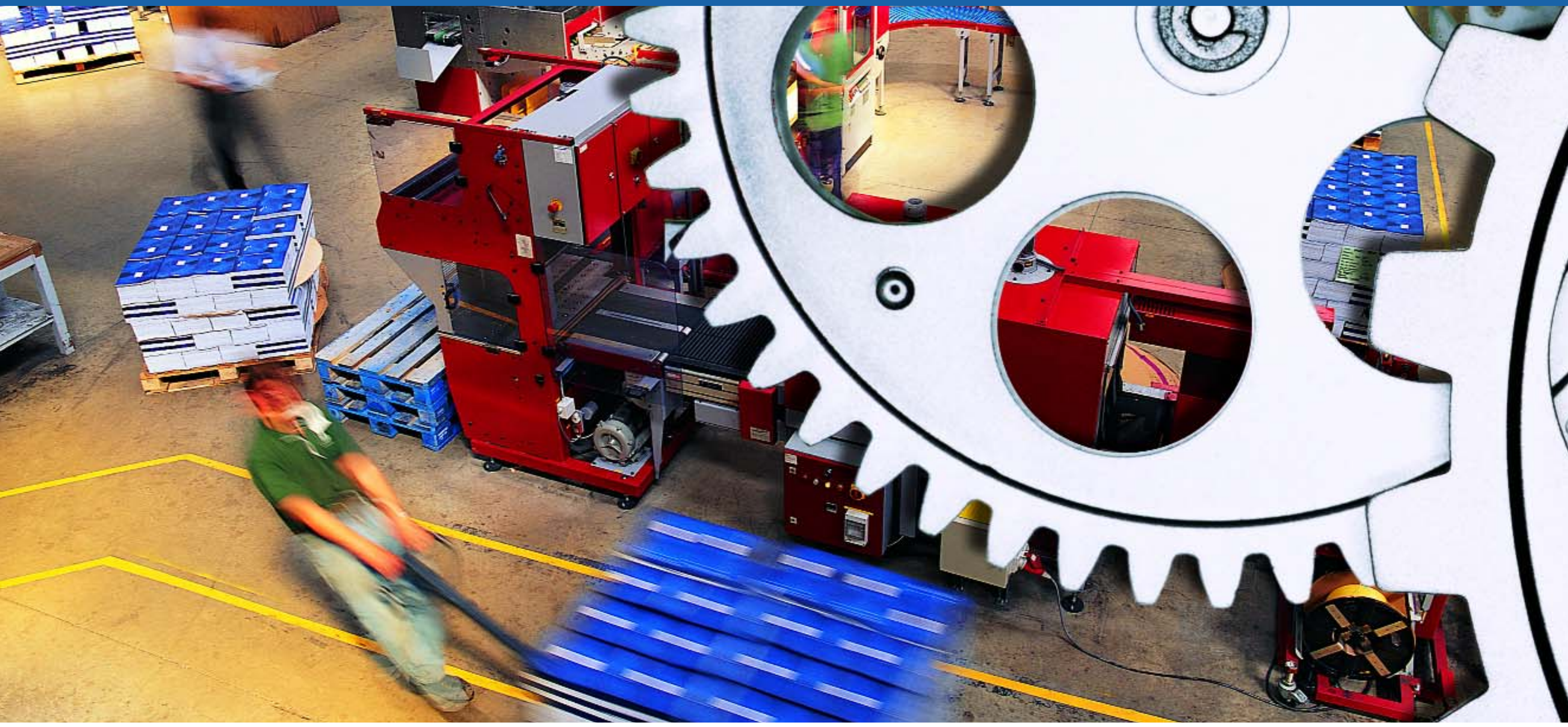

The baseline vs the bottom line

Resource efficiency schemes can not only help manufacturers get more bang for their buck, but also carve a way forward for continuous innovation and improvement. By Simon Clay of Sustainability Victoria and Anthony Peyton of consultancy GreenChip.

Businesses, particularly in the manufacturing sector, are continually striving for ways to maintain global competitiveness and increase profitability. One common drive is cost reductions, with the main response being to focus on labour costs and efficiencies. An alternate focus on resource costs and efficiencies can also contribute significant cost reductions. Improving the efficiency with which materials, water and energy are used will also help businesses respond to the increasing pressure to reduce their environmental footprint.

In manufacturing, the costs associated with purchasing resources are often higher than the costs of labour. A study in 2000 by the Victorian Department of Innovation, Industry and Regional Development, *Environmental Best Practice Benchmarking Report*, showed waste disposal costs in food companies were typically about 0.5 per cent of total manufacturing costs, where resource costs are more typically 50-60 per cent.

These data are consistent with Australian Bureau of Statistics reports across 10 industry sectors that show the cost of material inputs as a percentage of turnover ranged from 29-51 per cent, with an average of 42 per cent. Data from the manufacturing sector in Germany indicates a similar contribution (see Figure 1).

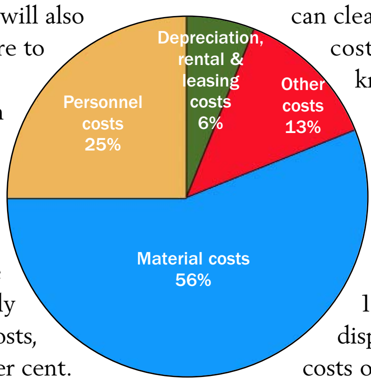

Figure 1: typical cost structure in German manufacturing.

Sustainability Victoria's work with businesses suggests the main reason for the focus on labour rather than resource efficiency is because they do not see the bottom line impact of non-productive resource flows, largely due to accounting deficiencies or because they don't measure resource efficiencies in a transparent manner. Better information on resource efficiency can clearly identify and quantify opportunities to strip out costs, with companies usually then having the knowledge and resources to drive innovation and continuous improvement.

The 12 companies that participated in Sustainability Victoria's resource efficiency program in 2004/05 identified more than $23 million per annum of lost value through non-productive resource flows. This was associated with 12,500 tonnes of waste that cost them $950,000 in disposal fees, a ratio of lost resource value to disposal costs of 23:1.

This article presents a methodology for implementing a resource efficiency scheme, indicating how existing systems provide the basis for its success and presents examples of successful outcomes. A comparison to Six Sigma is included to show how resource efficiency is an extension of this popular business improvement model.

Defining resource efficiency

Resource efficiency can be considered as both a business performance measure and an improvement strategy.

As a measure, a resource efficiency program can indicate how efficiently raw materials are being converted into finished goods. A review of a soft drink filling operation showed 99.8 per cent of PET bottles were being successfully filled, a very high resource efficiency for PET containers. In contrast, a steel foundry found the efficiency of steel usage was only 51 per cent and a fabrics manufacturer had a resource efficiency of 85 per cent for one product and 77 per cent for another. Efficiencies will obviously range across different sectors, but the key is to use this measure as a baseline for ongoing improvements.

Where resource efficiency is adopted as an improvement strategy, the program will use the measured baseline data, identify priority areas for improvement and set targets and actions to improve the efficiency year after year.

Measuring resource efficiency

Resource efficiency can be measured for the overall business, a single process or a single raw material. The resource efficiency of a process is measured by comparing the weight of the inputs to the weight of the finished product. The difference between these weights is the waste, which provides the mass balance.

$$\text{Inputs}(X) = \text{Products}(Y) + \text{Waste}\ (Z)$$

The Resource Efficiency (RE) is calculated using the weights for each measure. For the example of the PET soft drink bottles, the approach focused on one input weight (kg) and one output weight (kg).

$$RE_{PET} = (Y_{PET}/X_{PET}) \times 100$$

This type of measure is straightforward for PET bottles but more complex for a process such as peanut butter production which includes a number of ingredients combined in the final product. The resource efficiency of the overall process can be measured by summing the weight of the finished product made in a nominated period and dividing this by the sum of all inputs.

$$RE = \frac{(Y1+Y2+...Yn)}{(X1+X2+...Xm)} \times 100$$

Linking resource efficiency to lean manufacturing

FACT FILE

INC Corporation is a medium-size supplier of high-performance engineered materials for automotive manufacturers, with products such as acoustic materials, automotive trim, thermal insulation and textile laminates and coatings. A significant driver for its pursuit of resource efficiency has been the increasing contribution of material cost to total sales (see Figure 2).

INC includes all material inputs in its Bill of Materials (BOM), including raw (and auxiliary) materials, consumables and packaging. An allowance is made in the BOM for a degree of intrinsic waste, including cut-outs, perimeter waste from moulds and yield from a bulk quantity, such as the length of a roll. But it does not allow for poor quality (rejects), testing, inventory and distribution losses. A major objective of its lean manufacturing program is to identify and eliminate these wastes to increase materials and labour efficiency.

Using financial data, INC quantified its overall materials efficiency as 85 per cent for the 2005 financial year. Further evaluation of individual products identified which products and processes contributed to the overall loss of incoming raw materials. This was done by comparing BOM requirements with actual usage over a defined period. The wastage was calculated by:

$W = M.(P - Q.V - \Delta R - \Delta F.Q)$ kg

where

M = mass of raw material

P = purchase quantity received

Q = allowed quantity from bill of materials

V = volume sold

ΔR = difference between opening and closing stock of raw materials

ΔF = difference between opening and closing stock of finished goods

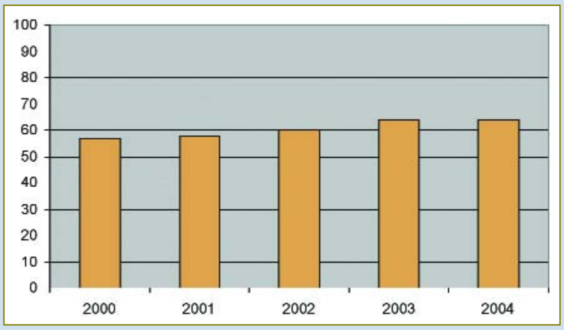

Figure 2: material costs are up as a proportion of total sales.

Where the quantity (weight) received could not be obtained, the formula was adjusted to use the actual purchase costs divided by the unit raw material cost to calculate quantity received. INC found just four materials contributed significantly to the non-productive material flows, with annual loss of value of about $1.4 million, and even higher when system costs including wasted labour, energy, waste disposal and capital were included. A further analysis of the BOM revealed on-costs such as packaging, logistics and quality costs were under-recovered. Through a series of measures, INC increased overall materials efficiency to 93 per cent, reducing the cost of non-productive flows by $750,000 pa. The measurement technique also highlighted a range of unprofitable products, prompting INC to exit them which improved materials efficiency another five per cent and reduced the total cost of materials to sales by almost 20 per cent.

> "Efficiencies will obviously range across different sectors, but **the key is to use this measure as a baseline for ongoing improvements.**"

Stock levels at the start and end of the period may need to be considered. For example, existing stock may have been consumed and therefore the use of purchase data would underestimate the actual inputs. However, if the nominated period is long enough and there is reasonable regularity with purchases and sales, an assumption that the stock levels remain the same could be valid.

Sourcing data

To measure the resource efficiency of a business or process, data can be obtained in a number of ways, including:

- physical measurement of resource flows;
- examination of purchasing and sales records;
- examination of quality control records;
- interrogation of company production management systems, such as Bills of Materials (BOM), Materials Requirement Planning (MRP) and Enterprise Resource Planning (ERP) systems; and
- evaluation of finance reports.

It is important to gather data in a form that can be aggregated. Weight is generally used as it can be applied to most resources. Some data conversion may be needed to calculate the weight of inputs and finished goods. This could come from sales data that identifies numbers of units or financial numbers only (conversion: weigh a single unit), sheets of material (determine weight as kg/m^2), volumes of water or other liquid inputs (calculate density as kg/l) and yield data that reports production rates or time-based efficiencies (if unit weights are known).

One area where errors can be made is converting volume to weight as the density of the material may be altered during the process. For example, as a material is ground its volume will decrease but its weight will be the same, therefore its density will have increased.

Beyond Six Sigma

Six Sigma is a quality measurement tool developed by Motorola in the 1990s that is being adopted by many Australian companies. It is supported by a methodology for organisational improvement, known as DMAIC, which is an acronym for the five stages of the model: define, measure, analyse, improve and control.

DMAIC is further explored below as it can provide the framework for a resource efficiency improvement program. Six Sigma records defects in a process and the reasons for them. More particularly, it focuses on variations from an accepted position by examining the standard deviation. A highly variable process will report a lower Six Sigma measurement, indicating a lower quality.

Production processes adopting Six Sigma will use defects to measure quality performance. However, this measure alone does not address the loss of material as by-products or other wastes generated during production. A resource efficiency program can therefore extend a Six Sigma program to account for all losses in a process, which can deliver greater benefits than by using Six Sigma alone (see Fact File).

The DMAIC framework

As described above, DMAIC can help realise a range of business opportunities, including increased customer satisfaction, reduced defects and increased resource efficiency.

DMAIC needs to be implemented as a formal project within the business, with appropriate levels of resources and management commitment. Without this support the program is unlikely to be fully completed, meaning the full potential will not be realised.

“A resource efficiency program can therefore extend a Six Sigma program to account for all losses in a process”

1) Define: The first stage is to define the project, including its problem statement, scope, objectives and timeline. It is useful at this stage to map the process so all materials and other utilities can be identified.

2) Measure: As noted earlier, the measuring stage should initially draw on existing data sets and then augmented with a planned sampling program to identify where wastes are being generated along the process. The costs of the raw material, energy and labour can also be collated at this stage so the full cost of waste can be calculated. Once the input and output data has been collated, a baseline resource efficiency estimate can be calculated.

3) Analyse: At the analysis stage the root causes of the various waste streams should be identified and priority areas for attention highlighted. This may involve benchmarking resource efficiency against other similar processes or businesses. While benchmarking has its limitations due to the variation in businesses, industry data may provide a useful context for the current performance.

4) Improve: The improvement stage will involve brainstorming sessions and various trials to identify optimal solutions for improving resource efficiency. This will include constructing financial models, forecasting any consequential impacts of the proposed changes and consulting people who may be affected by the changes. Once the solution has been identified an action plan should be prepared to detail the various tasks that must be completed, including the required resources and any timelines that need to be met, such as allowances for any shutdowns.

5) Control: The final stage is important as it will ensure that changes are integrated into the business, including updating of procedures, implementation of new monitoring and reporting systems, and the training of staff.

(Continued over)

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Inside Six Sigma

FACT FILE

A manufacturer uses 350 kg of raw materials to produce 1,000 chocolate bars with a target weight of 300 g/bar.

Quality control criteria are set for the products that define whether a finished good is too light or too heavy, in other words, defective. The upper control limit (UCL) and lower control limit (LCL) are presented in Figure 3 along with a histogram presenting the weights of the 1,000 bars produced. It shows 80 bars outside the weight criteria, so the yield of the produced bars is therefore 92 per cent.

The number of defective opportunities (reasons) is reported to be six. On this basis the process would have a Sigma Level of about 3.7. If the number of defects was reduced to 1 per 1,000, the Sigma Level would increase to 5.1, which would indicate very high quality. However, even with no defects the total weight of the 1,000 bars would be only 300 kg. The weight of raw materials was 350 kg and therefore almost 50 kg will still have been wasted during production. The 85 per cent resource efficiency measure therefore highlights opportunities for further waste reduction and cost savings, even in a high quality process.

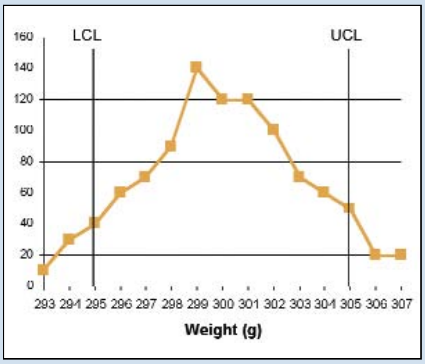

Figure 3: 80 chocolate bars were outside the upper and lower control limits.

FACT FILE

MTM-Auto increases steel yields

"When you put data in front of people it's amazing what happens," says Peter Sloan, plant manager for MTM, a tier one supplier to the automotive industry of products such as autoshifts, door checks, interior and exterior door handles, park brakes, steering columns and hinges.

Its main processes involve metal stamping, plastic injection moulding and assembly (Figure 4). MTM defines scrap material as waste that is intrinsic to the process, such as sprues and runners in plastic moulding operations and left-over steel from stamping processes, whereas reject material is defined as product that is not acceptable for sale, perhaps because of defects.

It undertook a detailed measurement of the yield on all its plastic and steel raw materials – 100 different flows – and also the value of this lost raw material. The low yield on one high volume steel material prompted MTM to examine and adjust the tooling design associated with the stamping process (Figure 5). Savings in scrap meant an improvement in yield of more than 100 per cent.

Why did it happen? The design was left to the toolmaker, who is typically paid for a tool that produces a good product, not for one that has high resource efficiency. As stamped parts get closer together, edge effects occur that can cause quality problems, so the toolmaker inevitably took a conservative approach.

MTM undertook the necessary experiments to optimise steel strip width and stamping distance without affecting quality, then supplied this information to the toolmaker. The cost of the tooling change was more than offset by the increase in resource efficiency and subsequent reduction in raw material costs. WME

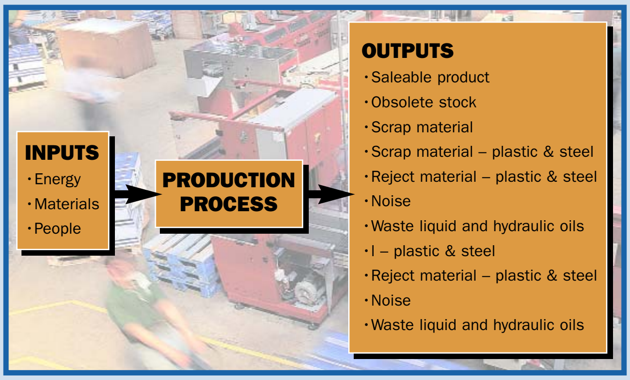

Figure 4: MTM's production process.

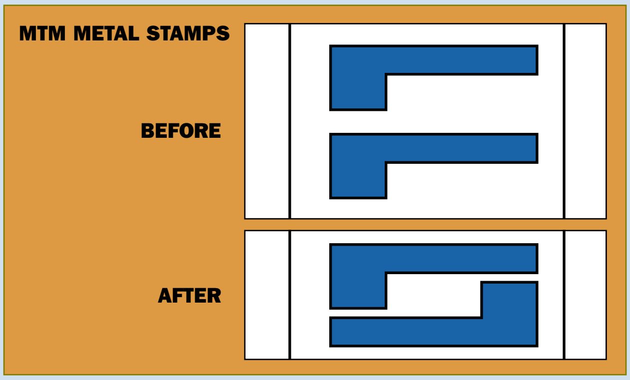

Figure 5: towards a resource efficient stamp for parts.