Having defined and discussed some of the more commonly used costing and accountancy terms, we are now in a position to investigate the major types of costing systems used in manufacturing industry.

When a company is deciding the prices it is going to charge for its products, it has to have a basis on which to compute these. There are three essential requirements for such a system:

- it must ensure that all costs are recovered;
- it must include the required element of profit; and
- it must be competitive.

Whatever system is used it should reflect how easy or difficult the product is to make and take account of any extra requirements like secondary operations (e.g., hot foil stamping/annealing) or special packaging and so on.

There are several different methods of costing and each company will have its own preferences. The actual method used is not as important as whether the chosen system works. The simpler the system is, the easier it will be to understand and implement.

However, there are four main costing systems that we will now examine in detail:

- Standard costing
- Absorption costing
- Marginal costing
- Machine hourly costing.
3.1 Standard Costing

This is arguably the most used costing method for the manufacturing industry. It is based on setting specific standards for each manufacturing activity or process. These standards are agreed between all the interested parties within the company and represent normal, reasonably efficient manufacturing performance.

It is most important to note that this system is not based on targets or goals based on optimum manufacturing performance that may or may not be achieved.

There are several advantages to using a standard costing system which are summarised below:

- It measures the expected performance at all levels in the company.
- It provides a standardised product costing system that can be used for direct product pricing comparison.
- It provides a system that may be used for non-financial assessment. For example:
  - labour and management performance; and
  - machine and equipment performance.
- It gives a stable platform for taking major management decisions like:
  - product pricing for new or existing lines; and
  - production capacity assessment.
- It provides a standardised system for developing future growth plans.

For new products, the initial standard cost will have to be based on previous experience with other similar products and subsequently developed and refined as more accurate costs become known.

It is essential that each company has a clearly defined meaning for its standard costing system and ensures that it is completely understood and implemented properly.

The following guidelines would be typical of a manufacturing business based on allowable expenditure for:

- direct material costs;
- direct labour costs; and
• production overhead costs (including depreciation allowances).

Additionally it must be based on manufacturing at a standard level of production and achieve the following:

• the required quality level;
• the required rate of production;
• the necessary functional performance; and
• the designated level of efficiency (not an optimum goal).

Example. This example illustrates a standard costing analysis for a typical product. Table 3.1 gives the ABC standard costing for an industrial pump per unit. From this table, the standard costing for this item is 1016p.

If these products were produced in high quantities, small variations in any of the individual costs can affect the profitability of the project quite significantly.

This is why it is so important to ensure that all individual cost components accurately reflect realistic performance levels and not targets. Standard costings based on overoptimistic targets frequently lead to reduced profitability. This effect will be amplified in high-quantity production.

### 3.2 Absorption Costing

Absorption costing is a method that ensures that all the manufacturing costs are absorbed (or recovered) by the products produced. In other words, the cost of a product will include direct and indirect labour and both the variable and fixed overheads.

This method is often referred to as a full costing or complete absorption method. It ensures that all costs are recovered.

#### 3.2.1 Steps in Introducing an Absorption Costing System

1. Identify and make an accurate assessment of all costs in the business.
2. Classify these costs into cost categories.
3. All direct costs are allocated to the manufacturing output.
### Table 3.1 Standard costing example

<table>
<thead>
<tr>
<th>Part</th>
<th>Source</th>
<th>Standard unit time (s)</th>
<th>Quantity per unit</th>
<th>Material cost per unit (p)</th>
<th>Labour cost per unit (p)</th>
<th>O/head cost per unit (p)</th>
<th>Total cost per unit (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump body</td>
<td>ABC</td>
<td>20</td>
<td>1</td>
<td>20</td>
<td>12</td>
<td>80</td>
<td>112</td>
</tr>
<tr>
<td>Pump lid</td>
<td>ABC</td>
<td>15.5</td>
<td>1</td>
<td>16</td>
<td>9</td>
<td>62</td>
<td>87</td>
</tr>
<tr>
<td>Seal</td>
<td>Ext</td>
<td>Nil</td>
<td>2</td>
<td>16</td>
<td>9</td>
<td>62</td>
<td>87</td>
</tr>
<tr>
<td>Lever arm</td>
<td>ABC</td>
<td>18</td>
<td>1</td>
<td>12</td>
<td>5</td>
<td>45</td>
<td>62</td>
</tr>
<tr>
<td>Float</td>
<td>ABC</td>
<td>35</td>
<td>1</td>
<td>18</td>
<td>15</td>
<td>20</td>
<td>53</td>
</tr>
<tr>
<td>Counter weight</td>
<td>Ext</td>
<td>Nil</td>
<td>1</td>
<td>55</td>
<td>Nil</td>
<td>25</td>
<td>80</td>
</tr>
<tr>
<td>Switch housing</td>
<td>ABC</td>
<td>17</td>
<td>1</td>
<td>12</td>
<td>8</td>
<td>18</td>
<td>38</td>
</tr>
<tr>
<td>Switch</td>
<td>Ext</td>
<td>Nil</td>
<td>2</td>
<td>85</td>
<td>Nil</td>
<td>12</td>
<td>97</td>
</tr>
<tr>
<td>Assembly</td>
<td>ABC</td>
<td>185</td>
<td>1</td>
<td>Nil</td>
<td>55</td>
<td>215</td>
<td>270</td>
</tr>
<tr>
<td>Packaging</td>
<td>ABC</td>
<td>11</td>
<td>1</td>
<td>27</td>
<td>35</td>
<td>105</td>
<td>167</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td><strong>301.5</strong></td>
<td><strong>12</strong></td>
<td><strong>280</strong></td>
<td><strong>139</strong></td>
<td><strong>597</strong></td>
<td><strong>1,016</strong></td>
</tr>
</tbody>
</table>

**Notes:**
1. Entries listed 'ext' are bought out items from external suppliers and hence have no labour content. However, they attract an overhead charge to cover purchasing and processing costs, etc.
2. The following activities have been included in the costing: design drawings; inspection and quality control; an allowance for wastage and rejects; amortised tool costs where applicable; plant and equipment used; purchasing costs; storage costs.
3. Labour costs are based on standard times established through work study analysis.
4. Overheads used are those allocated per cost centre. (Note that these could also be based on a standard overall (global) cost allocation.)
4. Allocate all the indirect costs to individual service departments.

5. Re-allocate the costs from production support services to production departments.

6. Establish an accurate overhead rate.

7. Absorb all direct and indirect overhead costs into each product.

3.2.2 Absorption Rate

The absorption rate (also known as the recovery rate) is the method of assigning overheads to a product or service and may be based on:

1. Direct labour hours.
2. Direct material costs.
4. Units of output.
5. Percentage of the product sales prices.

If a company is producing several different products then each of these may attract a different absorption rate because each product may make a greater or lesser demand on support services like purchasing or human resources.

For each product, all production costs directly associated with it and all related overheads are allocated to this product cost centre.

However, sometimes it is possible to establish an overall relationship between certain costs for the manufacture of a wide range of different products.

Example. A company manufactures a large range of different products with the overall production costs given in Table 3.2.

It has been established that there is a close relationship between the material costs for each product and the overhead cost. In this case the absorption rate would be

\[
\frac{\text{Direct material cost}}{\text{Total overhead}} = \frac{585}{730} = 0.8 = 80\%
\]
This relationship can now be used to determine individual product costings (Table 3.3). In this case, there is a relationship between direct material costs and the manufacturing overhead cost. However, any other cost may be used as a base for a similar relationship – like the labour or total costs.

If a global relationship like this can be established, it clearly makes for a simpler method. If such a relationship cannot be established then each product would include its own individual overhead allocation as previously explained.

Table 3.3 shows the basic absorption of manufacturing overhead costs. This shows the product costing for manufacturing overheads but there are other overheads that have to be added to these. Examples are selling and distribution costs which may be a mixture of direct and indirect costs and advertising campaigns for specific products or global advertising. These non-specific costs are usually absorbed in one of the following ways:

- as a percentage of the selling price;
- as a rate per unit; and
- as a percentage of the manufacturing costs.

**Table 3.2 Production costs**

<table>
<thead>
<tr>
<th></th>
<th>Cost (£000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct materials</td>
<td>585</td>
</tr>
<tr>
<td>Direct labour</td>
<td>550</td>
</tr>
<tr>
<td>Direct works expenses</td>
<td>175</td>
</tr>
<tr>
<td>Total cost</td>
<td>1,310</td>
</tr>
<tr>
<td>Total overhead</td>
<td>730</td>
</tr>
<tr>
<td>Total works cost</td>
<td>2,040</td>
</tr>
</tbody>
</table>

**Table 3.3 Basic absorption costing for three typical products**

<table>
<thead>
<tr>
<th>Category</th>
<th>Product A (£)</th>
<th>Product B (£)</th>
<th>Product C (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>25</td>
<td>35</td>
<td>15</td>
</tr>
<tr>
<td>Labour</td>
<td>20</td>
<td>38</td>
<td>12</td>
</tr>
<tr>
<td>Expenses</td>
<td>15</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Total cost</td>
<td>60</td>
<td>85</td>
<td>32</td>
</tr>
<tr>
<td>Works overhead</td>
<td>20 (25 × 80%)</td>
<td>28 (35 × 80%)</td>
<td>12 (15 × 80%)</td>
</tr>
<tr>
<td>Total works cost</td>
<td>80</td>
<td>113</td>
<td>44</td>
</tr>
</tbody>
</table>
3.2.2.1 Percentage of the Selling Price

This method is usually used where sales are made through a variety of different sales outlets. For example:

- a direct sales force;
- through national distributors;
- through local dealers;
- retail chain stores;
- online sales via a web site; or
- through agents.

Each one of these categories will require a different discount from the nominal sales or list price. Table 3.4 shows the absorption of selling and distribution costs for four categories.

The published list price is rarely charged out in full but serves as a base figure against which discounted prices are established. This example shows that the company will have to manufacture this product at 48% of the list price to absorb or achieve the manufacturing costs + profit margin.

This method is also useful for establishing the optimum ex works or production cost of a product by using the list price of a competitor’s product and working backwards.

| Table 3.4 Absorption of selling and distribution costs |
|-----------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| List price                                   | 100             | 100             | 100             | 100             |
| Discount                                     | 12              | 40              | 45              | 30              |
| Total sales revenue                          | 88              | 60              | 55              | 75              |
| Sales and distribution costs                 | 40              | 12              | 7               | 27              |
| Production cost + profit                     | 48              | 48              | 48              | 48              |
3.2.2.2 Rate Per Unit

This method allocates a separate proportion of the total overhead costs to each product item so that all the overhead costs are absorbed by the total of all of the products manufactured.

Fixed costs like rent, insurance, showrooms, etc., can be allocated by the turnover of the product or by product volume. The variable costs can then be allocated on a rate per item basis. This method is shown in Table 3.5. These results are added to the manufacturing costs per unit plus a profit element if one has not already been included.

| Table 3.5 Absorption of selling and distribution costs on rate per unit basis |
|--------------------------------------------------|------------------|------------------|------------------|
| Category                                         | Product A         | Product B         | Product C         |
| Fixed costs                                      | £10,000           | £20,000           | £50,000           |
| Sales volume                                     | 15,000            | 40,000            | 100,000           |
| Fixed cost per unit                              | £0.67             | £0.50             | £0.50             |
| Variable costs per unit                          | Nil               |                  |                  |
| Packing costs                                    | £0.35             | £0.30             | £0.40             |
| Delivery costs                                   | £0.25             | £0.30             | £0.20             |
| Commissions                                      | £0.30             | £0.30             | £0.35             |
| Sales and distribution cost per unit             | £1.57             | £1.40             | £1.45             |

3.2.2.3 Percentage of the Manufacturing Cost

This system is used where the products are of a similar nature or a similar price. In this case it should be relatively straightforward to establish a fixed percentage to add on for administration and selling costs. In Table 3.1, the production cost was established as £101.60. Using this figure, the final product cost can be arrived at as shown in Table 3.6. In this case the percentage added is the standard company figure for this product.

| Table 3.6 Absorption by adding percentage of the manufacturing cost |
|---------------------------------------------------------------|------------------|
| Standard cost from Table 3.1                                 | £10.16           |
| Distribution costs                                           | £3.50            |
| Administration and selling costs at 12%                       | £12.19           |
| Total                                                        | £12.54           |
3.3 Marginal Costing

With both standard costing and absorption costing, the allocation of fixed and overhead cost can be complex (but necessary) to analyse and apply to establish complete costings.

Costs behave in different ways as the production or sales volumes change. In marginal costing it is the behaviour of the associated costs that is measured rather than the origin of the cost. It measures relative effects rather than total costing. It determines the change in cost that occurs when the output volume changes by one unit. This is quantified by the total variable cost for a single unit.

To carry out a marginal costing analysis it is first necessary to identify the fixed and variable cost elements. The following example demonstrates the procedure for establishing a marginal costing for a small company producing a single product.

*Example.* Table 3.7 summarises the procedure for establishing a marginal costing. To look at these results on a marginal costing basis, it is necessary to rearrange the figures as shown in Table 3.8.

With each product the company sells, it will receive £1.25, and, as this is greater than the £0.42 variable cost, there will be a *contribution* to cover the fixed costs. Hence, \( \text{contribution} = \text{sales value} - \text{variable costs} \) – in this case £0.83 per unit. It directly follows therefore that \( \text{profit} = \text{contribution} - \text{fixed costs} \) – in this example £0.17.

<table>
<thead>
<tr>
<th>Table 3.7 Cost analysis for 160,000 units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
</tr>
<tr>
<td>Sales (160,000 units)</td>
</tr>
<tr>
<td>Costs</td>
</tr>
<tr>
<td>Direct materials</td>
</tr>
<tr>
<td>Direct labour</td>
</tr>
<tr>
<td>Production overheads</td>
</tr>
<tr>
<td>Sales and marketing</td>
</tr>
<tr>
<td>Development</td>
</tr>
<tr>
<td>Administration</td>
</tr>
<tr>
<td>Distribution</td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
</tr>
<tr>
<td><strong>Net profit</strong></td>
</tr>
</tbody>
</table>
The results from this analysis reveal an important point. That is, if more than 160,000 products are sold, the profit will increase as the fixed costs cannot change. Hence for each additional product sold, the profit on a marginal basis is equal to the contribution – in this case £0.83.

These results can also be demonstrated on a graph that gives a convenient method for viewing the effect of varying different parameters (Figure 3.1). This clearly demonstrates how increasing output, and hence sales, increases the profit. It also shows the break-even point, which is simply the point at which the number of items sold is sufficient to make the sales revenue equal to the total costs.

In this case this figure is around 127,000 items sold which corresponds to £159,000 of sales. If more items than this are sold, a profit will result. If less than this number is sold, a loss will result where the costs exceed the sales revenue.

Figure 3.2 shows how the basic graph is constructed.

1. Establish a table similar to Table 3.8 based on your figures.

<table>
<thead>
<tr>
<th></th>
<th>£</th>
<th>£ per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>200,000</td>
<td>1.25</td>
</tr>
<tr>
<td>Less variable costs</td>
<td>67,500</td>
<td>0.42</td>
</tr>
<tr>
<td>Contribution</td>
<td>132,500</td>
<td>0.83</td>
</tr>
<tr>
<td>Less fixed costs</td>
<td>105,500</td>
<td>0.66</td>
</tr>
<tr>
<td>Net profit</td>
<td>27,000</td>
<td>0.17</td>
</tr>
</tbody>
</table>

2. Draw the axes for the sales/costs and number of item sold.

3. Draw a line from point A horizontally across the graph representing the budgeted sales – in this case £200,000.

4. Draw a line vertically upwards to represent the number of items sold – in this case 160,000.

5. These two lines will intersect at point C.

6. Draw a line from the origin through point C and continue it a little further.
7. Draw another line horizontally from point B at a distance up the sales/costs axis representing the total costs (variable + fixed costs) – in this case £173,000. Where this line intersects the vertical line already drawn we obtain point D.

8. Now draw a line from point F through point D and extend it a little further.

9. The break-even point is the intersection of these two lines at E.

The figures obtained from the graph give a reasonable estimate but, of course, will depend upon the accuracy with which the graph has been drawn and interpreted. For
those who prefer a more accurate graphical method, a Microsoft Excel spreadsheet may be used (Figure 3.3). A better visual result is obtained by altering the row and column sizes to suit the figure involved.

An alternative algebraic approach gives an accurate result and can be put into program form in a computer for added convenience.

Using basic algebra, the break-even point can be established by the following equation where all figures have been taken from Table 3.8:

Figure 3.2 Basic construction of break even graph for data in Table 3.8
where $S = \text{sales value, } V = \text{variable costs, } F = \text{fixed costs, } N = \text{number of items sold}$ and $B = \text{number of items required to be sold to break even.}$ We can simplify and transpose Equation (3.1) to give

$$B = \frac{N \times F}{S - V}$$

(3.2)
If we now substitute the values from Table 3.8 in Equation (3.2), we get
\[
B = \frac{160,000 \times 105,500}{200,000 - 67,500} = 127,396
\]
which corresponds to \(127,396 \times £1.25 = £159,245\) of sales.

Looking again at the graph in Figure 3.1 we can also see that we can determine the profit as the sales or the number of items sold increases. For example, if 200,000 parts were sold we could expect the profit to increase to approximately £60,000.

We can similarly arrive at an equation to determine this algebraically:

\[
P = \frac{S \times N_v}{N} - \left( \frac{V \times N_v}{N} - F \right)
\]

(3.3)

where \(P = \text{profit}\) and \(N_v = \text{different number of items sold, chosen for the analysis}\). On simplification this gives:

\[
P = \frac{(S - V)N_v}{N} - F
\]

(3.4)

Substituting the values from Table 3.8 gives:

\[
P = \left( \frac{200,000 - 67,500}{160,000} \right) \times 200,000 - 105,500
\]

\[
= 0.828 \times 200,000 - 105,500
\]

\[
= £60,100
\]

Note that Equations (3.2) and (3.4) are powerful results allowing other variables to be established once the break-even condition is known, for example establishing what the variable cost will be for a given level of profit. Another useful result is writing:

\[
C = S - V
\]

where \(C = \text{contribution}\) since \(C = \text{sales minus variable costs}\). Hence, Equation (3.4) may be written as:
3.4 Machine Hourly Rates

This method of costing is frequently used where the majority of production is machine based. For example:

- injection moulding;
- blow moulding; or
- extrusion.

Clearly it would cost more to run a larger machine than a smaller one since:

- the capital cost is greater;
- the energy required to operate it is greater; and
- the maintenance and servicing costs are greater.

These facts must be reflected in the prices charged for manufacturing parts.

The difficulty is in establishing the amounts to charge for different size machines and for machines of differing ages. A number of methods have been developed for taking this into account, including those previously discussed, but by far the most frequently used is based on the *machine rate per hour* (or machine hourly rate, MHR).

First of all we will examine what would happen if we only had one machine. This is, of course, very unlikely in practice but it illustrates the principle more clearly. We will then extend this principle to any number of machines. The following analysis is based on injection moulding but a similar procedure can be adopted for any primarily machine-based production activity.

3.4.1 Computation of the MHR

The following analysis applies to an injection moulding operation only, based on custom moulding or general trade moulding.

There is no way of knowing in advance exactly what the mix of new work will be: whether the parts will be large or small, how many impressions the mould tools will be, what materials will be required and so on.
This is where analysis of past performance is extremely valuable. From such information we should know:

- the invoiced sales;
- the total cost of all moulding materials used;
- the energy costs;
- all other direct and indirect costs.

In fact by analysing the figures from several previous years, a trend can be established without too much difficulty. For example, previous labour costs can be projected forward, as can energy and several other costs. There may well be a variation from year to year but these can be averaged out.

Example. To illustrate this we will re-introduce our fictitious injection moulding company, ABC Products Ltd (ABC). The board of ABC has decided the performance for the forthcoming year:

- Invoiced sales: £10,000,000.
- Profit required: 15%.

This is based on previous years’ figures given in Table 3.9, in which the material usage factor is defined as

\[
\text{Material usage factor} = \frac{\text{Cost of materials used}}{\text{Invoiced sales}} \times 100\% 
\]

From this analysis we can establish the average of the last three years’ material usage factors: \((29 + 31 + 28.5)/3 = 29.5\%\).

The decision is taken in this case to adopt 30\% for the forthcoming year. In view of this we can establish the following:

<table>
<thead>
<tr>
<th>Table 3.9 Analysis of previous years’ figures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year 1</strong></td>
</tr>
<tr>
<td>Invoiced sales</td>
</tr>
<tr>
<td>Materials used</td>
</tr>
<tr>
<td>Material usage factor</td>
</tr>
</tbody>
</table>
Methods of Costing

invoiced sales: £10,000,000

less profit (15%): £1,500,000 = £8,500,000

less materials used (30%): £3,000,000 = £5,500,000.

This means that all remaining costs will have to fall within £5,500,000.

The accountant and production manager have established to support this level of sales that all remaining costs (except material costs) amount to £5,000,000. This is less than the projected ‘surplus’ of £5,500,000 and leaves a factor of safety of £500,000 – a 10% margin on costs in case the actual costs are higher than expected.

ABC works a 125-hour week, 50-week year, giving a utilisation of 6,250 hours per year – a UF of 74.5%. From similar analyses of previous years’ performance it is known the efficiency factor is 80%. With this information, we can now establish the average MHR for one (virtual) machine.

If we can imagine for a moment that ABC does have only one machine, all the costs of all work processed on it would be charged out in two basic parts:

1. The cost for the material.
2. A charge to cover all other costs.

The material cost would depend on the size of the parts, the runner system and the price of the material – the costs varying from job to job. Hence, these costs would have to be charged separately.

The machine charge would have to cover all the remaining costs. In order to do this we have to predict how many hours per year the machine is going to be actually producing parts and divide this figure into these costs. This gives us a machine rate per hour. Dividing this by 3,600 would give the machine cost per second.

If we then estimate the cycle of a job, we can determine how much we should charge per shot by multiplying the cycle by the machine cost per second. This gives a machine cost for the shot. Adding this cost to the material cost for the shot gives us the total cost for producing one shot. Dividing this figure by the number of impressions in the shot will give the cost per part.

To illustrate this procedure we will establish the MHR for one machine for the company ABC as follows:

Total number of hours worked = 6,250
Budgeting, Costing and Estimating for the Injection Moulding Industry

Productive hours worked = 5,000 \times (6,250 \times 80\%) per year

Total costs to be recovered = £5,500,000

Therefore average MHR = £5,500,000/5,000 = £1,100.

Clearly it would be an understatement to say achieving a turnover of £10,000,000 with one machine with an MHR of £1,100 would be difficult!

We will now assume that ABC has 14 machines ranging from 25 tonne lock to 350 tonne lock and that its policy is to depreciate all machines over five years on a straight-line basis. The details of these machines are given in Table 3.10.

All that remains now is to apportion the MHR of £1,100 for this single machine over all the machines the company has. There are several methods used to achieve this but we will concentrate on four:

- capital cost method;
- machine lock method;
- book value method; and
- kVA (kilovolt ampere – see appendix) rating method.

<table>
<thead>
<tr>
<th>M/C lock</th>
<th>No.</th>
<th>Age (years)</th>
<th>Original cost each (£)</th>
<th>Total cost (£)</th>
<th>Depreciation each/year (£)</th>
<th>Book value (£)</th>
<th>Total book value (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>2</td>
<td>2</td>
<td>25,000</td>
<td>50,000</td>
<td>5,000</td>
<td>15,000</td>
<td>30,000</td>
</tr>
<tr>
<td>50</td>
<td>1</td>
<td>1</td>
<td>35,000</td>
<td>35,000</td>
<td>7,000</td>
<td>28,000</td>
<td>28,000</td>
</tr>
<tr>
<td>50</td>
<td>2</td>
<td>1</td>
<td>40,000</td>
<td>80,000</td>
<td>8,000</td>
<td>32,000</td>
<td>64,000</td>
</tr>
<tr>
<td>100</td>
<td>3</td>
<td>3</td>
<td>70,000</td>
<td>210,000</td>
<td>14,000</td>
<td>28,000</td>
<td>84,000</td>
</tr>
<tr>
<td>250</td>
<td>1</td>
<td>4</td>
<td>150,000</td>
<td>150,000</td>
<td>30,000</td>
<td>30,000</td>
<td>30,000</td>
</tr>
<tr>
<td>250</td>
<td>2</td>
<td>1</td>
<td>210,000</td>
<td>420,000</td>
<td>42,000</td>
<td>168,000</td>
<td>336,000</td>
</tr>
<tr>
<td>350</td>
<td>2</td>
<td>2</td>
<td>375,000</td>
<td>750,000</td>
<td>75,000</td>
<td>225,000</td>
<td>450,000</td>
</tr>
<tr>
<td>350</td>
<td>1</td>
<td>4</td>
<td>150,000</td>
<td>150,000</td>
<td>30,000</td>
<td>30,000</td>
<td>30,000</td>
</tr>
<tr>
<td>Totals</td>
<td>14</td>
<td></td>
<td>1,845,000</td>
<td></td>
<td></td>
<td>1,052,000</td>
<td></td>
</tr>
</tbody>
</table>
3.4.1.1 Capital Cost Method

This consists of expressing each machine cost as a percentage of the total original capital cost for all machines:

\[
\text{Capital cost MHR} = \frac{\text{Original capital cost of machine}}{\text{Total capital cost of all machines}} \times £1,100
\]

If we take the first machine listed in Table 3.10 (25 tonnes):

\[
\text{MHR} = \frac{25,000}{1,845,000} \times 1,100 = £15
\]

3.4.1.2 Machine Lock Method

With this method the machine MHRs are grouped by their locking forces. To use this method we first need to work out the total locking force of all the machines. In this case we have:

\[
(2 \times 25) + (3 \times 50) + (3 \times 100) + (3 \times 250) + (3 \times 350) = 2,300 \text{ tonnes}
\]

Then each locking group is expressed as a fraction of the total locking force of all the machines added together:

\[
\text{Machine lock MHR} = \frac{\text{Locking group}}{\text{Total locking of all machines}} \times £1,100
\]

Taking the 25 tonne machine this gives:

\[
\text{MHR} = \frac{25}{2,300} \times 1,100 = £12
\]

3.4.1.3 Book Value Method (or Depreciation Method)

As the term implies, the book value or written down value of the machines is taken as the basis for computation for this method:
Budgeting, Costing and Estimating for the Injection Moulding Industry

Book value MHR = \frac{\text{Book value of each machine}}{\text{Total book value of all machines}} \times £1,100

The book value of the first machine is £15,000. Hence:

\[
\text{MHR} = \frac{15,000}{1,052,000} \times 1,100
\]

\[
= £16
\]

Table 3.11 gives the capital cost, machine lock and book value MHRs for all machines.

3.4.1.4 kVA Rating Method

As we have already discussed, the electrical power requirements for moulding machines generally increase as the sizes of the machines increase in terms of their locking capacity. This is the basis of the machine lock method of determining the MHR. However, it is not the most accurate method.

Whilst there is a loose relationship between locking force and power consumed, it does not represent the actual power requirement of each machine. In this respect, the locking force MHR method can best be described as a reasonable estimate, although it will still recover all the costs of running all the machines.

A more accurate method is to use the total installed power of each machine as a basis for determining the MHR. The total installed power is the maximum amount of power each machine will consume and is measured in kilowatts (kW).

It is unlikely that every job being processed will need this maximum amount of power. Clearly, in practice there will be many jobs that may only require half or less of the available power on every machine on which they run. However, the same reasoning applies to the machine lock method in the sense that many jobs will not require the maximum available locking force of the machine on which they run, and hence use less power.

The reason why the kVA method is more accurate is that it uses power directly as a basis for costing rather than the locking force method that uses the machine lock capacity to estimate the power consumption. Since the power used represents a major cost component in running a machine, this is an important factor.
Table 3.11 MHRs according to machine lock, capital cost and book value methods

<table>
<thead>
<tr>
<th>No. of M/C</th>
<th>Lock</th>
<th>Total lock</th>
<th>Original cost per M/C</th>
<th>Total original cost per M/C</th>
<th>Book value per M/C</th>
<th>Total book value per M/C</th>
<th>Depreciation per M/C</th>
<th>Total depreciation per M/C</th>
<th>Capital cost MHR</th>
<th>Machine lock MHR</th>
<th>Book value MHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>25</td>
<td>50</td>
<td>25,000</td>
<td>50,000</td>
<td>15,000</td>
<td>30,000</td>
<td>5,000</td>
<td>10,000</td>
<td>15</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
<td>50</td>
<td>35,000</td>
<td>35,000</td>
<td>28,000</td>
<td>28,000</td>
<td>7,000</td>
<td>7,000</td>
<td>21</td>
<td>24</td>
<td>29</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>100</td>
<td>40,000</td>
<td>80,000</td>
<td>32,000</td>
<td>64,000</td>
<td>8,000</td>
<td>16,000</td>
<td>24</td>
<td>24</td>
<td>33</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>300</td>
<td>70,000</td>
<td>210,000</td>
<td>28,000</td>
<td>84,000</td>
<td>14,000</td>
<td>42,000</td>
<td>42</td>
<td>48</td>
<td>29</td>
</tr>
<tr>
<td>1</td>
<td>250</td>
<td>250</td>
<td>150,000</td>
<td>150,000</td>
<td>30,000</td>
<td>30,000</td>
<td>30,000</td>
<td>30,000</td>
<td>89</td>
<td>120</td>
<td>31</td>
</tr>
<tr>
<td>2</td>
<td>250</td>
<td>500</td>
<td>210,000</td>
<td>420,000</td>
<td>168,000</td>
<td>336,000</td>
<td>42,000</td>
<td>84,000</td>
<td>125</td>
<td>120</td>
<td>176</td>
</tr>
<tr>
<td>2</td>
<td>350</td>
<td>700</td>
<td>375,000</td>
<td>750,000</td>
<td>225,000</td>
<td>450,000</td>
<td>75,000</td>
<td>150,000</td>
<td>224</td>
<td>167</td>
<td>235</td>
</tr>
<tr>
<td>1</td>
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<td>350</td>
<td>150,000</td>
<td>150,000</td>
<td>30,000</td>
<td>30,000</td>
<td>30,000</td>
<td>30,000</td>
<td>89</td>
<td>167</td>
<td>31</td>
</tr>
<tr>
<td>14</td>
<td>1425</td>
<td>2300</td>
<td>1,845,000</td>
<td>1,052,000</td>
<td>369,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Another compelling factor is that electricity suppliers normally base their charges on the maximum kVA requirement for each factory. This is because they have to ensure they can supply the maximum amount of power at all times in case it is needed.

A further case for the kVA method is that moulding machine manufacturers are now marketing machines with all-electric drives, thus eliminating the traditional hydraulic motor driven by a pump. This is designed to increase the operating efficiency and therefore reduce the power requirements substantially. However, the cost of these machines is up to 50% more than the cost of the equivalent hydraulic machines. Hence it may take several years before the savings in power costs offset the extra capital expenditure.

We re-list in Table 3.12 all the ABC machines with their kW ratings to establish the kVA MHR. The difference between kVA and kW depends on the power factor of the installed electrical supply and is discussed in the appendix in further detail.

<table>
<thead>
<tr>
<th>Locking force (tonnes)</th>
<th>Rating (kW)</th>
<th>MHR (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>8</td>
<td>18.57</td>
</tr>
<tr>
<td>25</td>
<td>10</td>
<td>23.21</td>
</tr>
<tr>
<td>50</td>
<td>15</td>
<td>34.81</td>
</tr>
<tr>
<td>50</td>
<td>15</td>
<td>34.81</td>
</tr>
<tr>
<td>50</td>
<td>16</td>
<td>37.13</td>
</tr>
<tr>
<td>100</td>
<td>18</td>
<td>41.77</td>
</tr>
<tr>
<td>100</td>
<td>19</td>
<td>44.09</td>
</tr>
<tr>
<td>100</td>
<td>19</td>
<td>44.09</td>
</tr>
<tr>
<td>250</td>
<td>50</td>
<td>116.03</td>
</tr>
<tr>
<td>250</td>
<td>53</td>
<td>123.00</td>
</tr>
<tr>
<td>250</td>
<td>56</td>
<td>130.00</td>
</tr>
<tr>
<td>350</td>
<td>63</td>
<td>146.20</td>
</tr>
<tr>
<td>350</td>
<td>65</td>
<td>150.84</td>
</tr>
<tr>
<td>350</td>
<td>67</td>
<td>155.48</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>474</td>
</tr>
</tbody>
</table>
Methods of Costing

The same procedure is used to establish the MHRs for each machine as in the previous examples. Taking the first machine in Table 3.12, we have:

\[ \text{kVA MHR} = \frac{\text{kVA rating of each machine}}{\text{Total kVA rating of all machines}} \times £1,100 \]

\[ = \frac{8}{474} \times £1,100 = £18.57 \]

It can be seen from this analysis that there are some significant differences between the machine lock MHRs listed in Table 3.11 and those obtained using the kVA method shown in Table 3.12.

3.4.2 Selecting the Best Method

3.4.2.1 Capital Cost Method

Clearly, this method weights the MHR strongly in favour of the newer and more expensive machines. The lower the original cost of the machine, the lower the MHR and vice versa.

If two machines have the same locking force but one cost more than the other, this is reflected in the MHR and thus the prices charged out.

Different MHRs for the same locking values could also be due to one machine being older than the other. Alternatively the machines could have been purchased at the same time, with one being more sophisticated than the other.

This method has the advantage of lower MHRs for older and less sophisticated machines and higher MHRs for newer machines and those with higher specifications and thus capital cost.

3.4.2.2 Machine Lock Method

This is one of the most widely used methods in the injection moulding industry and is a straightforward system related to the locking force irrespective of the original or written down values of the machines.

It does not take account of differences of quality or age of machines of the same locking force. Therefore the same MHR would be charged for an old basic workhorse as a new high-specification machine of the same lock.
3.4.2.3 Book Value Method

This method does take account of the age and value of machines and clearly weights the MHR in favour of newer more expensive machines. Once the book value of a machine reaches zero, the theoretical MHR of the machine would also be zero.

In practice, of course, a charge would still have be made for such a case since the machine would still require energy to run as well as possibly more maintenance and repair.

The effect of zero rating an MHR for a fully written down machine is to increase the MHRs of all the remaining machines, which are still being depreciated.

Whilst this method is used, it is not as widely used as the capital cost and machine lock methods. Where a machine has been fully written down, a decision has to be made regarding what should be charged. In some cases a quite low MHR is used to attract very competitive business which otherwise may be lost.

However, once a machine has been fully depreciated or written off, it should be replaced by using the funds acquired from the depreciation account – which is the whole purpose of depreciation in the first place.

3.4.2.4 kVA Rating Method

This is a similar but more accurate method than the machine lock method, but it also takes no account of the age or original cost of the machines. This method is becoming more widely used as electric-drive machines are introduced.

It also has the advantage of allowing the selection of the lowest cost machine to run a job on in the same locking group. For example, if a job requires the mould to be run on a 250 tonne machine, Table 3.12 shows which machine would be the cheapest on which to run it. By contrast, the machine lock method does not make this distinction.

3.5 Adjusting the MHR

So far, we have arrived at an MHR by grouping machines into four categories or groups:

- capital cost of the machines;
- locking force;
Methods of Costing

- book value of the machines; and
- machine kVA rating.

As we have mentioned, the actual method selected to use would depend upon the nature of the work a company undertakes.

3.5.1 Normal Difficulty Work Mix

For general trade moulding, the usual MHR method would be that based on the locking force grouping of the machines. This would not reflect the age of machines or the original prices paid for them. A company may estimate a job on their newest most expensive machine but may not be able to use a higher MHR than the oldest least expensive machine in the same locking group.

This is often simply because their competitors may estimate on the basis of running the same job on a less expensive machine within the same locking group at a lower MHR. In other words a higher MHR cannot be charged because it would not be competitive.

Should the occasional job come along that was more demanding than normal then a higher than normal MHR charge should be made to reflect this. In this case a moulder may either apply a factor of difficulty on cost to the normal MHR as discussed below or use an isolated MHR computed using the capital cost method.

3.5.2 Varied Difficulty Work Mix

If the work mixture ranges from reasonably straightforward to quite complex and technical, a company may have to purchase a range of machines with differing degrees of sophistication but within the same locking force groups.

Hence if, say, three 100 tonne machines were purchased at different prices reflecting their differing quality and sophistication, the MHR of each should be different. Each MHR would reflect the degree of difficulty, cost of running and the original cost of each machine.

This situation is a clear candidate for the capital cost method, providing the same spread of work applied generally over all machines. Should an extremely difficult job occur, a company may decide to apply a degree of difficulty factor for that one job to reflect this.
This is often applied as a percentage on cost on top of the MHR. For example, if the normal MHR for a difficult job on the ‘best’ machine was £100, then for this situation an on cost of 25% may be warranted, giving a new MHR of £125. Each case is considered on its merits and charged out accordingly.

3.6 Discussion

In practice each company will adopt its own customised costing procedure which reflects the nature of the type of work it processes. This can take the form of completely different MHR systems for different categories of work being run on the same machines: for example, one MHR for straightforward standard products and another for general trade work.

Companies that specialise in a particular field may apply a wide range of modified MHRs to cover the varying job requirements within that field. If, for example, a company does a large amount of assembly work as well as moulding, the running costs may well be split into two cost groups: one for the assembly and one for the moulding.

Each of these groups may have separate hourly charging systems for each process. In these cases the same approach may be taken by dividing the appropriate costs for each activity by the expected number of productive hours.

3.6.1 Varying MHR System

Some companies keep a very close control over costs and monitor these on a continual basis. These costs are analysed and projected forward for the remainder of that financial year. This enables the MHR figures to be continually reviewed and changed if necessary.

This gives the company the advantage of being able to offer lower prices when the predicted costs decrease and increase prices when the predicted costs rise. This system may be combined with any of the MHR systems described above.

3.6.2 Observation

Although, the examples presented above are based on injection moulding, the same approach may be used with blow moulding (based on machine size) and with extrusion processes (based on machine size or plasticising capacity).
3.7 Checking the Calculated MHR

All the calculations carried out so far are theoretical. They are modelled on predictions about turnover and hence costs. These predictions, however, are based on previous trends and results and represent the best basis we can use in advance of the event.

In view of this, it is important to continuously monitor the actual costs and review the MHR being charged.

Often, the most vulnerable predicted cost is the material usage factor. This can represent up to 50% of the total running costs of a company and is, therefore, highly significant.

Once a new financial year has started, it is vital to regularly check that this cost is within the budgeted amount. If it is significantly greater than budget, then action should be taken immediately as this could lead to a depleted profit margin or even a loss.

Indeed, all costs should be carefully checked to ensure the MHR is neither too high nor too low.

3.8 Observation

- MHR figures are rarely checked frequently enough to guarantee their accuracy.
- If each job makes a profit there should be an overall profit at the end of the year.

3.9 Summary

3.9.1 Standard Costing

- A widely used method for manufacturing industries.
- Must be based on realistic, achievable performance.
- Must not be based on targets or goals.
- Can cover a wide range of labour-based and machine-based production. Often used for a combination of both.
- Provides a standard to compare company performance and competitiveness.
3.9.2 Absorption Costing

- A method that ensures that all the manufacturing costs are absorbed (or recovered) by the products produced.
- It provides a standard or base selling price for discounting sales prices to national and local distributors and own sales force.
- The absorption rate (also known as the recovery rate) is the method of assigning overheads to a product or service and may be based on:
  - direct labour hours
  - direct material costs
  - machine production hours
  - units of output
  - percentage of the product sales prices.
- Non-specific overhead or other costs may be added as follows:
  - as a percentage of the selling price
  - as a rate per unit
  - as a percentage of the manufacturing costs.

3.9.3 Marginal Costing

- Marginal costing measures relative effects rather than total costing.
- It determines the change in cost that occurs when the output volume changes by one unit. This is quantified by the total variable cost for a single unit.
- It is a very good method for quantifying the additional profit that occurs after the break-even point has been reached.

3.9.4 Machine Hourly Rate

- The most commonly used costing system in the injection moulding industry is based on the MHR.
- The basic MHR is the total running cost (except the material cost) divided by the
Methods of Costing

number of productive hours worked in the financial year. This is further refined depending on the requirements of each company.

- The most commonly used MHR systems are based on:
  - capital costs of the machines
  - machine locking groups
  - machine book values
  - kVA machine power ratings.

- MHR systems may vary or be combined depending on the nature of the business.

- Whatever MHR system is used, it must ensure all costs (other than material costs) are recovered.

- The MHR must be checked frequently to check its accuracy.

Figure 3.4 shows a summary of the different MHR methods.

All the above analyses are based on charging out the material cost as a separate cost to the MHR due to the widely varying types and costs number of materials.

There is, however, an important exception to charging the material cost separately. If a company is using a single material only for all its products then it is easier to include this in the MHR. For example, a company producing, say, disposable tableware comprising cups, saucers, cutlery, beakers and so on all in high-impact polystyrene, the material cost would be included in the MHR.

3.10 Combined Costing Systems

There are many occasions when a company may choose to operate a number of different costing methods simultaneously. This can occur when a company is producing a range of standard products that require a number of different manufacturing processes of which the injection moulding process is just one. In this case, it is usual to adopt a costing system that may include all the different costing methods so far described treating each operation as a separate cost centre. For example, a company manufacturing a hair dryer may have the following production stages:

- injection moulding to produce the main body parts;
- insertion of metal inserts into body mouldings;
Budgeting, Costing and Estimating for the Injection Moulding Industry

- printing;
- electrical subassembly; and
- final assembly.

In this case, the costing system may look like that shown in Figure 3.5.

If a company were making several standard products all of which use injection moulded parts made from the same material, the costing model may change. In such cases, the company will try to minimise the number of machine locking groups it has for maximum versatility and economy to ensure:

Figure 3.4 MHR costing summary
Methods of Costing

- interchangeability of mould tools between several machines in the same locking group;
- purchasing advantages in buying several machines of the same locking group at the same time; and
- standardisation of support equipment on identical moulding machines.

For example, this operation may be based on just three locking groups, say 10 of each of 50, 150 and 250 tonne machines.

With large production volumes, the material would be stored in silos and delivered automatically to the moulding machines thus eliminating contamination and labour costs.

<table>
<thead>
<tr>
<th>Production Stage</th>
<th>Activity</th>
<th>Costing method</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injection moulding</td>
<td>Manufacture of main body parts and smaller components</td>
<td>MHR system for machines based on locking groups or kVA rating</td>
<td>Costed separately</td>
</tr>
<tr>
<td>Inserting</td>
<td>Primarily a labour based activity on pre-assembly stage</td>
<td>Based on standard costing method</td>
<td>Included in costing</td>
</tr>
<tr>
<td>Printing</td>
<td>Fully automated process</td>
<td>MHR system for machines.</td>
<td>Costed separately</td>
</tr>
<tr>
<td>Sub assembly</td>
<td>Mainly labour based</td>
<td>Based on standard costing method</td>
<td>Included in costing</td>
</tr>
<tr>
<td>Final assembly</td>
<td>Semi automatic</td>
<td>Based on standard costing method or absorption method</td>
<td>Included in costing</td>
</tr>
</tbody>
</table>

Figure 3.5 Costing model for hair drier production
Such an operation is a prime candidate for the standard costing model since:

- only one moulding material is being used for the moulding operations;
- the moulding machine costs should be well known as relatively few mould tools are being used; and
- all the other operating costs and material costs will be accurately known through continual reassessment.

Frequently, companies will develop their own custom costing methods that consist of a combination of the methods previously discussed. Costing systems will naturally evolve to suit the type of business and the markets each company is serving. As market trends change, costing systems may have to change to stay in tune with that particular market.