Introduction of CAD/CAM Technology into MKW Engineering

Adam Davidson, Philip Hackney

MKW Engineering Ltd, Stargate Business Park, Tyne & Wear, NE40 3EX, England, Tel 0191 413 000
Fax 0191 413 2736, Adavidson@mkw.co.uk
School of Computing, Engineering and Information Sciences, Northumbria University. NE1 8ST,
Tel: 0191 227 4589, Fax: 0191 227 3854, Email: Phil.Hackney@unn.ac.uk

Abstract

The manufacture of complex components is engrained in the United Kingdoms history, as technology progresses new methods of manufacture evolve leaving the previous methods obsolete. Industry demands that components are stronger, lighter and manufacture to higher tolerances and specifications using more exotic materials. Traditionally complex components would be manufactured using techniques such as fabrication, and machining. However, due to the capabilities of modern CNC machines the traditional methods are being removed and replaced by a CNC machining that can manufacture the component from a solid billet of material. The next step is to reduce costs, lead times and increase the scope of work and productivity. This can be achieved through the implementation of an integrated CAD/CAM system. This paper introduces the MKW group and focuses on MKW Engineering ltd as manufacturer of bespoke components to a range of engineering sectors. Explaining the benefits of introducing new technologies into a competitive market place.

Keywords: Integrated CAD CAM, Off line CNC Programming, Multi Axis Milling

1. INTRODUCTION

The MKW Group has responded to the challenges facing industry in the early 21st century to become an innovative leader in the provision of engineering solutions.

Within the MKW group, there are no problems in engineering: only challenges and solutions. That's because of the MKW Group's across-the-board engineering capability - from design, to manufacture, testing and installation, as well maintenance and project management.

The MKW Group is made up of four associated companies, all based at Stargate Business Park, Ryton, Gateshead. Together they employ some 150 people, boasting a combined turnover of close to £6 million (9 million Euros).

- MKW Engineering Ltd was established in 1976 and, over the years, has built an extensive blue chip client base across the sub-sea, defence and other sectors. It has invested heavily in cutting edge technology to ensure it can deliver high quality bespoke solutions to specific customer challenges.

- Total Maintenance and Engineering Ltd (TME) was set in 1995 to provide an engineering maintenance and installation service to complement MKW Engineering.

- Stargate Precision Engineering Ltd (SPE) specialises in the production of precision-machined components for the aerospace, sub-sea and pharmaceutical industries. The company was also established in 1995.

- Gazelle Wind Turbines is the newest company in the MKW Engineering family and was established in 1998 in response to an opportunity to produce small to medium-sized wind turbines for the UK and other markets.

MKW Engineering Ltd has responded to far-reaching changes to the UK engineering sector to become an innovative leader in the provision of engineering challenges and manage the entire process from design, to manufacture, assembly and installation, all from one site.

Typically, MKW Engineering's design team creates bespoke solutions in response to client inquiries. These can range from design work on specialist machinery, to process equipment, product redesign, production, and project management.

MKW Engineering frequently produces for clients in significant quantities. These include sophisticated components for the Defence, Aerospace, Medical and Sub-sea sectors.

MKW Engineering, with a £5 million (7.5 million Euros) turnover, has invested heavily in state-of-the-art machinery centre of its kind in the UK. Other on-site capabilities include assembly, fabrication, inspection and welding of carbon steels, aluminium and stainless steel, sheet metal working and painting.

The company's 100-strong workforce prides itself on its core skills, which are, fabricating, machining and assembly of complex components working to short lead times, or alternatively finding manufacturing solutions to complex engineering challenges.

Among the on-site specialist facilities are a Clean Assembly area for fitting, for example, electrical wiring components, and testing products such as medical and defence equipment. The fully equipped paint shop boasts an extensive range of key industrial capabilities.

MKW Engineering Ltd is committed to quality and ensuring the company's people maintains its reputation for innovation and adaptability in the face of difficult challenges. This company gained Investors in People accreditation in 2001 and has held British Standards Quality Systems approval since 1988. This registration covers all the key functions managed and carried out the Stargate site: *[1]*

- Design
- CNC machining
- Fabrication
- Welding
- Sheet metalwork
- The building of special-purpose machinery
- Painting

2.0 MACHINING TECHNIQUES PRIOR TO THE INTRODUCTION OF AN INTEGRATED CAD/CAM SYSTEM

Prior to the introduction of an integrated CAD/CAM system, MKW manufactured all components directly from engineering drawings (On-Line Programming). The operator would read the drawing and manual program the component by NC code, machine cycles and co-ordinates. The method of programming would be dependent on the control system installed on the machine. e.g. Heidenhain, Maztrol, of Fanuc.

2.1 DRAWBACKS OF ON-LINE MANUAL PROGRAMMING:

Manufacturing using this method alone limits the complexity of the component to be manufactured. Examples of the limits of manual programming would be curves with no particular radius, complex shapes or angles, machining on tilted plans or 3D machining.

Errors are more likely to occur as the operator is operating in a noisy atmosphere where concentration can be affected.

Increased machine cycle times due to each section of manufacture programmed then machined one step at a time, this can lead to a lack of planning in the most appropriate method of manufacture.

Enhanced possibility of human error occurring within the program cycles this is commonly due to the operator working on a job single-handed. Other reasons being that the operator may misread or miss interpret the component, where the computer could not make this error, and would even detect a small difference that would be missed by the operator.

A CNC machine has limited storage space for raw data, therefore operators would often find that a proven program might be deleted to free up space on the machine. This leads to operator frustration, as the program would need to be re-programmed and proven once again. The knock on effect of this is increased time and increased costs.

Another major flaw in the system is the engineering drawing that the operator is required to manufacture to, these can often be unclear and sometimes ineligible. This increases the difficulties for the operator as he tries to visualise the component prior to manufacture. The drawing will be inconsistent from client to client enhancing the operator's difficulties, whereas 3D data can only be interpreted in one way, and any queries can be quickly confirmed using analysis tools built into the software.

Data storage is another major problem caused by on-line programming, this is often un-controlled and methods vary from operator to operator. This causes programs to be lost or incorrectly over written. This problem is eliminated using offline programming as programs are generated sequentially.

Where the manual programming excels is in traditional shapes and contours with drilling details on PCD's. Using basic shapes to define the component the operator can program step by step to progress until the component is completed.

2.2 MACHINING POST CAD/CAM IMPLEMENTATION

Current technology within the computing industry has given desktop PC's large processing power and enabled CAD/CAM software to develop very rapidly. This in turn has encouraged the demand for the manufacture of complex components from solid billets that previously would have been fabricated. The software used within MKW is an integrated CAD/CAM software package called Topsolid produced by Missler. Topsolid is in the top-ten sellers of CAD/CAM software in the World (Refference)xxx.

Using this software has enabled MKW Engineering to compete in new sectors and has a broad spectrum of components that can be manufactured, all of the following are machined from solid. As shown in Figures 1 to 4

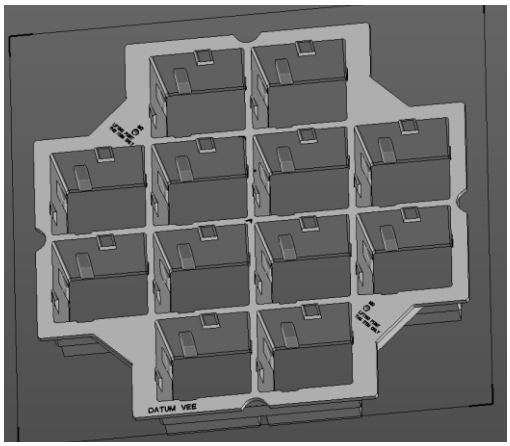

Figure 1: Chemical storage 940mm Square (SS)

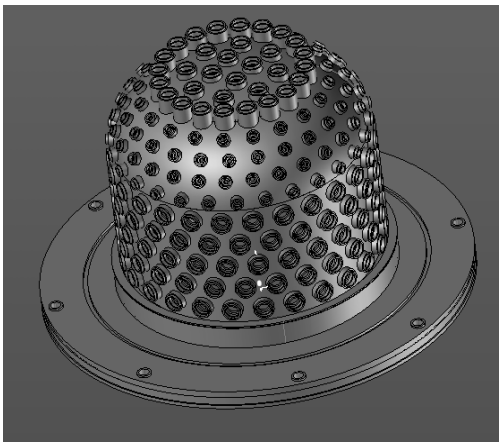

Figure 2: Manufacturing process 1000mm Ø (AL)

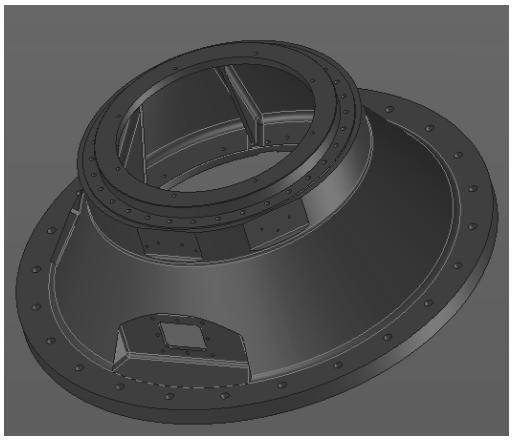

Figure 3: Communications equip 800mm Ø (AL)

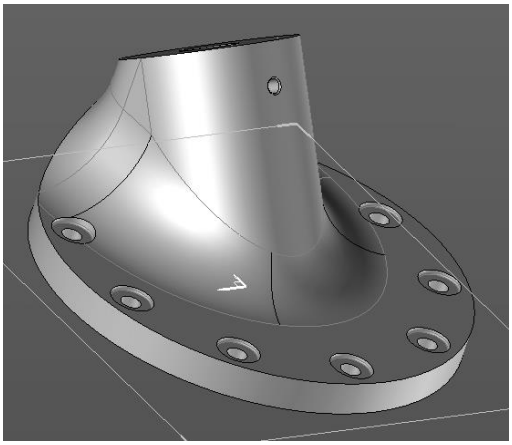

Figure 4: Aerospace equip 200mm Ø (AL)

CAM software uses 3D models provided by clients in there in house design office, these models are produced on CAD software such as PRO-Engineer, Catia, SolidWorks or Topsolid. CAM systems were created to solve the shortcomings of manual programming. Most CAM systems work such as Edge CAM, Power Mill and Delcam operate in a similar fashion. First, the geometry, or shape of the part is defined from the 3D data. Second, the raw material is placed around the model. Third the machine selection and positioning on the work surface, Forth the tool or cutter path is generated selecting the most appropriate method for manufacture. Then collision detection and simulations takes place. Lastly, the program is converted into the format the machine understands (usually called post processing).

Offline programming, means the program was developed somewhere other than at the machine control. This generally means sitting at a desktop PC. This is a better method as the engineer is away from any noisy machines that may cause an error to occur, and allows production of the components on fully enclosed machines. CAM cycles can be used to program both simple and complex components quicker and more efficiently with a higher level of accuracy.

2.3 ADVANTAGES IN PROGRAMMING OFFLINE

A 3D model is more flexible than an engineering drawing as the finished component can be visualised in 3D and rotated to see any orientation, the programmer should then be able to spot any difficulties in the manufacturing process. Before any material has been removed.

Each phase of manufacture can be accurately analysed to ensure the correct amount of material has been removed within Topsolid there are 3 methods of verification. Tool path, machining, and simulation.

In verification the programmer can watch the material being removed from the billet, and analyse what material is still on the billet using colour codes. If the colour is green the product is finished, dark blue is + 0.4, dark red is –0.4, the value can be altered by adjusting the settings. This analysis would also highlight, gouges, tool clashes and tool holder clashes, as shown in Figure 5

The tool path displays the entire tool paths including, cutting paths, retracts and rapids, theses again uses colours to define the type of movement. From this information the programmer can ensure minimising cutting time by altering the tool paths, as shown in Figure 6

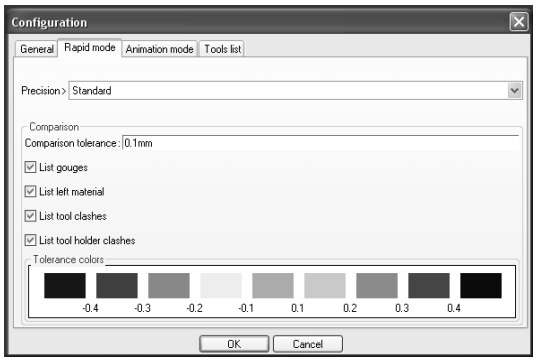

Figure 5: Display of colour codes +/- values

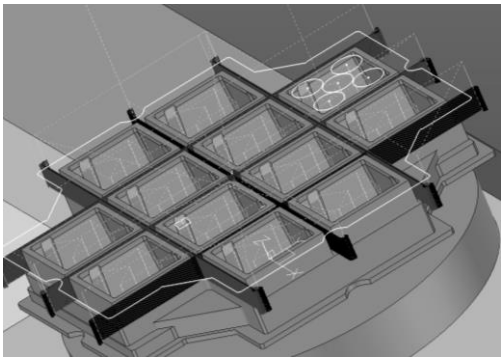

Figure 6: Screen shot displaying toolpaths

The third method actually shows the movements of the machine in accordance with the billet of material. This method allows the programmer to visualise the actual motion of the machine prior to machining along side material removal. As shown Figure 7 and 8.

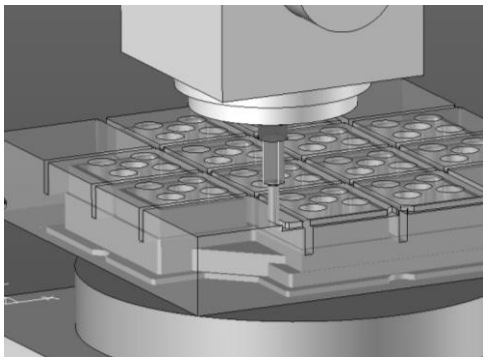

Figure 7: Displaying material removal

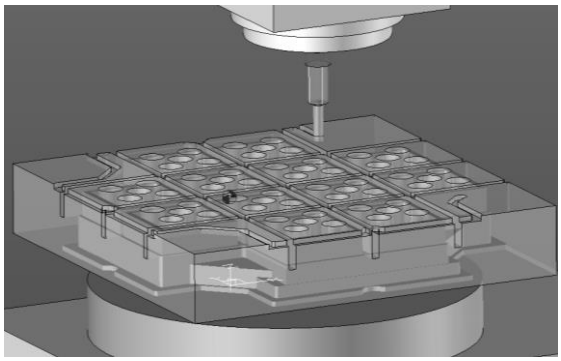

Figure 8: Displaying further material removal

This method of programming allows the user to visualize the part on-screen during each phase of the programming process. Being able to verify each toolpath at the computer instead of at the machine reduces errors and saves valuable machine time. The computer calculates the mathematics involved in the part program and the post processor generates the ISO program, both of which produce more accurate and error-free part programs. Other advantages of CAM systems are that a single CAM system can usually program a variety of part types (parts for mills, lathes, CMM's, etc.). Also, because a CAM system does not reside within a machine control, parts can be post processed for a number of different machine/control combinations. Therefore, a single CAM system can support many different machines.

With CMM capabilities built into the software the customer has the confidence that the component will be fully machined and inspected to the same model, minimising the chance of error, in manufacture.

When introducing new technology into a successful business, there will always be some resistance, however, the workforce within MKW Engineering has embraced the new technology and understand that as a team need to stay ahead of the competition at the fore front of engineering in an ever increasing market. Therefore the introduction of an integrated CAM/CAM system only secures a more diverse range of blue chip clients for the future.

Another major benefit of using CAM within MKW is the ability to estimate machine time for a component prior to any machining. This has now changed the method of estimating for machining components. The estimator will now liaise with the programmer at a very early stage, this process is called programming for estimates. This enables the estimator to have a very good indication on how long a component will take manufacture excluding, tool changes, set-up's etc. In turn, increases the accuracy of estimate. During the process complex sections of a component can be picked up on and discussed finding the most appropriate method of tackling the problem.

3.0 DISCUSSION

The major disadvantage of offline programming is the initial set-up cost in the case of MKW this was in the region of £50,000. This is a substantial outlay including software, computers, staff training and telephone support. Further yearly costs include continuous training that is a daily cost of £250 per head per day. Maintenance renewal costs, which would include: software updates, and telephone support this cost is in the region of £4000 per year.

The financial cost of incorporating CAM capabilities into a manufacturing company with modern CNC machinery is insignificant in comparison to the possible benefits. A good example is a pedestal that MKW manufactured before and after the implementation of offline programming. See figure 9.

Case Study: Prior to the introduction of CAM the base plate (As shown in Figure 9)was manufactured in just over 50 hrs not including multiple set-ups, the cost centre for this particular machine is £90 per hour so the total manufacturing time equates to £4500. With the introduction of CAM software the total manufacture time was reduced to 24 hrs not including set-up. Therefore the cost reduction per base plate equates to £2340, the base plate is a long running product for MKW Engineering, often running batch quantities of 10-20 at a time. So on a batch run of 20 the total savings would be approximately £46,800.

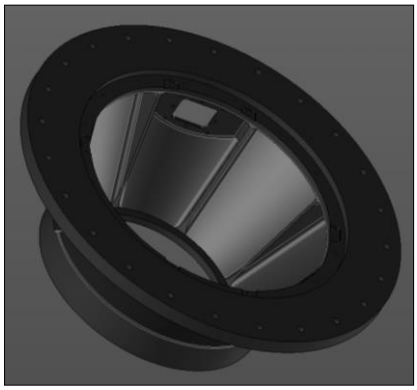

Figure 9: Base plate

The product data flow chart displays how the integrated CAD/CAM system is now the hub of MKW Engineering. The initial starting point of the cycle is the input of raw data from the client using a generic neutral format file such as, STEP or IGES format. The product data is based in the centre of the cycle and is used to generate the quotation, produce the programs to manufacture the component and then inspect the component before being signing off by Q/C as complete. This cycle is shown in Figure 10.

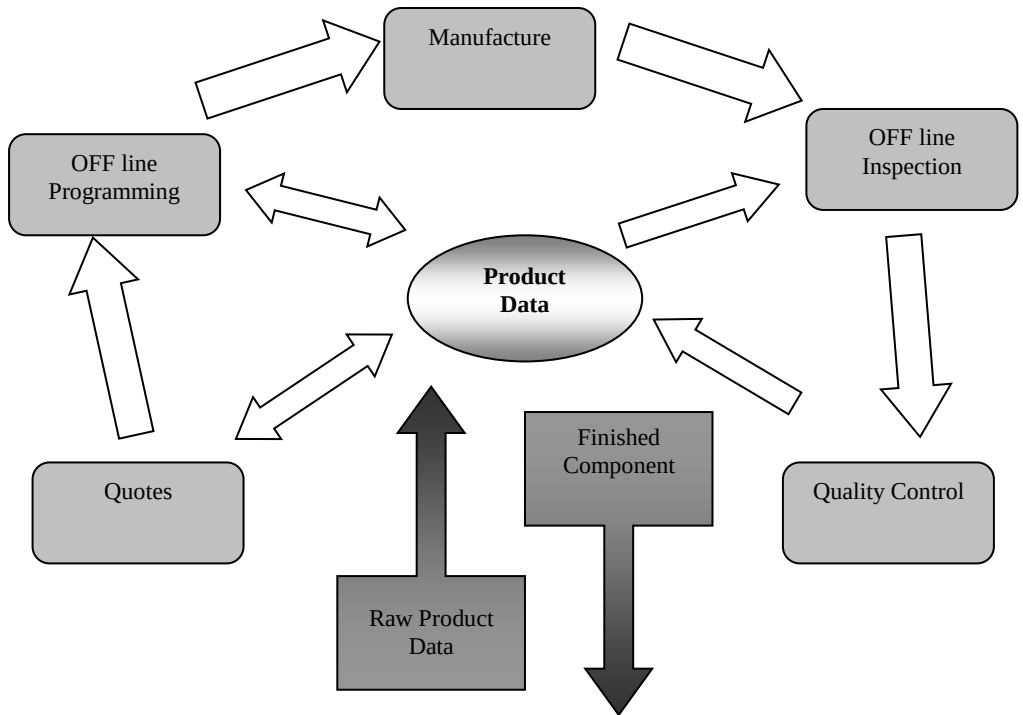

Figure 10: Product Data flow chat

4.0 CONCLUSION

The benefits of MKW Engineering investing in an integrated CAM/CAM package far out weigh any draw backs the system has have opened up new markets, for MKW Engineering to explore and pushes there modern 5 axis CNC machines towards there limits. To Summaries the benefits of the integrated CAD/CAM are:

- Compete in a competitive market, with modern technology.
- Times savings on machined components.
- Cost savings are achieved due to reduced time.
- Widen customer base as more complex components can be manufactured.
- Increase capacity, due to the reduction in time to machine components.
- Push the boundaries of the CNC machines using 5-axis machining.
- Increased productivity.
- Increase knowledge base for operators.
- Improved accuracy and repeatability.
- Reduction of scrap materials, limit human error.
- Off line inspection capabilities.

4.0 ACKNOWLEDGMENTS

The Author would like to thank Michael Keith Wright the founder of the MKW Group, Ian Young the Managing Director of MKW Engineering Ltd & Mike Larkin owner of MCL CAD/CAM Ltd, supplier of Topsolid.

5.0 REFERENCES

[1] History of MKW Group: http://www.mkw.co.uk, accessed xxxx

[2] Topsolid top 10