Profit Contribution Stream Mapping

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Abstract

Profit Contribution Stream Mapping. This paper introduces a new technique used to identify and display operating costs and profits to improve the management of plant and equipment assets. Maximising profit from a business requires both efficiency and effectiveness from the production operation. An effective production process makes and delivers what the customer wants. An efficient production process delivers the profit the business shareholders want. Profit Contribution Mapping extends the value stream mapping concept and introduces financial measures to identify where profits are made during production and where they are lost. It combines accountancy, economics, engineering, maintenance, operations management and asset management to create a powerful management tool to control effectively at the 'global' production process level and also efficiently at the 'local' process step level.

Keywords: value stream mapping, profit contribution stream mapping,

A production or manufacturing process should be viewed as a system for supplying the customer's requirements. A system implies many interrelated parts working seamlessly together in a coordinated effort to provide an important and necessary function.

A production system involves the seamlessly operation of people, equipment and practices working in an ordered way to produce what the customer wants at a sustainable profit for the producer. An important job of managers, economists, accountants and engineers is to develop business systems that reliably and ethically achieve this seamless operation to the benefit of the organisation, its customers and the community. It is desirable to continually improve and tune the organisation to make it more efficient and do its functions faster, better and cheaper.

Production, processing and manufacturing systems turn raw materials into finished products through a series of steps that progressively convert them into saleable products. The conversion process typically requires added inputs such as labour, utilities like power and water, specialist services like maintenance, added materials like boxes for packaging, along with other numerous requirements to make products customers buy.

Production process and indeed service operations can be symbolized by a block diagram containing a series of boxes for each conversion step in the process, with materials, utilities, services and labour shown by arrows to represent their flow. Such a symbolic production, manufacturing or service process used to convert raw materials to customer-desired products is shown in the process flow diagram of Figure 1.

In Figure 1 raw materials are the direct materials used in the production process. The added inputs include the utilities (power and water) and services (such as boxes for the product, labour man-hours, lubricants for machines, etc) needed to complete the process step. The process steps use these to add value and make the products produced by the organisation. During production the product increases in value equal to the value added in each conversion step. Each value-

adding step contributes part of the profit made when the product is sold to the customer. A process step does not produce perfect conversion and some losses occur.

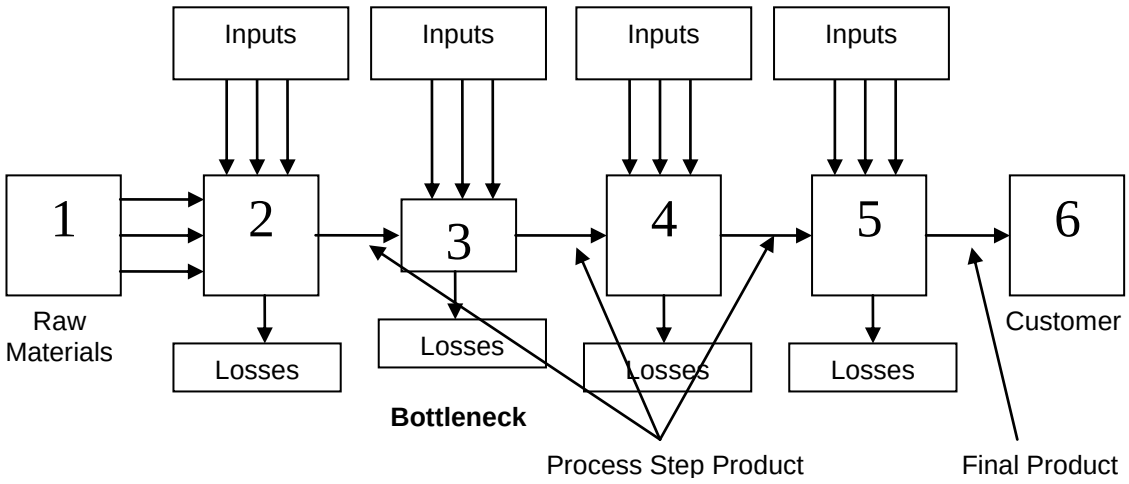

Figure 1. A Production Conversion Process

From Figure 1 a few simple properties of a production process can be observed:

i. The process design establishes the process' capability to make the product.
ii. Product quality is determined by the process design.
iii. The bottleneck limits the maximum throughput rate for the process.
iv. The efficiency of operating each process step determines it profit contribution.
v. The customer demand rate dictates the product manufacturing rate.

Properties of Production Process

A production process should only make what the market will purchase. A production system has inbuilt natural checks and balances that keep a production process in-step with the market for its products. The rate of sale of the product to the customer is naturally controlled by what the customer wants and when they buy. It is important that production does not to make more product than can be sold; otherwise money is tied-up in product and inventory that no one wants.

The amounts of raw materials put into a process are governed by the market demand, the production usage rate and the ability of the business to pay for them. Similarly the added inputs throughout the process are governed by the individual process step needs and the cash flows available to pay for them. Where the customer demand rate is above the process' capacity to make the product, they are brought at the rate that the process can use them and can afford to pay. Market economics and business economics act to regulate and control the production rate.

This is the essence of a market-based, capitalist economy – the manufacture of products that people want in production systems that are balanced to the demand.

There is one more issue to consider in a production process - the losses. The process losses behave differently, very differently, to anything else in the production process! They are not naturally limited by demand. They are only limited by how much money is available to the production system. Because there are no systematic internal constraints on waste they are actively managed by minimising them at the design phase of the process and by managing them to minimal levels during the long operating phase of the business.

Bottomless Pit of Losses and Waste

Usually not considered seriously important in business process design are the amounts of losses produced – the waste! The wastes include the obvious waste product and scrap materials commonly associated with production waste. But there are many other types of waste produced. All wastes take money from the profits that could have been made.

The other wastes, which are numerous and common but not often noticed, include such things as excess movement, lost heat, lost water, lost energy, excess storage space, excess in-process inventory, excess time, lost time, quality defects, excess forklift pallet hire, excess equipment hire, safety incidents, environmental incidents, excess paperwork, excess manning, and many, many more. (See Appendix 1 for a list of common costs in a production process.) Figure 2 shows the same process as before and includes all the wastes from the business and production process.

Some of these wastes are identifiable by using value stream mapping analysis. Profit Contribution Stream Mapping spots all wastes and gives them the financial value lost to the business to justify and encourage their rapid elimination.

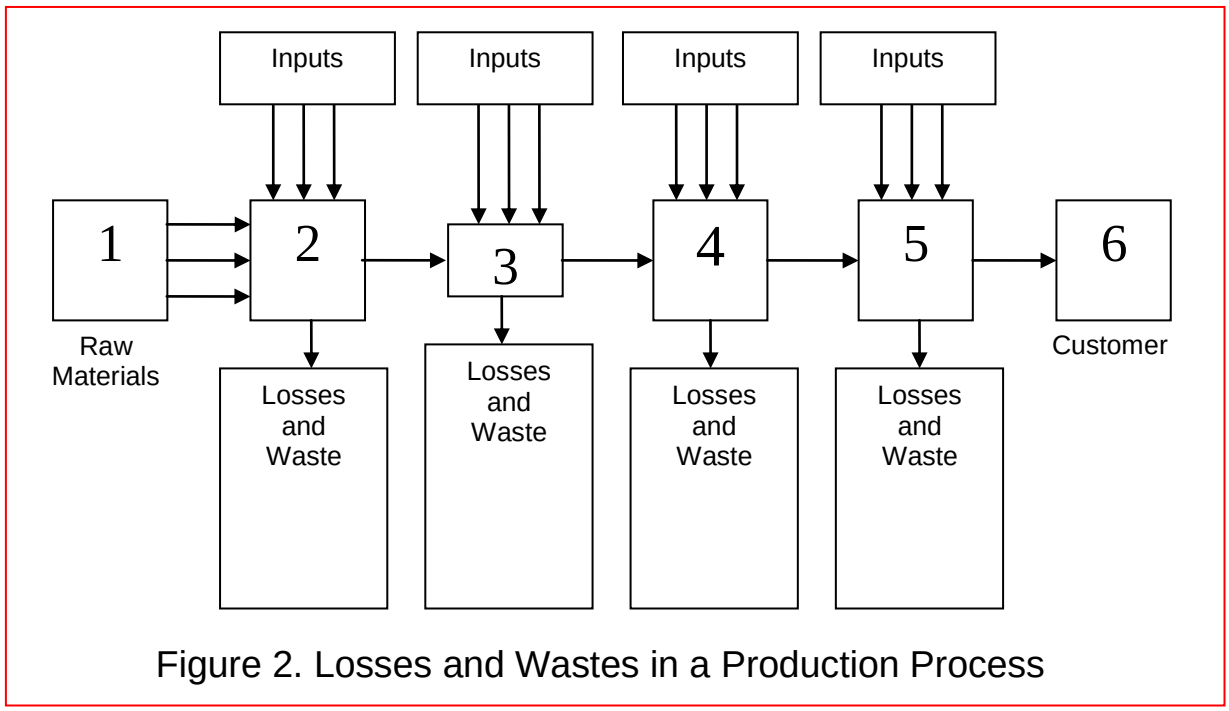

Figure 2. Losses and Wastes in a Production Process

The only natural means of waste control for a production system is how much money can be spent on raw materials and added inputs. Since creating waste has no natural means of self-control beyond bankrupting the business, it becomes necessary to develop business control systems that monitor the waste and force its minimisation and eventual total elimination.

There are now two other properties of a process that was not clearly evident before:

vi. Wastes extract effort and profits from a process.
vii. The process can turn raw materials and inputs into waste so that the process makes waste instead of profit, to the point where waste consumes all the profits.

Based on these seven properties, a business' production process can be interrogated to understand how money behaves within it and to identify the wastes that reduce its performance and profit. This analysis process is called Profit Contribution Steam Mapping (PCSM).

Once a process is operating, people's concerns naturally turn to making the product on time. What most people forget to do is to also make it efficiently, while their meeting customer's requirements. The demand to make product on-time often overrides the need to make it cost effectively. This leads to the situation in business where everyone is busy making product, but no one is busy making profit! If this situation occurs in an organisation, the creation of waste instead of profit dramatically rises. PCSM is a new way to help manager and engineers collect the cost information needed to operate a production system efficiently and effectively.

Identifying the Profit Contribution Streams

Figure 1 indicated that there are discrete steps in make a product and delivering a service. Each step has its own raw materials, which is the feed from the prior process step. It has its own added inputs needed to make the conversion. From each step come a 'product' and the wastes. Each process step is clearly identifiable from its predecessor and its successor and is self-contained in performing its conversion.

Since each process step is independent of the others it can be taken in isolation and viewed as a whole system in itself. This allows analysis of the process step separately. To make it clear which process step is being reviewed you draw a boundary around it on the process flow diagram. An example of segregating a process step for analysis is shown in Figure 3.

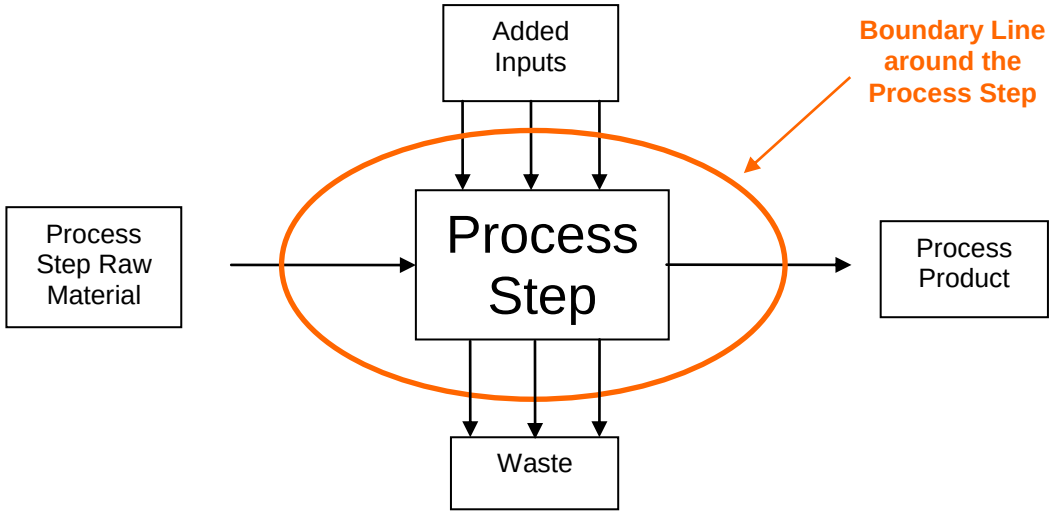

Figure 3. Local Process Step Profit Contribution Map

To determine process effectiveness and efficiency we need a measure. A good measure to use is money. Money is the universal language of business and most people understand the concept of using money to value an item or service. By using money to measure process product cost, added input cost, cost of wastes and the profit contribution from a process step, we can trend the process profit contribution step by step as the product is made. Figure 4 indicates the various money flows, both in and out of a production process.

Though only the money flows for Process Step 2 are shown, they equally apply for each step. By analysing each process step, the true costs of the raw materials, the additional inputs, the wastes from it and the total process step profit contribution can be determined.

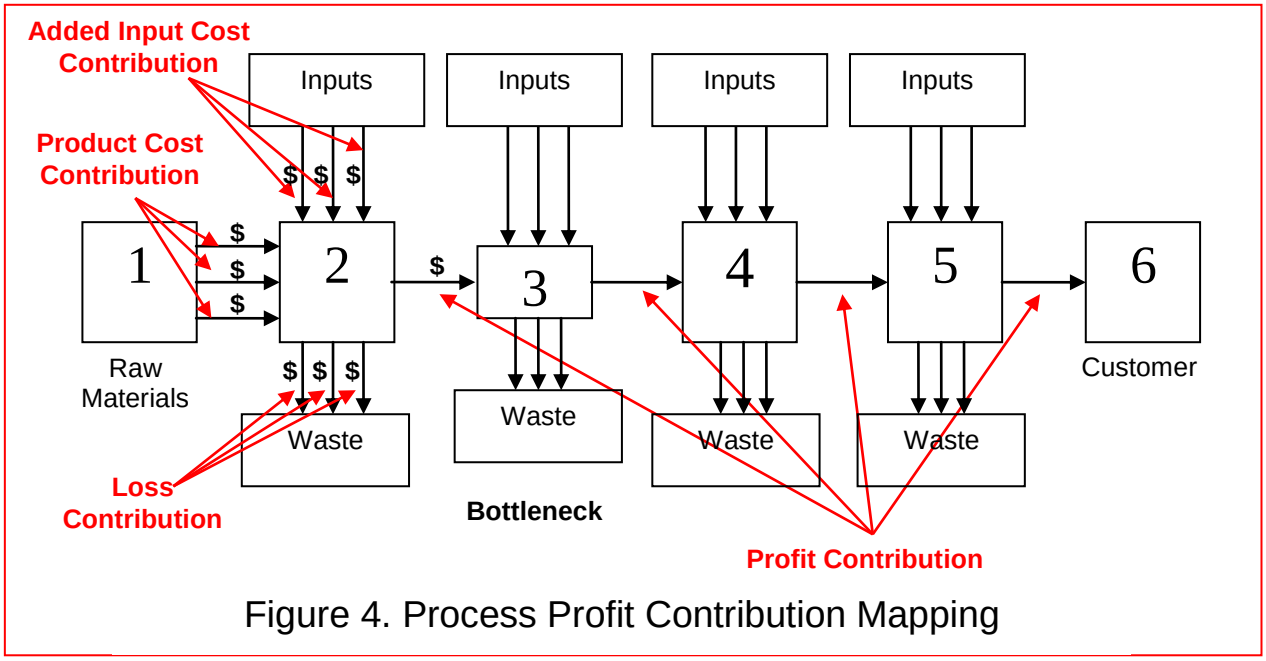

Figure 4. Process Profit Contribution Mapping

Monitoring the costs and profit contributions of each process step provides a means to measure the efficiency of the conversion processes. The more profit contribution generated from a conversion step the more financially efficient is the step. By knowing the cost of all inputs and all wastes, the profit contribution made to the total profit by each process step can be identified. With profit contribution information managers, accountants and engineers can focus on new cost reduction, productivity and process improvements that return the best value for the operation.

Figure 5 indicates how to identify each money flow associated with a process step. The boundary line makes it clear there is money coming into it from 'raw materials' and the added inputs required to make the process conversion. Each process step delivers its own process 'product' with its profit contribution from the value-adding performed in the step. In addition there are lost moneys that reflect process and operating inefficiencies, wastes and losses.

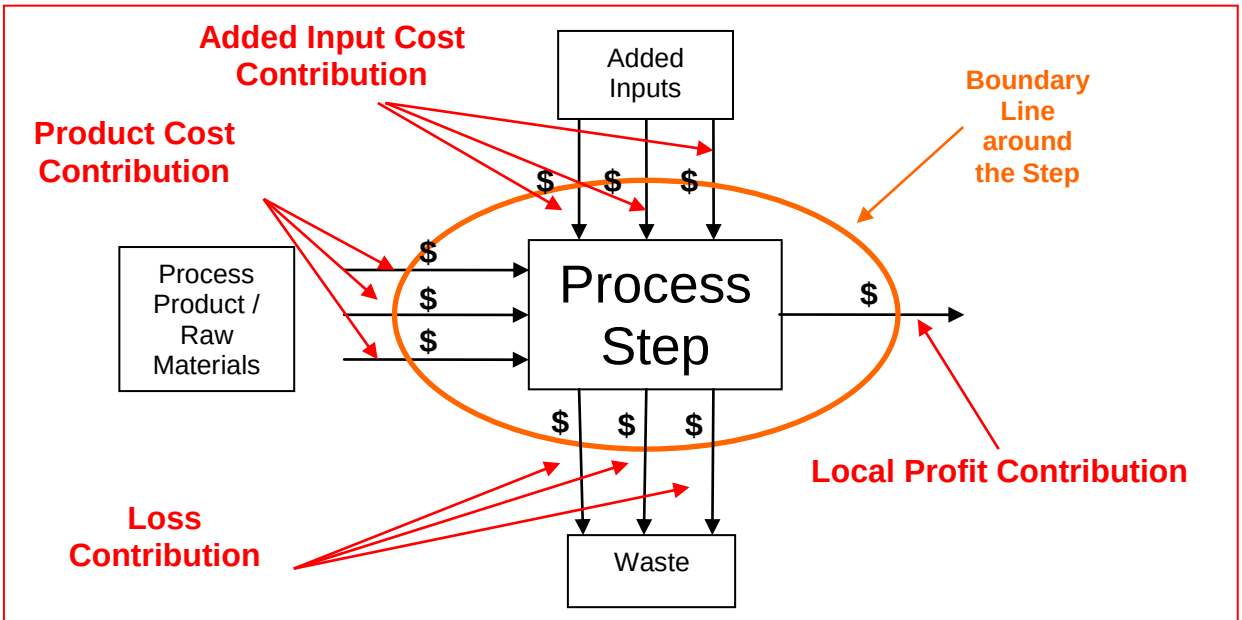

Figure 5. Local Process Step Profit Contribution Map

Figure 5 makes clear the importance of cost control in each process conversion step. If so much money is wasted in each step that the customers will not pay what it costs to make the product, there will be no sales and the organisation goes out of business. For products of equal quality it is very likely that the customer will find and use the cheaper producer.

With all the in and out money 'flows' in a process step identified they are used to analyse the profitability of the process step by calculating the costs and losses to determine its profit contribution. This can be represented by a simple equation.

Cost of Process + Cost of Added Inputs = Local Profit Contribution + Cost of Waste *Eq 1*
Product Input

Alternately the equation can be written as:

Cost of Process + Cost of Added Inputs - Cost of Waste = Local Profit Contribution *Eq 2*
Product Input

Strangely, from equations 1 and 2, it could be said we pay for waste twice, once when we buy it as an input and second when we throw it away as lost profit.

Cost Analysis

The power of Profit Contribution Stream Mapping is the clear understanding of production money flows it delivers through the use of visual management. A display of the business process is developed to indicate where the money goes into, around and out of the business. What happens with costs and profits is clear and issues highlighted by the mapping can be addressed.

Activity Based Costing

Activity Based Costing (ABC) is the most appropriate accounting technique to apply when determining process step costs. Standard costing is not suitable since overheads are allocated to direct costs. Rather it is necessary to capture every cost, from the smallest cost to the largest, as it is really spent. A total and true reflection of what happens in each process step during a set period of time is necessary.

Because the profit stream costing process identifies every cost individually, overheads allocation is not permitted. All overheads are identified separately and costed in exact proportion to their usage in each process step. If overhead costs were allocated to direct labour an incomplete mapping of the true costs would result.

The accuracy and completeness with which the process step costs are collected will directly determine the effectiveness of the profit contribution map as a management control tool. If data is complete and true then good, reliable business-improving decisions will be made to make the operation more efficient and profitable.

The appropriate time period to be used to collect the mapped costs may be an hour, day, week, month and even a year. The time period is dependant on the cycle time for the process step and the size of the time window necessary to identify all money flows for the process step.

Applying ABC permits identification of every cost with its component costs, and even sub-component costs. It is important that every dollar spent in the production of goods is accounted for and shown on the profit stream contribution map.

Collecting Cost Data

The cost data needed to analyse and manage a process is typically generated by the process as it produces its product. The cost of materials, labour, utilities, overheads and services are found on invoices or payslips. What is not normally available are the process costs accurately allocated to the process steps that incurred them. To manage a process step's efficiency it is necessary to cost every one of its inputs, products and wastes accurately.

An approach used to identify the money flows in a process step is to take the process step procedure and work through it. As it is read the process step raw materials, the added inputs, the wastes and the produced product are identified.

As shown in Figure 3, a boundary is drawn around the process step to clarify its associated 'flows'. Many of the inputs, wastes and products are shown on the process design drawings, or found in engineering documents, equipment manuals and in standard operating procedures. The data is confirmed by also personally observing the process step for a full cycle of production.

When onsite identify all electrical power supplies to the equipment, all pipes suppling services, all process products into the step, all added inputs into the step, all outputs and wastes from the step. This includes measuring the manpower, management, supervisory and maintenance efforts, times and costs incurred by the process step. It includes measuring forklift movements, vehicle movements, personnel movements, etc. that occur in the time period observed. It includes counting the number of lights and time they are on, how often equipment is hosed down and the amount of water used. All activities are collated and costed in a spreadsheet.

It will be necessary to go as far as identifying minor costs, like rags used for cleaning equipment and the cleaning detergents used. Another example would be to identify the use of personal safety equipment and company brought clothing each operator requires during the time period. Over a year these minor expenses can grow into serious costs that are easily wasted.

Find every dollar that goes into a process step and that comes out of it. Put on the mantle of the television movie crime investigator and look for all the clues to the puzzle. Unearth the truth, the whole and total truth of where money goes in each process step.

When studying a process step that involves movement of product and/or people, for example storing materials in a warehouse, time the length of the move, measure the distance moved and identify the equipment used in the work. Put a cost to the movement of product and materials so that it can be tested to see if it delivers real value for the expenditure.

All the process costs can be found in the business systems such as payroll, inventory and accounting. Unfortunately they most likely will be totalised costs. The labour will be for a person's total time at work and what is needed is what they spent in the process step. The power bill will likely be for the whole of a building, whereas the cost of lights and power for a machine in that building is required. The purchase of safety gloves will be in batches of dozens at a time but it is necessary to know how many are used by the people working in the process step.

The most accurate approach is to get the real usage of inputs and wastes. For example, the power used by the lights and machinery in the process steps need to be collected for the time period concerned. If that is not possible it becomes necessary to proportion the machine's share of the building's power based on the electric wattage stated by the manufacturers of the equipment used in the process step. By proportioning inaccuracies will be introduced that may eventually cause people to question the final conclusions.

If necessary introduce special means to capture cost information. Time sheets and record-of-use sheets can be developed, chart recorders can be connected to electrical equipment and meters can be installed to measure flows in pipes. When accurate cost control is important to the success of a business spare no effort to discover the total true costs of production.

Labour

Direct Labour comes from the time sheets of the people employed directly in the process step being analysed. If the people are used in another process step then only cost time expended in the process step being investigated. The direct labour cost is the pay rate paid to the people working in the process step, multiplied by the time they spend in the process step during the selected time period costs are being collected for. Include all their on-costs such as allowances, superannuation, benefits, etc, proportioned to the period. Do not include allowance for overheads, as they will be separately identified.

Indirect labour costs are the time spent by persons, other than the directly involved people, whose services are needed to ensure the process step is completed. It is necessary to measure and allocate times for indirect labour. This includes such costs as maintenance, supervision, middle and senior management time, inventory and storage personnel, purchasing department personnel, quality control personnel, etc. Identify these costs by interviewing relevant people to determine the time they spend in the process step. During a site inspection watch the process for a full production cycle and observe who interacts with the process step.

The indirect labour cost is the pay rate paid to the indirect people, multiplied by the time they spend in the process step during the selected time period. Include all their on-costs such as allowances, superannuation, benefits, etc, proportioned to the period.

If a short time period is analysed, say a week, and not all indirect labour is captured, it is still necessary to allocate a proportion of all the indirect labour costs to the time period. In this case take a longer time period, say a month or quarter year, and collect all the costs for the longer period then proportion and allocate them in weekly quantities.

Indirect expenses are those costs incurred due to the presence of the people in the operation. An example is a manager's car and fuel which is paid out of operating revenue. Allocate them in proportion to the hours spent in the process step by the expense owner.

Subcontractors

Subcontract labour costs and materials used in the process step need to be recognised and allocated in the same way as employed direct labour. There will be an invoice for the subcontractor's time and materials and the allocation of times and materials for the work done in the process step can be extracted from it.

Utility Services

Electricity, water and such services will need to be measured and allocated to the process step usage during the time period.

Management, Engineering, Administration and Supervisory Costs

These costs cover the time managers, engineers, supervisors and administrative support staff spend doing work related to requirements of the process step. For example daily meetings, site inspections, human resources requirements, problem solving process issues, invoicing matching purchases, maintenance planning, etc. All support persons who interact with the process step need their times and costs recorded against the step.

Initially interviews can be held with people to ask them to estimate the time they spend on the process step. If necessary have them keep time sheets to record the actual times spent involved with the process during the time period.

Added Input Materials

Direct material costs are for added input materials actually used in the process step. They are the obvious additions of substances into the process step. This includes such things as electricity for motors, boxes for packaging, lubricant for equipment gearboxes, air for pneumatic rams, etc. Typically these materials can be identified as entering the process step in a physical form. The parts of them wasted can be measured and given a value.

These costs depend on the quantity and value of each input material used during the time period. It requires counting the amount of the material used and multiplying by the cost of the added material. Material costs can usually be identified from invoices for the material. Sometimes the added material has been made by the organisation and no invoices are available. In such cases it will be necessary to get an accurate cost for it from the organisation. If none is available it will need to be calculated from the cost of the labour, ingredients, handling and manufacturing charges used to make it.

Indirect material costs are the costs associated with the indirect functions required to perform the process step. Such as paper for recordkeeping, electricity for lighting, a maintenance planner's computer, the cost of forklift hire to move pallets, the building storage space for spare equipment parts, etc. All these costs are real costs incurred to conduct business that supports the production processes and need to be identified.

It is necessary to measure them and quantify them so that they can be given a value. Measurement can be by stopwatch, distance, counters, etc. Their use in a process step needs to be identified and quantified to reflect how much is used in the process step conversion and how much is wasted.

Product Costs

The cost of a product entering a process step is needed. An accurate value may be available from the accounting, or production department. If it is not available accurately it will need to be calculated for each prior process step commencing with the start of production.

Identifying and Costing Wastes

Direct waste is any unused direct labour or direct materials added into the process which are not fully used in making a product. Even if the added input is gradually converted through a number of process steps, as long as it is fully used it is not waste. Unconverted added input is waste.

For example, in some chemical processes the chemical reaction absorbs only a portion of the mixed ingredients. Those ingredients that are not converted by the reaction are wasted. A laboratory can analyse for the unconverted ingredients and tell how much was unused.

Another example is water used to clean equipment. If the water is not fully used in the process to make product but disappears out of the process, then it is wasted. Leakage out of the process is waste. Spillage from a process is waste. Another example of waste is side-steam materials collected in bags or bins to be disposed of outside of the process.

Indirect wastes are those wastes that relate to the unnecessary use of indirect labour and indirect materials. They are more difficult to identify because they are not easily observable. Examples include wastes related to lost time in meetings, to lost energy, to lost compressed air, to safety equipment thrown away before being fully used, to storing unneeded materials in a storeroom. There are numerous instances of such wastes.

The detection of indirect wastes is through observation. That is why it is necessary to be present during a full cycle of a production process and observe all process steps and their inputs to identify wasted costs, materials and product. Look in the rubbish bins used in the process step area of the business and see what is thrown away. Are lights and air conditioning left on overnight unnecessarily? If required develop and instigate systematic means to spot and record the waste and its value during the period investigated.

Comparison with Standard Costs

Every organisation should have a standard costing system for its products. If there are standard costs available compare them with the costs from the profit contribution mapping analysis. Using existing standard costs double-checks the analysis and concerns can be raised when costs are far from the standard costs previously allocated.

Use of Computerisation and Technology to Capture Costs

The work involved in identifying and costing component inputs, products and wastes for each process step can be large. If a company choses, it can use modern technology and computerisation to capture many of the costs automatically. Labour can be identified electronically by using electronic cards and time clocks. Materials can be identified electronically via electronic tagging or bar coding.

Wastes are difficult to identify electronically. It may be necessary to change work procedures and include the recording of waste. Introducing counting and measuring of wastes will allow people to identify the causes and address them before they get even worse.

Through the use of Global Positioning Systems equipment, materials and people movements can be tracked and any time losses identified and addressed.

Managing With Profit Contribution Mapping

Once all the flows into and out of a process and its steps are identified and costed the profit contribution map can be created.

The Profit Contribution Stream Map

A simplified partial sample of a Profit Contribution Stream Map is shown in Figure 6 for a section of canning line. All the costs are shown cascading to and from the process steps. The time between updating the map depends on the urgency of the situation. If it is necessary to make changes quickly, then more updates are needed than if the situation is stable.

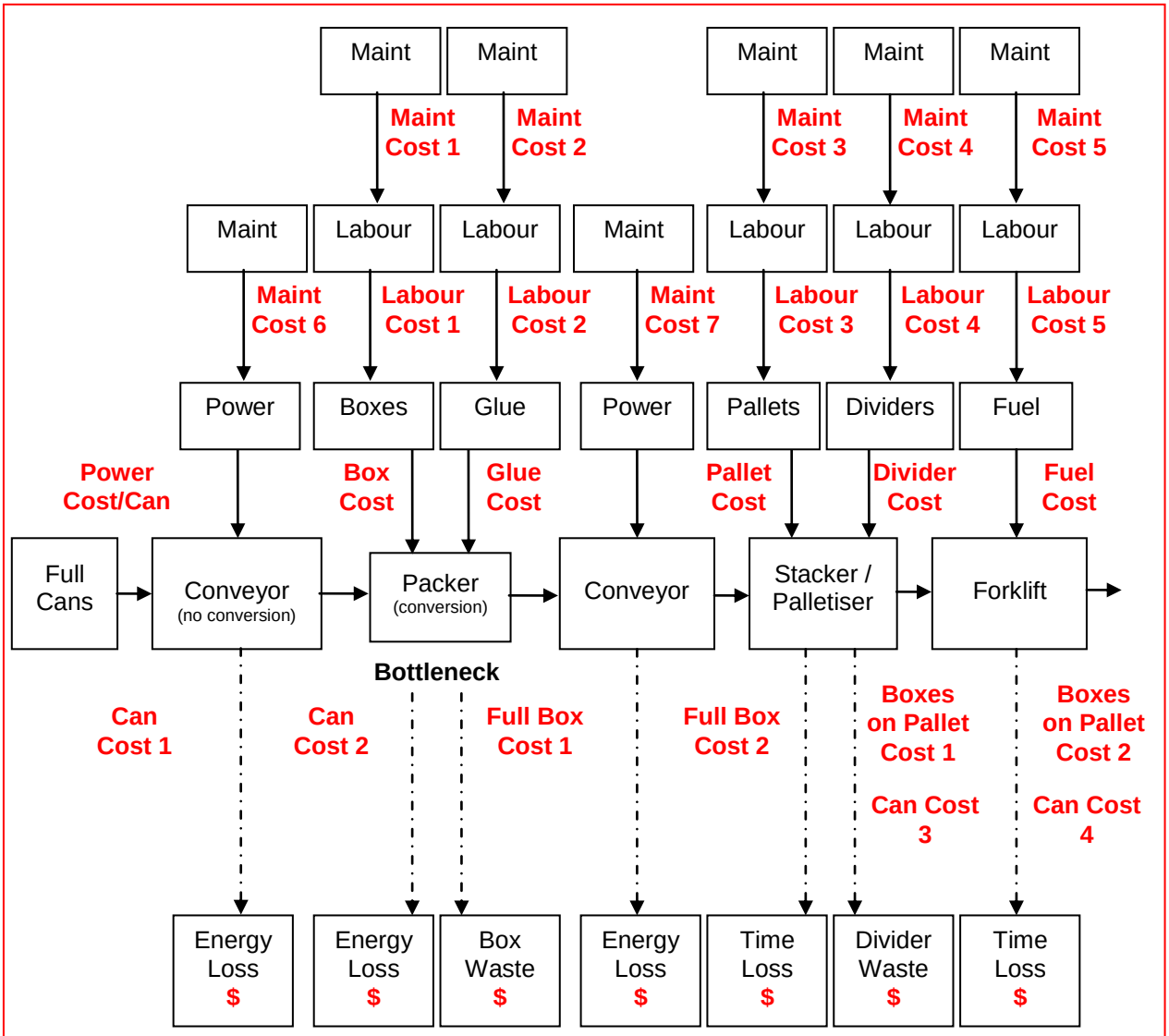

Figure 6. Profit Contribution Map for a Canning Line

At least every month the profit contribution map ought to be updated. If the mapping process can be done electronically it would be useful to do an update weekly, as this frequency allows better control of the operation. In some cases it might be necessary to map a particular process step more often than the entire process because of the importance that step has in the operation.

Performance Measures and Reporting

The problems that are highlighted by the profit contribution analysis can be addressed by the business management and personnel with new strategies applied to maximise the profit contribution. After a process step is analysed in detail it is easy to understand and appreciate how its many factors interact and impact each other. The accurate costing of inputs, wastes and conversions will identify problems. Through detailed questioning the reasons can be uncovered and the required changes made.

If change is required it is necessary determine what that change will be. The issues will need to be discussed with everyone concerned to fully appreciate and understand the situation's history and reasons for occurring. The new changes will also need discussion, review and analysis for

possible unwanted consequences. Finally a decision will be taken and changes will be made. When the changes are introduced they too will need to be measured, monitored and reported.

Performance Measures

Selecting the right measures to monitor and report will be critical to the success of the change process and to the speed of its implementation. The measures need to be meaningful to the users, truly reflect the situation, are within their control to improve and inspire continued improvement.

One of the change strategies will be to introduce performance measures that identify poor efficiencies and the practices that cause them. Performance measures based on the issues identified by the analysis will drive the right behaviours and actions from people. The measures can be graphed and trended to show performance improvement.

Some typical measures to use are listed below. Measures can be developed that are suited to specific circumstances. The purpose of measuring is to know exactly what is happening. Once the current situation is clearly understood an assessment can be made as to whether it is satisfactory or it needs to be changed. If a change is made the effects will be seen in the performance measures. It may take several months for the effect of a change to be observed. Where the measures indicate an unsatisfactory result, a correction is necessary to get on-track.

Usage Efficiency: This is the classic output divided by input. Select the process flows that are important and develop an appropriate efficiency measure for each and trend them over time.

Productivity: These are measures of process performance. They are time based ratios of output during the time period. From the profit contribution map select the productivities which are important to measure. Productivity can be measured at the process step level and at the global process level.

Throughput: This measure is a count of what passes a selected point in the production process during a period of time.

Waste Cost: This measure counts the cost of waste in dollars per dollar spent to purchase the original material.

Quality: This is the proportion of production that meets customer specification. It is another measure of a wasteful process.

To get a complete understanding of what happens in a process requires more than one measure. Business processes involve many interactions that affect each other and it requires a number of ratios to identify what is occurring in a process. Do not use any more measures than necessary. Maintaining measures requires time and money, which are then not available for use elsewhere. Experiment with the right measures to apply before deciding which ones to keep and use.

Profit Performance Reports

Keep reports simple by using headings to categorise the report and visual means for displaying information. Show trends graphically in a suitable form to make their message clear to users. Use balloon notations in the graphs to highlight issues that need attention. Apply colour and font variations to enliven the report.

When a table is required to list details show summary entries and totals for each category. Keep the details for when people ask. Draw people's attention to the conclusions and their implications by providing an executive summary at the top of the report.

Conclusion

Engineering asset management is as much about the wise use of money as it is about the wise use of operational management, engineering and maintenance to deliver top performance from production equipment and processes. By fully understanding the costs and money flows in a production operation, its managers and employees can make good decisions that are effective and efficient for the well-being of the business, the shareholders, themselves and their community.

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Appendix

The Many Components of Production Costs

- Labour : both direct and indirect
  - operators
  - repairers
  - supervisory
  - management
  - engineering
  - Overtime / penalty rates
- Product waste
  - scrap
  - replacement production
  - clean-up
  - reprocessing
  - lost production
  - lost spot sales
  - off-site storage
- Services
  - emergency hire
  - sub-contractors
  - travelling
  - consultants
  - utility repairs
  - temporary accommodation
- Materials
  - replacement parts
  - fabricated parts
    - materials
    - welding consumables
    - workshop hire
  - shipping, loading, transport
  - storage
    - space
    - handling
  - disposal
  - design changes
  - inventory replenishment
  - quality control
- Equipment
  - energy waste
  - start-up
  - shutdown
  - inefficiencies
  - emergency hire
  - damaged items
  - moving in, out, about
- Additional capital
  - replacement equipment
  - new insurance spares
  - buildings and storage
- Consequential
  - penalty payments
  - lost future sales
  - legal fees
  - loss of future contracts
  - environmental clean-up
  - death and injury
- Administration
  - documents
  - purchase orders
  - meetings
  - planning and schedule changes
  - investigations and audits
  - invoicing and matching
  - utilities