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CLEANER MANUFACTURING

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CLEANER MANUFACTURING

Course Overview

Cleaner manufacturing is the (re-)specification, implementation and control of production processes to minimise environmental impacts while maintaining other aspects of cost and technical performance. This approach commonly minimises waste and reduces costs with the potential for increased market competitiveness.

This course aims to introduce cleaner manufacturing, also know as Cleaner Production, particularly with SMEs in mind.

It outlines the benefits, the basic practices and gives case studies to illustrate potential results. Concluding with a checklist, the course is a primer enabling further steps to be prioritised

Course Structure

CLEANER MANUFACTURING

Module 1 – Benefits

1.1 Context

Waste and pollution from manufacturing processes are a major concern.

Cleaner manufacturing is manufacturing which addresses pollution and waste at source, not through end-of-pipe mitigation of impacts, but through the redesign of production processes and where necessary product redesign for cleaner manufacture. The aim is to minimise emissions and resource inputs according to priorities for environmental protection.

The drivers to improve the environmental performance of manufacturing processes are increasing:

- European & UK government policy; stricter process-related environmental legislation
- Changing customer & supply chain demands and enhancing market appreciation
- Good business practice – fulfilling part of an environmental policy
- Savings from waste minimisation / resource efficiency

Like production costs, manufacturing operations' ongoing impacts are largely determined by how the processes are specified. Integrating cleaner manufacturing into the (re-)specification of manufacturing performance enables the environmental performance to complement technical and economic goals.

There are examples of proactive companies in many sectors who have successfully undertaken cleaner manufacturing and reduced production costs while maintaining competitiveness and future proofing against legislation.

1.2 Complying with Legislation

Manufacturing which complies with current legislation is a first step. Legislation affecting manufacturing should be identified within a review of all environmental legislation relevant to business operations. Maintaining a register of legislation is part of an environmental management system.

In the UK, the NetRegs service (http://www.netregs.co.uk) helps those without in-house legislation monitoring to identify relevant legal requirements specific to their business operations. Simplified guidance to legislation applicable to many industrial sectors, sub-sectors and processes is available, identifying any variations between England, Scotland and Wales. The associated pointers to good practice may also be helpful, although specialist advice may be considered necessary to address the risk of non-compliance.

1.3 Meeting and Exceeding Customer & Supply Chain Demands and Enhancing Market Appreciation

Larger companies are exerting pressure down the supply chain by:

- Asking suppliers to demonstrate environmental responsibility, for example in materials sourcing and control of manufacturing waste.
- Dealing only with suppliers that have implemented or are working towards implementing an Environmental Management System (EMS) such as ISO 14001.

Trade associations may also be encouraging cleaner manufacturing as part of a drive towards best practice.

Suppliers who can innovate to include environmental performance in their manufacturing proposition ahead of responding to demands are likely to be favoured and have the best chance of sustaining the business in the longer term.

1.4 Good Business Practice – Fulfilling Environmental Policy

A company's environmental policy promotes reductions in environmental impact and the overall environmental impacts of a manufacturing operation are largely determined by how it is specified and controlled.

Integrating cleaner manufacturing thinking into production practices enables enhanced environmental performance to complement functional and economic performance, delivering against company objectives.

Improving occupational health & safety and extending training towards cleaner manufacturing can help motivate employees.

Employees and other stakeholders in the business are able to appreciate and contribute to a responsible approach, made evident through production engineering. Improved company image, staff morale and customer relations are seen in a number of case studies.

1.5 Savings from Waste Minimisation / Resource Efficiency

Typically 90+% of production materials do not end up in saleable products. Some raw materials are becoming scarcer and material price rises reflect this.

Reducing the variety of resource inputs to production saves material, energy, water and hence expense. For manufacturing companies, on-going savings can be significant, frequently with little or no capital investment. Experience in the UK suggests that a wide range of industries can save between 4 and 5% of turnover by employing waste minimisation techniques, mostly from production changes.

Material wastes may be;

- prevented by process changes,
- reused or recycled internally to displace material use, or,
- recycled externally, perhaps earning revenue.

Incorporating energy and water savings in production targets can lead to changes which also save time and better satisfy internal and external customers.

Waste savings will become increasingly valuable as taxes based on the 'polluter-pays' principle such as the Landfill Tax favour reduced waste disposal. The real cost of waste in terms of treatment, energy and labour is often 5-20 times the cost of disposal.

Where is your company in taking the following steps towards eliminating waste?

"Waste is only a disposal issue"

"Waste is a cost and regulatory issue"

"We plan to reduce waste"

"We have identified our waste and are monitoring it"

"Waste is coming down as we change the way we work"

"We are optimising processes & reducing costs"

The following module explains some cleaner manufacturing practices – particularly to enable waste minimisation and resource efficiency.

CLEANER MANUFACTURING

Module 2 – Practices

Consider the opportunities to (re)define activities through the production process covering the following aspects:

- minimising direct or indirect wastes
- reducing water and energy consumption,
- reducing pollution,
- enabling longer life, reuse and recycling.

Alongside an appreciation of the commercial and technical thinking embodied in the production process, those responsible for detailed decision making need a sufficient level of understanding of;

- the key environmental considerations and priorities – representing internal & external customer needs and current & future legislation,
- both existing and potentially available consumables & manufacturing processes and their environmental characteristics,
- environmental impacts during manufacturing, disposal and at other stages of the lifecycle, and,
- the potential to extend the life of production processes and reuse, remanufacture, repair, upgrade or recycle all or part of the process equipment and consumables.

The checklist at the end of this course illustrates the scope of the questions that may need to be answered and indicate areas where further training may help.

Once awareness and skills are available, experience suggests a systematic approach is needed, working alongside existing processes for improvement, to;

- gain high-level support,
- establish responsibilities – those who can react quickly to waste or pollution,
- gather information on current manufacturing practices; sources and amounts of waste and resource use for example, and,
- evaluate the current situation and communicate priorities for change, preferably visually.

A balanced and integrated evaluation of commercial, technical and environmental benefits, feasibility and risks with all interests represented enables;

- agreement on priorities and a specification for each production proposal,
- options to be chosen to take forward to implementation, and,
- progress to be reviewed.

Showing progress and positive feedback on achievements can gain further support and enable responsibilities to be shared more widely within an ongoing process of improvement. All employees are in favour of improving quality and cutting waste.

2.1 Minimising Waste and Using Resources Efficiently

Waste minimisation involves a systematic reduction of waste at source in a way where benefits can be quantified and built in to revised practices.

Waste minimisation is not just concerned with material going into a skip. It involves an examination of wasted raw materials, energy, emissions and effort. It is broadly recognised that 'only an activity that physically changes the shape or character of a product or assembly can add value'. In other words; any activity that does not change the product or assembly can be seen as waste.

According to Envirowise, raw materials, energy and labour costs 5-20 times the direct cost of waste disposal. Skips filled with rejected components may cost £10,000/year to dispose of to landfill, but the real cost of the wasted material could be a further £50,000-£60,000/year when labour, overheads, wasted raw materials, energy, insurance and other factors are taken into consideration.

Waste minimisation is concerned with reducing:

- raw material consumption;
- water and energy use;
- emissions to air, land and water;
- wasted effort.

A key element of any waste minimisation programme is measuring resource use and waste generation, and then analysing data to identify opportunities for improvement. Savings from each change could be as much as 1% of turnover, given raw material costs are often 30-60% turnover. When the full cost of waste is understood, typical waste reduction projects show payback periods of less than 1 year.

The Waste Hierarchy

Considering where value is added in the production process, the waste hierarchy shows the priority for action. The higher in the waste hierarchy action is taken, the greater the cost savings as fewer resources and effort will have been put into the waste. So, in order of priority:

1. **Eliminate** as much waste as possible at source
2. **Reduce** the amount of waste that is generated through the production process
3. **Reuse** as many items as possible during the process
4. **Recycle** what is not suitable for reuse
5. **Dispose** of what is left in a responsible way

Tracking the sources and streams of waste is a valuable process. A flowchart of the material and waste flows is the best place to start, before putting amounts and costs

- Calculate the weight of materials bought and consumed in the production process for a number of units of production*
- Subtract the weight of the material that should be in the finished goods for the same units of production*.

- Can the differences, the 'loss', be accounted for and perhaps costed, if not accurately, then categorised at least high, medium, or low with potential waste saving measures for each loss categorised as easy, medium or difficult?
- How much waste is invisible, even to those controlling the process?
- What process controls are available which would reduce waste?
- How would process operators suggest measuring and reducing waste?

Such 'mass balance' calculations should include stock gains and losses, so
* a period of production between two stocktakes may be best.
In that case:
Material consumption = purchases + opening material – closing material stock
Production = (sales – returns) + (closing finished goods stock – opening stock)

The **mass balance yield** (MBY)…

Weight of production *divided by* Weight of virgin material used

… is a useful benchmark to track and compare with sites making similar products.

A good first measure of **annual material waste cost** is

(100 – MBY) x annual materials cost /100

Other waste-related costs include the cost of wasted capacity, waste handling equipment & containers, disposal and transport charges, legal compliance and reporting, plus the allocation of labour to manage these activities.

Having identified waste streams and their costs, a closer examination of what is in them, where the causes are and how the waste is (or is not) managed, with any legislation that affects them, may help prioritise actions.

Waste measures should ideally be accurate, understandable, traceable and comparable over time. Segregating waste at source will help. Reporting waste as a percentage of production is a useful way of monitoring progress and continuous improvement is preferable to setting targets.

Taking each waste as an effect, what are the causes in terms of processes/products, people and procedures? What could be changed, how and when?

From the above analysis, the potential benefits of minimising waste and using resources efficiently should be clearer. Cost measures are important, but the reduction in environmental impacts should also be apparent.

Using Resources Efficiently

Just as the right tools for the job save time and improve quality, production changes can pay back beyond the simple measures of throughput. Establishing preventative maintenance, calibration and other procedures as accepted practice from the outset can prevent damage and waste from misuse.

Within the UK engineering industry 75% of the 80,000 companies employ metal machining operations - the main resources of concern in the metal machining sector being;

- metals used in the manufacturing process;
- metalworking fluids (MWFs), lubricating oils and hydraulic oils;
- water; and,
- energy.

Although specific materials and processes vary across manufacturing operations, the above aspects may offer guidance.

Metals

To maximise environmental performance, where practical, use should be made of metals that are both abundant in supply and have potential for recycling/reuse with no significant environmental impact.

The table below provides an overview of the environmental and broad cost factors to be considered when selecting metal types for manufacturing. Scores from 1 (best) to 5 (worst) have been allocated to various factors.

Factor	**Steel**	**Stainless Steel**	**Aluminium**	**Cast Iron**	**Titanium**	**Copper Alloys**
Abundance of raw material	2	3	1	2	5	4
Pollution during manufacture	3	4	1	3	3	3
Life of metal	4	2	3	4	1	3
Ease of recycling	2	3	4	3	5	1
Cost of finished product	2-3	4	2	1-2	5	4
Overall score	**13.5**	**16**	**11**	**13.5**	**19**	**15**

An estimated 50% of production costs in metal machining are spent on geometric shaping. Implementing near-net shaping techniques could allow standard mechanical components to be manufactured at substantially lower costs, due to the reduced machining & finishing operations and reduced material use.

Major advances in near-net methods have allowed the limitations (e.g. selective wear-resistant surfaces) of traditional techniques, such as sand casting, to be addressed. Casting, sintering, pressing and forming can therefore be lower waste alternatives to machining, where the design specification allows.

Metalworking Fluids

An estimated 400,000 tonnes of spent water-based metalworking fluids are disposed of in the UK each year.

Most metalworking fluids and other industrial lubricants are formulated from virgin mineral oils, which are obtained from non-sustainable crude oil extracts. Alternative naturally derived feedstocks are available (e.g. rapeseed, palm, sunflower and other vegetable oils), and use of these materials is growing as higher costs and reduced performance in some applications are addressed by suppliers.

Vegetable-based metalworking fluids utilise sustainable raw materials. They are also considered less toxic than mineral oil-based formulations and may offer improved working conditions for operators.

Dry machining offers the potential to reduce or eliminate the use of metalworking fluid for some applications where tool life can be addressed. It is estimated that 16% of machining costs are attributed to the metalworking fluid.

Associated benefits come from removing oil from swarf (making it easier to recycle), reducing coolant delivery and collection systems and improving air quality in machine shops.

The three commonly used categories of dry machining are:

- ‘true’ dry machining - with zero cutting lubricant;
- minimum quantity lubrication (MQL) - small quantities of lubricant are applied as a mist to the cutting process;
- air/gas cutting - the gas phase is applied under pressure to cool and remove the swarf from the cutting process.

The potential uses of the three dry machining methods for different materials and machine shop operations are indicated below.

Parameter	Dry	MQL	Air / Gas
Material			
Low alloy steel	✓	✓	✓
Medium alloy steel	✓	✓	✓
High alloy steel	#	✓	#
Stainless steel	×	✓	×
Cast iron	✓	✓	✓
Nodular iron	✓	✓	✓
Aluminium	×	✓	×
Exotic materials	#	#	#
Operation			
Turning	✓	✓	✓
Milling	✓	✓	✓
Drilling	✓	✓	✓
Tapping	✓	✓	✓
Reaming	×	✓	×
Key: Practical: ✓	By application: #	Poor: ×	

Like water-based metalworking fluids, neat oils should be checked for the condition of the product and, where necessary, be topped-up with additives. This will ensure that the fluid is replenished and stays in good condition. The effort is worthwhile as well-managed neat oils can last up to five years in the machine tool. However, oil maintenance requires skilled input.

2.2 | Reducing Water and Energy

Water

European and UK environmental legislation is demanding increasingly strict water quality standards. As a result, mains water, sewerage and trade effluent charges are all increasing steadily.

Water minimisation is one of the easiest ways in which industry can achieve cost savings. Simple and inexpensive measures can typically reduce water consumption by up to 50%.

To encourage more efficient water use and improvements in water quality, the government has developed the Water Technology List. This gives details of products and technologies that qualify for an Enhanced Capital Allowance (ECA) (100% tax relief on the cost of the products). By investing in products that use water more sustainably, businesses can expect an initial cash boost through the ECA, as well as on-going cost savings on water bills.

Most end-users do not reuse their spent water on-site. One barrier for its reuse is the difficulty in controlling the quality of spent water from a process. However, there are often potential applications (e.g. washing/cleaning processes or reuse into similar production processes with some carryover of 'raw material/finished product') that could be implemented without harm to the process.
However, minimising the amount of water used in the first place will give the most savings in water supply and effluent treatment/disposal costs.

Energy

In most cases, engineering companies can save money and improve their environmental performance by reducing energy consumption. The cost of electricity is expected to increase significantly in the future as government measures to tackle global warming, such as the Climate Change Levy, affect energy costs.

Energy is an essential resource for engineering companies; an estimated two-thirds of the electrical energy used by the metal machining industry is for running motors and drives, e.g. for cutting tools. The cost of this energy is about 100 times more than their initial purchase costs when used typically over a ten-year period. Compressed air is another major use of electricity in manufacturing which offers scope for savings.

In many cases, it is possible to reduce energy consumption by 20-30% without major expenditure, by for example:

- Ensuring motors/machines are running at lowest suitable speed, switched off when not in use and, when replaced, use of variable speed drives (which can save an estimated 30-40% of energy in some situations) or higher efficiency motors (Class EFF1), are considered.

- Inspecting and maintaining machine tools regularly; the frequency depending upon the type of machine, its age, condition, duration of use, and the type of process.

- Finding and fixing leaks in a compressed air system, also lowering the operating pressure. Typically, a reduction of 100kPa (1 bar) will save around 7% of the energy used.

- Turning off lights in unoccupied areas - especially at the end of the day.

- Considering heat recovery on-site wherever possible. For example, if it is possible to recirculate air from a filtration/abatement system back into the workshop.

In all cases consumption of electricity, gas, etc. should be checked regularly and ideally related to production to identify which base loads, e.g. those seen out-of-hours, are significant.

Increasing employee awareness of and involvement in measures to reduce energy consumption in all areas of the company's operations is important to maintain improvements.

2.3 Reducing Pollution

Pollution takes various forms, depending on the process outputs and by-products, which contribute to;

- air emissions,
- contamination of land, or,
- contamination of water.

References addressing environmental management should explain the major sources and means to measure and reduce impacts.

A typical case for engineering manufacture is metalworking fluid effluent.

Metalworking Fluid Effluent

Spent neat metalworking oils are classed as special/hazardous waste and should be labelled & stored as such. For example, a bund should be fitted round the area where collection bins are stored. Oils must be disposed of through a specialist waste treatment company.

Biological systems now offer a realistic and cost-effective option for treating spent water-based metalworking fluids. They provide an attractive alternative to the traditional separation and concentration process.

The specialised microorganisms used in such systems have the ability to degrade almost all components of metalworking fluid effluent, including the synthetic ones. They are also much more resilient than the microorganisms used in sewage treatment works because they are adapted for this polluting and toxic effluent. Waste disposal companies and larger engineering companies are now using biological systems to deal with this problem effluent.

The benefits of a biological treatment system include:

- generally lower capital and operating costs than those of alternative systems;
- the capability to treat the soluble synthetic components of modern metalworking fluids that tend to pass through most concentration systems (e.g. chemical separation and ultrafiltration);
- the fact that the pollutants are destroyed rather than concentrated;
- improved public image (using a ‘green’ option based on natural processes).

2.4 Longer Life, Reuse and Recycling

The ideal time to think about the lifecycle of production resources is when they are specified - to have the best chance to design in longer life, reuse or recycling and avoid obsolescence & costly disposal.

Lifecycle thinking aims to ensure all environmental aspects are considered and ensure changes to existing, or new, production processes reduce overall impacts. By considering all stages of the lifecycle from sourcing & installation, to use and end-of-life, the aim is to reduce overall impacts, which could otherwise be displaced from one stage to another.

Longer Life

Achieving longer life is a key contribution to reducing resource use. Avoiding obsolescence should start at the earliest possible stage, when specifying and purchasing production equipment. Key questions relate not only to the anticipated life, but also to the flexibility to maintain or reconfigure and the compatibility with an enduring range of consumables.

Reuse

Reuse is not just for products or components. Reuse of equipment and containers may be possible, simply by spreading news of what is available as a waste item and what purpose it could serve elsewhere, both internally and externally.

Not all unwanted items can be used elsewhere, but industrial 'waste' exchange schemes could find a grateful recipient and avoid costly disposal. Items need to be kept in good condition to offer the best value.

Recycling

Recycling is the reuse of spent materials, after a cleaning or a conversion process. Increasing waste disposal costs and stricter environmental legislation (e.g. the End of Life Vehicles Directive) have made recycling more advantageous.

Segregated waste materials with acceptable levels of contamination may yield a valuable income, as raw material costs rise and the processing of recyclates expands.

Swarf & Metal Waste

Many companies are both gaining revenue and improving their environmental performance by recovering and recycling swarf & metal waste (particularly that from non-ferrous metals) by selling it to a metal merchant or a foundry.

The main way of increasing the value of swarf & metal waste is to minimise contamination with other metals, metalworking fluids and/or rainwater. To increase the value of your swarf/spent metal:

- segregate different types of spent metal into separate bins and label them with a description of their contents;
- protect the bins from rain or other potential sources of contamination;
- drain or centrifuge the swarf to remove as much metalworking fluid as possible;
- use 'chlorine-free' metalworking fluid (those containing chlorine inhibit the swarf's recycling potential);
- compact materials for ease of transportation.

This should help prepare and negotiate in selling the swarf/spent metal directly to a recycling company.

Oils

Provided the spent neat oil is kept separate from other wastes, you may be able to sell it for reprocessing into 'lower grade' lubricants or for use as burner/support fuels.

CLEANER MANUFACTURING

Module 3 – Case Studies

The following case studies from the Envirowise programme show what steps were taken and what benefits were gained by companies of different sizes from a range of sectors. Generic lessons may be drawn from each.

3.1 Tier I Automotive Supplier

As a Tier I automotive supplier, Mayflower Vehicle Systems plc produces automotive body structures for commercial vehicle and specialist car manufacturers. The Coventry plant designs and/or manufactures vehicle bodies, truck cabs, assemblies and panels for a range of customers. The production area contains hydraulic presses, 'body-inwhite' assembly lines and sub-assembly lines, and automated and manual paint plants. The site employs 770 people and has an annual turnover of around £90 million.

Mayflower Vehicle Systems achieved accreditation of its environmental management system to ISO 14001 in April 1998, encouraging those involved to investigate more opportunities to reduce waste and to further improve environmental performance.

Reduction in Metal Waste

Development work on tooling began in 1995 with the aim of reducing the amount of sheet steel used. Improvements in press tools have enabled components to be cut from smaller blanks. With improved tracking and use of off-cuts and further tool development preparing shaped blanks from new blade & shear tooling, about 6% of the cost of material purchase has been saved, without associated problems in plant downtime or machine maintenance.

Water Recovery

Water recovery has reduced the site's water supply and trade effluent charges by 80%.

The site's effluent was previously treated by adjusting the pH to precipitate out heavy metals and allowing the solids to settle. Water supply, effluent discharge and wet sludge disposal costs totalled over £143,000/year.

Mayflower investigated two alternative technologies with the aim of saving money and recovering water of a quality suitable for pre-treatment rinsing. Ion exchange was rejected due to its high chemical costs, but reverse osmosis proved cost-effective. This produces a clean permeate which is reused on-site and the concentrate is disposed of (to drain) as trade effluent. The existing settlement tanks were retained, but enhanced with a new polyelectrolyte dosing and mixing system. A filter press was installed to dewater the settled solids to give a dry filter cake for landfill disposal.

These initiatives have produced significant environmental benefits, including:

- reduced purchases of sheet steel and the environmental impacts associated with its mining, smelting and production;

- reduced water consumption and effluent volume discharged to sewer.

"Mayflower has a policy of continuous improvement in both the quality of its products and its manufacturing operations. The environmental best practice initiatives have produced substantial benefits in both material savings and environmental terms. It has been found possible to introduce the necessary changes in working practices without increasing operating costs."
[Mr F Barton, Mayflower Vehicle Systems]

3.2 | Medium Sized Packaging Manufacturer

The carton division of Field Packaging in Bradford, employs 358 people and has an annual turnover of £39 million.

In 2001/2002, the carton division participated in a supply chain development project organised by one of its main customers. Involvement in this project prompted Field Packaging to examine ways of saving money and improving its environmental performance by reducing utility costs.

Utility consumption at the Bradford site is typical of a modern manufacturing plant: electricity is the largest cost at around £300,000/year, with gas costing £50,000/year and water £20,000/year.

Water Use

Historically the site had only the mains water meter, read by the local water company for billing purposes – insufficient to provide regular measures of water consumption in different parts of the plant.

A system of 28 meters was installed at the start of a water reduction campaign which highlighted high-use areas, unusual or out-of-hours consumption profiles and poor practices:

- A major water leak was identified and repaired saving 42% on the water bill.
- The habit of leaving parts under running taps during cleaning was identified and corrected.
- The hot water supply pressure was reduced to avoid excessive water use and heating costs.
- Urinal controls were fitted in the men's toilets to stop them flushing continually for 24 hours a day, seven days a week, regardless of the building occupancy.

Compressed Air

The demand for compressed air varies during the day and at night & weekends. Monitoring compressed air use in terms of flow showed an increase in pressure of approximately 1 bar at weekends. Sequencing the compressors according to demand has saved £7,000/year and a more efficient compressor has been installed.

In addition:

- A poster campaign was launched to raise operator awareness of compressed air costs.
- The operating pressure has been reduced by 20%.
- Consumption meters have been fitted to all compressors.

Electricity Use

A system of sub-meters is used across the site to monitor consumption and track improvements such as:

- Replacing drives with higher efficiency units.
- Lighting replacement using higher frequency models offering up to 40% savings in use.

Other Improvements

Other improvements made include:

- An inventory of waste showed one waste stream was responsible for 75% of process waste, so this was targeted for reduction.
- A check on deliveries from a supplier revealed a discrepancy between the advised and delivered quantities.
- A form of waste, previously sent to landfill is being converted to a fuel product, saving £10,000 a year.

The project has also yielded an overall improvement in operator awareness and less environmental impacts; including water consumption reductions and energy and associated CO_2 emission benefits.

Field Packaging received an award in 2003 for achieving significant and on-going cost savings by minimising waste without compromising quality and service.

"We chose to start our waste minimisation programme by focusing on utilities and have been surprised by how easy it has been to make significant savings just by taking better measurements of utility consumption. Our staff are now much more aware of the need to think about how much utilities cost and to switch off equipment when it is not in use. We continue to monitor utility consumption and are currently developing improved measures to control and minimise process waste - with even greater potential savings!"
[Mr S Fountain, Head of Engineering, Field Packaging]

3.3 Large Aircraft Systems Manufacturer

Martin Baker Aircraft Company Ltd has been manufacturing aircraft ejection and safety seats at its Higher Denham site since 1946. Ejection seats are high performance assemblies involving up to 2,200 components, many of which are complex parts that have to be machined to close tolerances using a variety of lathes and milling machines. The company has an annual turnover of some £85 million and employees 730 people, mostly at the Higher Denham site.

In 1997, Martin Baker Aircraft Company decided to implement an environmental management system (EMS) to improve its environmental performance and to achieve financial benefits. Initiatives in two key areas, swarf management and metalworking fluid recycling, had already begun. Certification to ISO 14001 was gained in April 2000.

Swarf Management

At the beginning of the initiative there was limited segregation of swarf. Scrap material awaiting collection was stored mainly in open skips. The existing scrap metal merchant was unwilling to help so the company asked a new contractor to assist in a review and the design of a new system, by:

- walking around the production area with the people recovering swarf,
- listing all the materials handled and categorising them into 11 compatible metal groups,
- providing new sealed and leak-proof skips and labelled wheeled bins to allow secure collection of different metals wastes, and,
- participating in workshops and training the workforce in new working procedures to collect bins on changeover - ensuring metals segregation.

Following this initiative, machine operators are responsible for the contents of their machine bin, the waste management contractor providing clean empty bins to replace those collected.

Approximately 60 tonnes/year of metals are recovered and the payback on the swarf management system was around nine months.

Metalworking Fluid Recycling

Drainage pipes fitted to the larger skips allow metalworking fluid to be recovered for recycling, improving the value of the recovered swarf.

Metalworking fluid was standardised and a centralised metalworking fluid recycling system was installed to remove tramp oil and particulates, reclaiming some 90% of the fluid and, with monitoring, enabling the correct composition to be pumped back to individual machines – saving cleaning cycles, employee exposure and disposal.
The payback on the centralised metalworking fluid recycling system was 2 years nine months, with metalworking fluid disposal reduced by 40%.

In Addition;

- Progressive rationalisation of raw material stocks and usage has reduced the number of metal bar sheet and rod sizes stocked from 345 to 198 and the number of metal types from 45 to 32. All components are now machined on-site from standard bar and rod sizes.
- Collection and recycling of consumables such as card, paper, plastic, newsprint and plastic cups have been introduced.
- Replacement of two single-speed compressors by two energy-efficient variable speed units and improved system maintenance has been carried out.

"Our team approach... has allowed us to realise major benefits for the environment, a clean and improved workplace, and significant cost savings."
[Mr G Dumbleton, Works Manager, Field Packaging]

3.4 Medium Sized Sports Equipment Manufacturer

Apollo Sports Technologies Ltd, part of the Coyote Sports Group, manufactures a range of speciality shafts for golf club manufacturers around the world. The Company has an annual turnover in excess of £14 million and employs 245 people at its Oldbury site in the West Midlands.

Action had already been taken to reduce; emissions to air, noise, energy consumption and water use. The Company then took the opportunity to work with the West Midlands Waste Minimisation Project.

The company examined the amount of scrap metal waste produced during the four processes used to manufacture golf club shafts. The review showed that more than 70% of total scrap metal waste was generated from only one of the processes, known as ‘cold drawing’. Efforts focused on increasing yield and reducing avoidable scrap during the cold drawing process.

The results were;

- improved yield, a reduction of scrap metal waste of 64 tonnes/year,
- less steel tubing used in the manufacturing process, and,
- a saving of £50,000/year.

CLEANER MANUFACTURING

Module 4 – Checklist

Review Against Checklist

A review against the checklist, such as that below, should reveal any items which are uncertain and need further work or which have scope for further improvement. It can be an individual exercise or focus discussion between manufacturers, designers and those responsible for purchasing, quality, testing, and sales & marketing.

A simple rating approach may be sufficient to identify, for example, that the majority of environmental impacts are caused by the consumption of resources in production. However, small items, such as traces of hazardous material or waste, may still cause unexpectedly significant impacts and the scope for improvements may be larger for aspects which are some way down the ranking.

Top level responsibility with a trained team approach offering positive reinforcement for environmental improvement may be needed, especially if production and management reviews would otherwise treat environmental performance as a late addition to the manufacturing agenda. Publishing and celebrating even small successes will help people see that there is top-level commitment and that they can make a worthwhile contribution.

Area	Subject	Prompt for action
Waste Minimisation	**Material Waste**	Are materials over-ordered - given the handling and disposal of excess has a cost to be weighed against supplier discounts for extra quantity? Can near net shapes be achieved by another method, or blank sizes reduced, to minimise machining waste at any stage? What materials are scrapped and how could this be reduced? Are there common factors which would address the waste with highest value or environmental impact? Is production waste going into the general waste skip & can metals in particular be segregated using coloured bins to make them more visible and valuable for recycling? Are wastes such as oil and coolants tracked and segregated and recycling options considered with disposal or supply agents? Is packaging wasted?

Area	Subject	Prompt for action
	Resource Efficiency and Lean Manufacturing	What is the value of the product(s) from the viewpoint of customers? Is there evidence of over-processing – doing more than the customer requires? For example, can suppliers be quality audited and then do their own inspection? Are Bills of Materials kept accurate? What actions do you carry out that add or do not add value? What causes people or machines to wait? Is there excessive movement or double handling of stock? Can changeovers be reduced by preparation off-machine? Do you have a continuous, smooth flow to minimise cost and improve response and quality? Is process variability monitored with process capabilities as low as 1? Would SPC help? Does the control of processes enable quick feedback by trained operators to prevent defects, without overcorrection? Are process settings related to the most productive output and recorded? Do you manufacture only to customer demand? Is there evidence of over-production? What creates inventory and why? How can inventory levels be reduced? Can more rejects be reprocessed earlier? Are the main consumables/ancillary materials controlled and can they be reduced by process changes? Do you pursue continuous improvement in value creation and eliminating waste? Are causes of scrap pursued to enable a downward trend?
Energy and Water	**Water**	Where is the majority of water used and are employees aware? Is it cost effective to reduce consumption? Can any waste water be reused, with on-site equipment to remove contaminants if necessary? How much water is going down the drain? Can washing and other processes use less water?
	Energy	Are lighting levels, duration and location more than required? For example, are lights turned off in unoccupied areas - especially at the end of the day?

Area	Subject	Prompt for action
		Are there alternative types of lighting which offer payback through energy efficiency? Are heating levels, duration and location more than required? Are there alternative types of heating which offer payback through energy efficiency? Can heat be recovered on-site? For example, is it possible to recirculate air from a filtration/abatement system back into the workshop? Are electricity and gas sub-metering locations and frequency sufficient to show where and when most consumption takes place? Does monitoring power consumption against production show residual uses of power, e.g. out-of-hours, which can be reduced? Are motors/machines running at lowest suitable speed, switched off when not in use and, considering replacement, could variable speed drives or higher efficiency motors (Class EFF1) be used? Can leaks in a compressed air system to found and fixed? Can the compressed air operating pressure be reduced? (A reduction of 100kPa (1 bar) will typically save around 7% of the energy used.) Are employees aware of measures to reduce energy consumption in all areas of the company's operations?
Pollution	**Air Emissions**	What measures of air emissions have been made and are there any changes between measurements? Can substitutes for any sources of volatile organic compounds (VOCs) be tested? Are covers for containers with contents which may evaporate sufficiently tight?
	Fluid Emissions	What is going down the drain? Is bunding effective where hazardous fluids such as oils and chemicals are stored? What would reduce spills?

Area	Subject	Prompt for action
		Can vegetable based metalworking fluids be used for some or all machining operations? Can drum, closed tank or pipework residues be reduced by using large mobile containers close to the machine for internal movement of liquids? Would extra dedicated piping and pumps save cleaning between batches of incompatible fluids?
	Solid Emissions	What is the inventory of solid wastes? What is the cost of disposal of each type? Are special wastes cross-contaminating general wastes, where they could be segregated (yielding more value for reuse or less disposal cost)?
Longer Life, Reuse and Recycling	**Longer Life**	Could the lifetime of production equipment be extended? How has the risk of obsolescence been addressed?
	Reuse	Can any over-production be passed on to the customer, gratis if necessary, to save storing and/or disposing of it? Can empty raw material containers be used to carry products or waste? (Plastic liners, where necessary, cost 10% of a new drum, enabling old drums to be reused.) Would unwanted items yield value through a waste exchange scheme? Can packaging, pallets and containers not of value elsewhere be returned for reuse more effectively? Can oily rags be cleaned and returned more efficiently than using new rags and disposing of them?
	Recycling	What outputs of the production process might become valuable to a waste contractor as new markets for recyclates emerge? Can segregated off-cuts be recycled, in-house or externally? What levels of contamination can be tolerated for potential recyclates?