Scenario A1**

Here, the UK has managed to capture sufficient foreign trade for remanufacture to grow steadily, despite a falling internal demand. The level of remanufacture has grown steadily at the same rate as the production of new equipment. By 2020, 476 machines will be remanufactured each year, equating to 1903 tonnes of material being diverted from the waste stream and a CO$_{2E}$ saving of 2284 tonnes. This is an improvement of 1430 tonnes CO$_{2E}$ over scenario Ref.

**Scenario A2**

In this scenario, the UK has succeeded in stimulating the growth of its machine tool industry as a whole, and as a consequence has managed to equal the growth seen in the rest of Europe. By 2020, 606 machines are being remanufactured each year, which saves 2375 tonnes of material from landfill and 2850 tonnes of CO$_{2E}$ from being produced. This is an improvement of almost 2000 tonnes CO$_{2E}$ over scenario Ref.