So what is the process industry? I found one of the best and simplest definitions in an article written for *Process Industry Journal*. This states that in the process industry, “ingredients are not so much assembled as blended together – stirred, if you prefer”. This defines the type of manufacturing systems used in the process industry, since it excludes industries which mass manufacture, or which assemble finished products from components. You cannot mix up components to make a calculator. Process industries mix, blend, and (chemically) synthesise raw materials into finished products.

An easy way to remember what is included in the process industry, and the reasons why material mix and yield variances are relevant to that industry, is a baking analogy. If you are aware of the problems and difficulties associated with home baking, you will find that the issues faced by process industries are similar, albeit on a larger scale. Once you understand this, you can go on to look at why material mix and yield variances are largely unique to this sector. The best way of illustrating this is to compare component-based manufacturing with process manufacturing.

A precise number and type of components is required to make a finished product in the component industry, and a bill of materials contains details of the components required to make a product such as a calculator. Consequently, it is simple to determine how many components are needed to make a particular number of finished products. The situation in the process industry is rather different since its manufacturing processes use dimensionless raw materials, not discrete components. So what does this mean in practice? Dimensionless raw materials are liquids, fluids, powders, solids or gases. The best way of illustrating them is to consider the type of raw materials that are required to make a particular product.

In order to make a cake, for example, a variety of ingredients are required and the recipe indicates the relative proportions of each one. These ingredients are held in bulk in silos or containers, and the amount used is determined by the size of the batch to be made – 100 kg, 500 kg etc. The same product is made in different sizes. Formulations, the recipes of the process industry, are based on percentages, eg 20 per cent of A, 50 per cent of B, or 30 per cent of C. Ingredients are also expressed in physical quantities, eg kilograms.

A typical formulation for coatings/paints would be as follows:

<table>
<thead>
<tr>
<th>Material mix</th>
<th>Std mix %</th>
<th>Input at std mix %</th>
<th>Actual input</th>
<th>Variance (kg)</th>
<th>Standard cost of ingredients £</th>
<th>Variance (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D735</td>
<td>20%</td>
<td>23,880</td>
<td>25,200</td>
<td>1,320 (A)</td>
<td>£3.50 per kg</td>
<td>£4,620 (A)</td>
</tr>
<tr>
<td>R128</td>
<td>50%</td>
<td>59,700</td>
<td>58,300</td>
<td>1,400 (F)</td>
<td>£0.82 per kg</td>
<td>£1,148 (F)</td>
</tr>
<tr>
<td>F215</td>
<td>30%</td>
<td>35,820</td>
<td>35,900</td>
<td>80 (A)</td>
<td>£2.00 per kg</td>
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119,400       | 119,400   | 0                  | £3,632 (A)   |

Note: (A): adverse; (F): favourable.

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The nature of the manufacturing processes in the two sectors gives rise to different types of losses. It is possible, although it is highly unlikely, to have a 100 per cent efficient process in the component industry, since all losses result from mistakes: defective components, breakages etc. The situation is rather different in the process industry where losses are always an inherent part of the manufacturing process. Industrial bakers, for example, face many of the same issues as home bakers:
- all of the raw materials cannot be extracted from storage containers;
- it is not possible to scrape clean mixing bowls and mixer blades;
- residue is left in ovens after baking.

Losses occur because it is not possible to devise a perfect manufacturing system. And even if it were possible to create a 100 per cent efficient system, it would probably not be financially viable to implement it. Process industry formulations must therefore take account of these expected losses.

While most process industries face losses similar to those described, some also have manufacturing processes that require losses to be made to enable production to take place. Solvent, for example, when it is used to aid the manufacture of coatings, is extracted at a later stage to produce a more viscous product. Different quantities of solvents must be used to make the same product in different parts of the world because of the effect of varying climates. Some production processes require a chemical reaction for production to take place. Materials are lost from a process if a chemical reaction produces heat.

Another feature that is unique to process industries is the ability to make the same product from a number of different formulations. This may result from the inability of systems to measure weights to decimal places, or from an adjustment being made to take account of slightly different chemical qualities of one of the ingredients. The most extraordinary situation occurs when the same product can be made from totally different recipes. It is sometimes possible, for example, to make the same resin from natural raw materials, synthetic materials, or a combination of natural and synthetic ingredients. The decision about which recipe to use is based on cost and availability of materials.

The losses and issues described above are unique to the process industry, and this is why material mix and yield variances provide useful information.

The following actual data was obtained for May's production of Basecoat 5:

<table>
<thead>
<tr>
<th>Material</th>
<th>Input (Kg)</th>
<th>Output (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D735</td>
<td>25,200</td>
<td>114,100</td>
</tr>
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<td>35,900</td>
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The material mix variance calculates the financial impact of the actual mix of raw materials being different from the expected mix. This variance is concerned with inputs to a process. A material mix variance will occur when the relative proportions of the raw material that are actually used to make a product differ from the relative proportions contained in the formulation. Like all variances, this does not explain why it has happened, it merely indicates that a (favourable or adverse) variance has occurred. The variance must be investigated, and then appropriate action can be taken.

Possible reasons include:
- inaccurate measurement systems;
- operator/machine error;
- a formulation adjustment because of the chemical properties of a raw material;
- an alternative recipe used because of a shortage of supply of the preferred raw materials.

Table A shows the adverse material mix variance. It indicates that more of the higher value raw material (D735) and less of the cheaper raw material (R128) was used to make Basecoat 5 in May.

The material yield variance calculates how the financial impact of the actual yield can differ from the expected yield – ie when output is greater or lesser than expected. The reasons why a variance has occurred must be determined, and then appropriate action can be taken. Possible reasons include:
- failure to extract enough materials from mixing bowls;
- operator/machine error;
- inefficient/ineffective chemical reaction.

The favourable material yield variance produced above, indicates that the output in May was greater (95.56 per cent) than had previously been expected (95 per cent).

It is also possible for yield to be affected by inputs in some manufacturing processes. Material mix and yield variances must therefore be viewed in combination to see whether the decision, for example, to include a more expensive mix of raw materials, has produced a favourable material yield variance that can outweigh the adverse material mix variance.

Process industries are characterised by manufacturing systems which blend, mix or synthesise raw materials into finished products. Material mix and yield variances provide a valuable insight into these manufacturing processes since they combine dimensionless raw materials, and losses are an integral part of these processes. While many process industries are highly technical, the easiest way to remember the issues associated with this sector is just to think of what happens when you mix together an egg, fat, flour and sugar.

Note: understanding the nature of material mix and yield variances is just a start. They can be calculated using a variety of different methodologies, and a further article in CIMA Insider will consider in detail how these should be used.

Graehme Steven is at Napier University

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