comprehensive description of the product characteristics wanted by the target consumers who are more clearly identified. The market research gives an indication of the probable sales of the product, the position of the product in the market, the possible prices, promotion and market channels. The technical study describes the possible products, processes and the probable costs and time for development and production. By a qualitative evaluation of the suitability of the product concepts and a quantitative estimation of the profits and costs ratio, and by predictions of the probabilities of successful development and launching, the most suitable product concepts for development can be selected.

The various activities needed for the project are firstly developed in the outcomes and then in the building of the product design specification. They are all brought together and integrated in the **operational plan** for directing and controlling the project. For the plan:

- list all the major activities;
- place them in a logical sequence, noting activities that run in sequence, in parallel, and those that need to be integrated (**project logic flow plan**);
- time each activity from start to finish (**project scheduling plan**);
- identify the money, resource needs, personnel, for each activity (**project resource plan**);
- identify activities that are critical for time and resources (**critical path network**).

Review the network so that it meets the required launch date and is within the resources designated for the project (**project operational plan**).

3.2 Product design and process development

The themes for Stage 2: product design and process development, are integration, creativity, systematic planning and monitoring. Food product development is process-intensive, the characteristics of the product are highly constrained by the processing. Therefore the process and the product are developed together. This tight integration of process development and product design, called concurrent or simultaneous engineering, is becoming more important because of the time and cost constraints on getting the product to the market (Fox, 1993; Stoy, 1996). Jonsdottir *et al*. (1998), reviewing concurrent engineering in seafood companies, defined the overall goal of concurrent engineering as quality, cost, schedule, product user requirements and reduction of the time the product takes to reach the market. They emphasised the information technology applications in product models, in particular the knowledge of the product's functional and structural characteristics, and the development of a system model that secures the integration and reuse of knowledge in the different stages of the product development process. The concurrent design also integrates with marketing and production (Hollingsworth, 1995) as shown in Fig. 3.7. Often in incremental development, the production

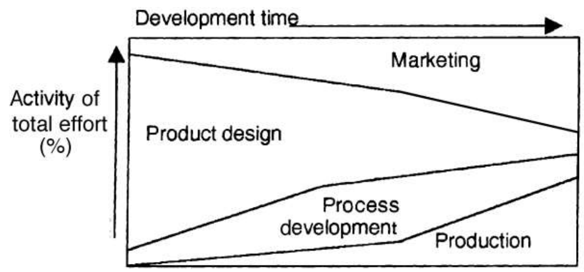

Fig. 3.7 Integration in product development.

plant is already in place, and the product has to be designed for that plant and the process can only be varied between narrow limits.

The company's identity or company's image is the sum of product design, communications design and environment design (Blaich and Blaich, 1993). Communication design directly supports the product in the marketplace with branding, packaging, advertising and promotion; therefore it needs to be closely integrated with the product design. Environment design is a concept that is not always considered, but it does influence the product and communications design, and the final acceptance of the new product. If a company wants to communicate the appropriate perception about its products, it must concern itself with the entire milieu surrounding the products, both inside and outside the company. If the company image diffused to the employees and the customers is quality, the new product is also seen as quality; if it is fresh and innovative, the product will be recognised as excitingly new. The company and distribution environments give the company and its new products an 'image' to the customers. Therefore product design needs to be integrated with communication and environment design throughout the design process.

3.2.1 Stages in product design and process development

The stages of the product design and process development are shown in Fig. 3.8; the activities are in the boxes, the outcomes in the ovals.

At the beginning of Stage 2, product design is the major part of the work, with process development considered in the design of the product. As the project progresses and the area for the product is more clearly defined, the study of the variables in the process becomes important so as to achieve the optimum product. The variables include both input and output variables.

- **Input variables:** raw materials (type, quality, quantity) and processing (types of processing, processing conditions).
- **Output variables:** product qualities and product yields.

The two main areas for research are formulation and processing; the first studying the type and quantities of raw materials and the second studying the

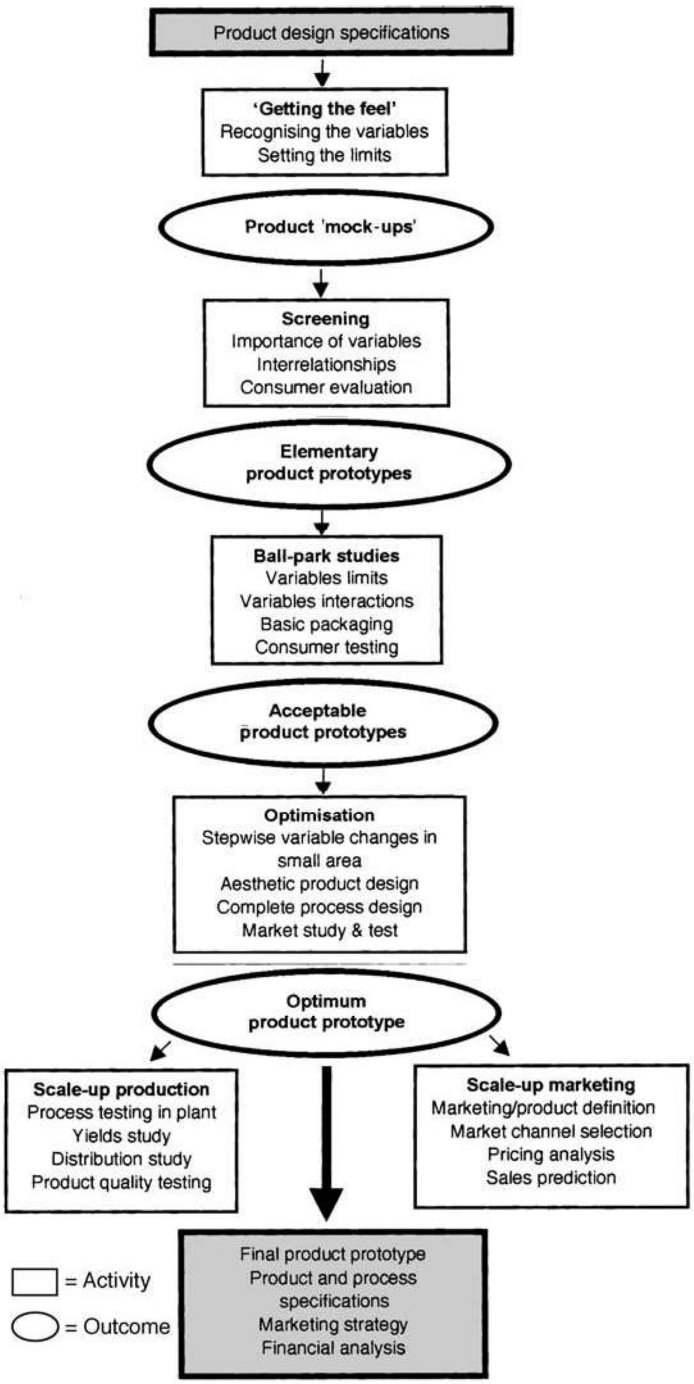

Fig. 3.8 Product design and process development: activities and outcomes.

effects of changing the processing conditions, but it is important that these are not studied separately as they are strongly interactive. The design is a continuous study of the relationships between the input variables and the product qualities, so that the final product is the optimum product under the conditions of the process. The prototype products are tested under the individual specifications set for the product design, so that product testing needs to be organised along with the product design and the processing experiments (Earle and Earle, 1999). Regular consumer testing of the product prototypes is necessary to confirm that the product has the characteristics identified in the product concept and not characteristics that are undesirable to the consumers.

Seldom does product design and process development occur in a straight line as in Fig. 3.8. There is back cycling because the prototype product is not completely acceptable to the consumer or the costs are not within the cost limits, or the chosen equipment cannot produce the product at the right yield or quality. It is important in each of these steps that there are technical, consumer and cost testings (Earle and Earle, 2000). The costs develop in stages from an identification of the parts of the company's cost system for this type of product and the limits for the various costs. Usually at the early stages, the raw material costs, their limits on the formulation, and the general costs of manufacturing are identified. The product, packaging and processing costs can be determined during the experimentation for the optimum product. After yield results during the production scale-up have been obtained and costs of marketing predicted, the total costs can be assessed.

3.2.2 Important factors in product design and process development

In food product design, there are some important points to consider:

Raw materials and ingredients

In many industries, there is increasing recognition of the place of suppliers in product development. In the past, the manufacturing company studied the effects of different raw materials and ingredients in the development of the product, and then produced specifications for the raw material/ingredient. Today, there is an increasing emphasis on working with suppliers in product development, and this is prevalent in the food industry (Hood *et al*., 1995). The ingredient supplier is introduced to the initial problem in the product design specifications and then cooperates in developing the solution. This is sometimes called the 'black box approach' and it is claimed to reduce the time for the project (Karlsson *et al*., 1998). Certainly the ingredient processor can be developing the process for the ingredient at the same time as the manufacturer is developing the consumer product. There needs to be a good relationship between the supplier and the manufacturer for this codevelopment to be successful. The food ingredient suppliers have actually gone further than this and developed the ingredient, the manufacturing process and the consumer product and handed this to the manufacturer. The reason for this may be the greater knowledge of product development in the food ingredient companies.

Quantitative techniques to integrate product and processing

In the past 20 years, there has been an increasing use of experimental designs and statistical analysis in food design and process development (Hu, 1999). There is software available that indicates suitable designs for the experimentation and analyses the results. Techniques such as linear programming have been used in animal feeds and petfood formulation for many years but have been slow to be used in human foods. Some of the problems in using quantitative techniques have been the variety of critical product characteristics, the poor definition of some characteristics and non-linear relationships between processing variables and product qualities. Food product design is complex but with increasing knowledge of the reactions in processing and new software, quantitative techniques will be increasingly the norm, but this will need increasing level of knowledge of the product designers and process developers. Hegenbart (1997) noted in product formulation, the use of spreadsheets to calculate formula costs, electronic information sources for ingredient supplier details, and company database of in-house ingredients; and in product testing the use of software for prediction of microbial growth in food and for sensory testing.

Aesthetic skills in product design

In the design of food, there has been extensive use of sensory science in developing a sensory product acceptable to the consumer. The industrial designers have not been greatly involved in the design of the appearance, colour, shape, but there has been interest in recent years (Pearlman, 1998; Capatti, 2000). Extended design is most immediately applicable to haute cuisine, but enters also into such items as extruded shapes and packaging. The package design is often by industrial designers and therefore relates to the artistic environment of the time. Airline meals (Kabat, 1998) and restaurant meals are influenced by aesthetic design and we have seen this with development of art nouveau, post-modern and other influences in meal presentation. Today, many food products are completely artificial, in that they are made from processed ingredients, and their design can be varied according to aesthetic environment. This is the area where aesthetic design can be a strong part of design – the question is how to encourage the industrial designer into food design or for the food designer to adopt some of the practices of industrial designers.

Values of the product characteristics

It is easy to spend a great deal of time designing a product characteristic that is of no importance to the consumer. Technical characteristics are often beloved by engineers in design but are of little consequence to the consumer. They may of course be an integral part of the product and therefore need some concentration in design. Value analysis or value engineering relates the cost of a product characteristic to its importance; and then selects the characteristics with the greatest value. There is a need to recognise the main aim of the product, for example long life, and then to identify the characteristics of the product that relate to this, such as low water activity and controlled atmosphere, and then the cost of achieving them. There will be other characteristics, such as convenience, sweet fruity flavour, which also need to be fulfilled and other characteristics of less critical importance. The cost of these characteristics in the design can be determined to see if the cost is too high for the product characteristic, in other words above the value to the consumer. The highest valued characteristics are then the major part of the design.

Ergonomics
A neglected area in some food design, particularly in packaging, is ergonomics, the relationship of the physical product to the person (Ulrich and Eppinger, 1995). An example of poor ergonomics is an aerosol can for depositing a dairy cream on a cake or a dessert, that is mostly used by women and children, but cannot be held and used in one hand by them. Food is opened from a package, used in cooking, served and eaten; so design needs to take into consideration the physical aspects of the product and their relationships to humans using and eating it in all these steps.

Semi-production plant facilities
The stumbling block in technology transfer is the movement of the product from the laboratory to the full-scale plant. This is caused by various factors such as lack of processing knowledge of the food designer, the change in the processing conditions as equipment is scaled up, the difference in process control in the experimental and production plants, the transportation by pumps and lines in the production plant. Some products made and poured from a bucket or a jacketed pan will collapse when pumped around a factory. Many of these problems can be studied in a semi-production plant, without incurring excessive costs in materials and processing. When new products are based on incremental product changes, a semi-production plant can be used for a number of years and so the capital costs are paid back.

Internal and external capabilities
In the past, the aim was to have and build up the necessary expertise inside the company; then in the last ten years there was a popular movement to contract expertise from outside the company. On the one hand there is a need to have the activities of strategic importance inside the company so that the direction of the project is maintained. But on the other hand, there is a need to accept opportunities when they appear and if expertise is not available internally, to go out and buy it. Usually it is agreed that it is best to have an internal product development process championed, directed and understood by people inside the company, and to buy expertise from outside as needed. In other words have the company define the decisions, outcomes and activities in the PD Process, but contract out some of the tasks used in the activities.

Review and control of design process

The design process delivers the optimum product in the predicted time and costs – too idealistic? Yes, the design process is creative and working in the unknown, so it is difficult to be specific about product quality, time and costs. But there is a need to follow the product by regular testing – by the design group in the beginning and by consumers as the prototypes become more refined – to see that it is delivering the product. There also needs to be a time and resource plan which can be reviewed at different times in the design process by peer review to see if the project is effective and efficient (Fox, 1993). Problems will be encountered and there needs to be a recognised method of problem solving available to solve the problem quickly before the project collapses.

3.2.3 Conclusions to product design and process development

It is important that there is a clear end to this stage, and also the knowledge available to make the decision to go on or stop the project before the more expensive next two stages. This may not be the time to commercialise or the time to launch, so the project has to be shelved; or it has to be admitted that the product did not fulfil the expectations and the project must stop. Five important outcomes are:

- clearly defined final product prototype with consumer acceptance;
- product specifications including processing method, physical distribution;
- market strategy including distribution, promotion, pricing;
- prediction of investment needed and financial outcomes;
- probability of achieving project completion and financial outcomes.

Think break

1. For the product design specifications you prepared in the last Think break, identify the stages in designing the product prototypes and developing the process.
2. Create the basic product options by doodling on paper or computer or on the bench, evaluate them and select the most suitable basic product.
3. Identify the raw materials and processing variables related to the specified product qualities, and outline an experimental programme to identify the ranges of variables where the optimum product could lie.
4. Design an acceptable aesthetic product using the basic product, including appearance, shape, colour, sensory attributes and relating the product to the present culture of the target consumers.
5. Identify the packaging needs for the product, including protection and use, and also the needs for promotion of the product.
6. Combine all the knowledge you have so far created, and develop the final design for total product and package.