1.Illustrate 5 steps concept generation method with block diagram.

The five-step concept generation method breaks a complex problem into simpler subproblems. Solution concepts are then identified for the subproblems by external and internal search procedures. Classification trees and concept combination tables are then used to systematically explore the space of solution concepts and to integrate the subproblem solutions into a total solution. Finally, the team takes a step back to reflect on the validity and applicability of the results, as well as on the process used.

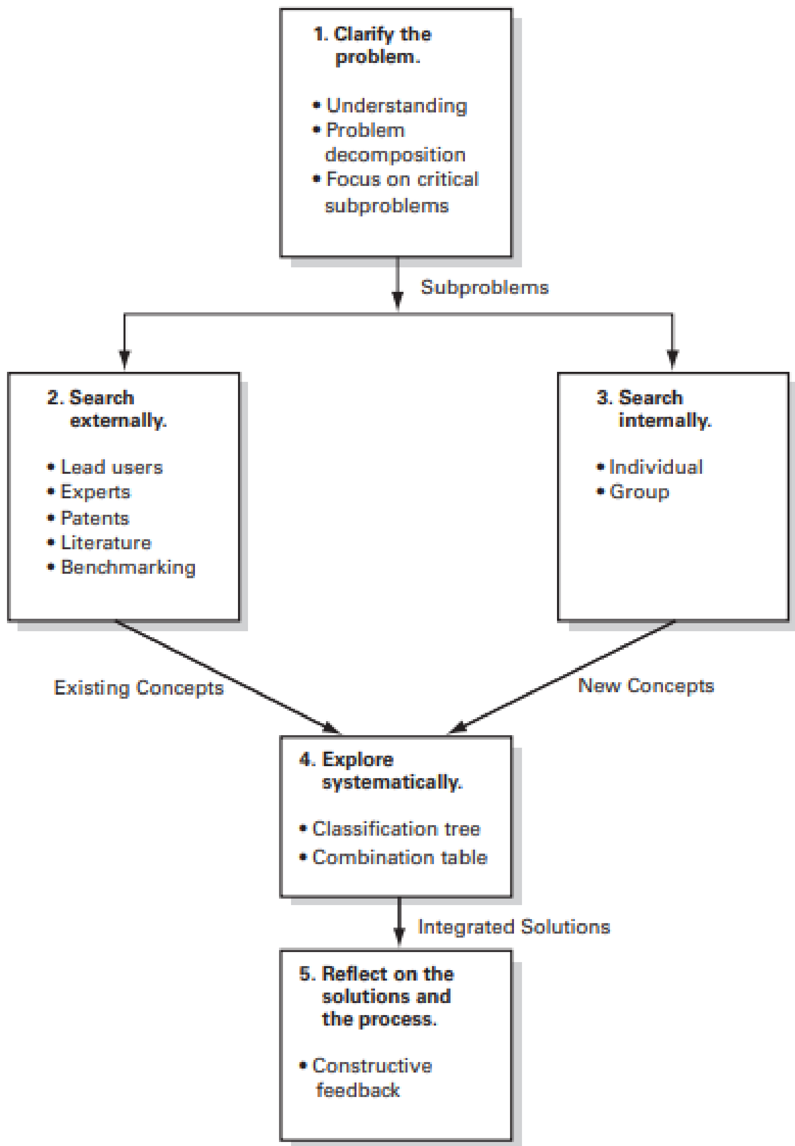

Fig: Five-step concept generation method

Step 1: Clarify the Problem

Clarifying the problem consists of developing a general understanding and then breaking the problem down into subproblems if necessary. The goal of the complex problem into simpler problems is that these simpler problems can be tackled in a focused way. Once problem decomposition is complete, the team chooses the subproblems that are most critical to the success of the product and that are most likely to benefit from novel or creative solutions.

Step 2: Search Externally

External search is aimed at finding existing solutions to both the overall problem and the subproblems identified during the problem clarification step.

Step 3: Search Internally

Internal search is the use of personal and team knowledge and creativity to generate solution concepts. Often called brainstorming, this type of search is internal in that all of the ideas to emerge from this step are created from knowledge already in the possession of the team. This activity may be the most open-ended and creative of any task in product development.

Step 4: Explore Systematically

As a result of the external and internal search activities, the team will have collected tens or hundreds of concept fragments—solutions to the subproblems. Systematic exploration is aimed at navigating the space of possibilities by organizing and synthesizing these solution fragments.

Step 5: Reflect on the Solutions and the Process

Although the reflection step is placed here at the end for convenience in presentation, reflection should in fact be performed throughout the whole process. Questions to ask include:

• Is the team developing confidence that the solution space has been fully explored?

• Are there alternative function diagrams?

• Are there alternative ways to decompose the problem?

• Have external sources been thoroughly pursued?

• Have ideas from everyone been accepted and integrated in the process?

2.What is product architecture? Demonstrate the types of modular architectures.

Product architecture is the assignment of the functional elements of a product to the physical building blocks of the product. The purpose of the product architecture is to define the basic physical building blocks of the product in terms of what they do and what their interfaces are to the rest of the device.

Modular architectures comprise three types:

• Slot-modular architecture: Each of the interfaces between chunks in a slot-modular architecture is of a different type from the others, so that the various chunks in the product cannot be interchanged. An automobile radio is an example of a chunk in a slot-modular architecture. The radio implements exactly one function, but its interface is different from any of the other components in the vehicle (e.g., radios and speedometers have different types of interfaces to the instrument panel).

• Bus-modular architecture: In a bus-modular architecture, there is a common bus to which the other chunks connect via the same type of interface. A common example of a chunk in a bus-modular architecture would be an expansion card for a personal computer. Nonelectronic products can also be built around a bus-modular architecture. Track lighting, shelving systems with rails, and adjustable roof racks for automobiles all embody a bus-modular architecture.

• Sectional-modular architecture: In a sectional-modular architecture, all interfaces are of the same type, but there is no single element to which all the other chunks attach. The assembly is built up by connecting the chunks to each other via identical interfaces. Many piping systems adhere to a sectional-modular architecture, as do sectional sofas, office partitions, and some computer systems.

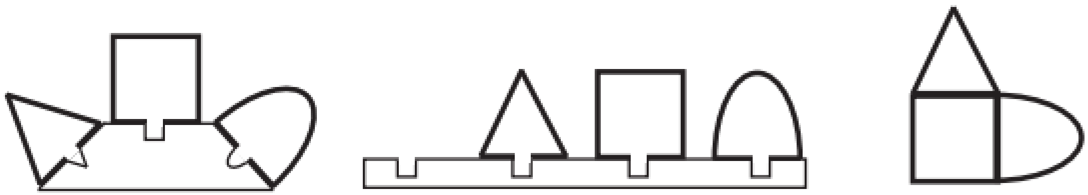

Fig: Three types of modular architecture

3.What is industrial design? Analyze the ergonomic and aesthetic needs.

The Industrial Designers Society of America (IDSA) defines industrial design as "the professional service of creating and developing concepts and specifications that optimize the function, value, and appearance of products and systems for the mutual benefit of both user and manufacturer".

Ergonomic Needs:

• **How important is ease of use?** Ease of use may be extremely important both for frequently used products, such as an office photocopier, and for infrequently used products, such as a fire extinguisher. Ease of use is more challenging if the product has multiple features and/or modes of operation that may confuse or frustrate the user. When ease of use is an important criterion, industrial designers will need to ensure that the features of the product effectively communicate their function.

• **How important is ease of maintenance?** If the product needs to be serviced or repaired frequently, then ease of maintenance is crucial. For example, a user should be able to clear a paper jam in a printer or photocopier easily. Again, it is critical that the features of the product communicate maintenance/repair procedures to the user. However, in many cases, a more desirable solution is to eliminate the need for maintenance entirely.

• **How many user interactions are required for the product's functions?** In general, the more interactions users have with the product, the more the product will depend on ID. For example, a doorknob typically requires only one interaction, whereas a laptop computer may require a dozen or more, all of which the industrial designer must understand in depth. Furthermore, each interaction may require a different design approach and/or additional research.

• **How novel are the user interaction needs?** A user interface requiring incremental improvements to an existing design will be relatively straightforward to design, such as the buttons on a new desktop computer mouse. A more novel user interface may require substantial research and feasibility studies, such as the "click wheel" on the early Apple iPod music player.

• **What are the safety issues?** All products have safety considerations. For some products, these can present significant challenges to the design team. For example, the safety concerns in the design of a child's toy are much more prominent than those for a new computer mouse.

Aesthetic Needs:

• **Is visual product differentiation required?** Products with stable markets and technology are highly dependent upon ID to create aesthetic appeal and, hence, visual differentiation. In contrast, a product such as a computer's internal disk drive, which is differentiated by its technological performance, is less dependent on ID.

• **How important are pride of ownership, image, and fashion?** A customer's perception of a product is in part based upon its aesthetic appeal. An attractive product may be associated with high fashion and image and will likely create a strong sense of pride among its owners. This may similarly be true for a product that looks and feels rugged or conservative. When such characteristics are important, ID will play a critical role in determining the product's ultimate success.

• **Will an aesthetic product motivate the team?** A product that is aesthetically appealing can generate a sense of team pride among the design and manufacturing staff. Team pride helps motivate and unify everyone associated with the project. An early ID concept gives the team a concrete vision of the end result of the development effort.

4.Illustrate the benefits of concept classification tree with a sketch.

The concept classification tree is used to divide the entire space of possible solutions into several distinct classes that will facilitate comparison and pruning. An example of a tree for the nailer example is shown in the below figure. The branches of this tree correspond to different energy sources.

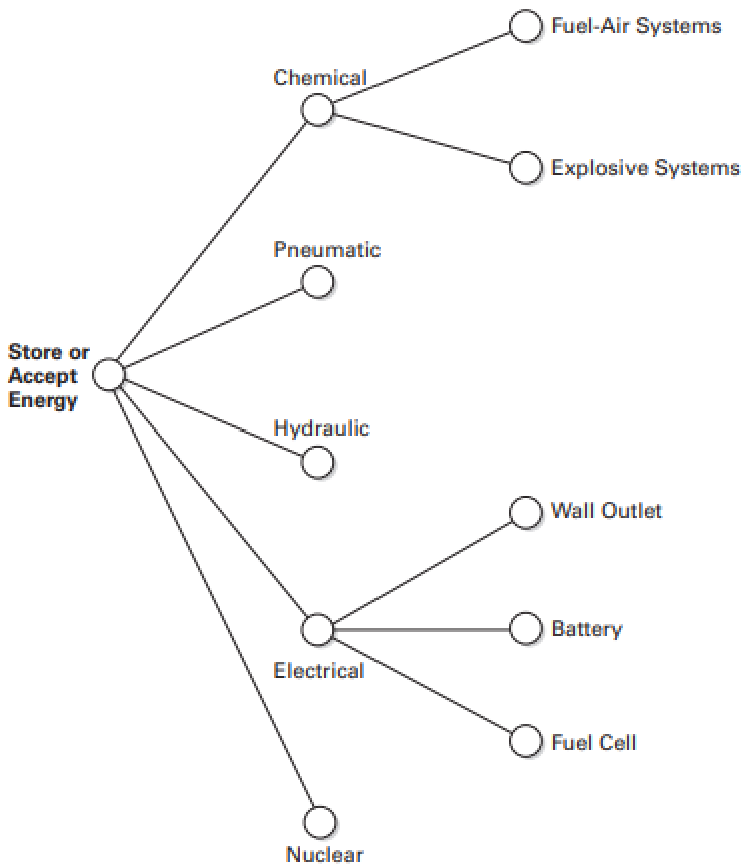

Fig: A classification tree for the nailer energy source concept fragments

The classification tree provides at least four important benefits:

1. **Pruning of less promising branches:** If by studying the classification tree the team is able to identify a solution approach that does not appear to have much merit, then this approach can be pruned and the team can focus its attention on the more promising branches of the tree. Pruning a branch of the tree requires some evaluation and judgment and should therefore be done carefully, but the reality of product development is that there are

limited resources and that focusing the available resources on the most promising directions is an important success factor.

2. **Identification of independent approaches to the problem:** Each branch of the tree can be considered a different approach to solving the overall problem. Some of these approaches may be almost completely independent of each other. In these cases, the team can cleanly divide its efforts among two or more individuals or task forces. When two approaches both look promising, this division of effort can reduce the complexity of the concept generation activities.
3. **Exposure of inappropriate emphasis on certain branches: Once** the tree is constructed, the team is able to reflect quickly on whether the effort applied to each branch has been appropriately allocated. The nailer team recognized that they had applied very little effort to thinking about hydraulic energy sources and conversion technologies. This recognition guided them to focus on this branch of the tree for a few days.
4. **Refinement of the problem decomposition for a particular branch:** Sometimes a problem decomposition can be usefully tailored to a particular approach to the problem. Consider the branch of the tree corresponding to the electrical energy source. Based on additional investigation of the nailing process, the team determined that the instantaneous power delivered during the nailing process was about 10,000 watts for a few milliseconds and so exceeds the power that is available from a wall outlet, a battery, or a fuel cell (of reasonable size, cost, and mass). They concluded, therefore, that energy must be accumulated over a substantial period of the nailing cycle (say 100 milliseconds) and then suddenly released to supply the required instantaneous power to drive the nail.

5.What is product architecture? Analyze the implications of the architecture.

Product architecture is the assignment of the functional elements of a product to the physical building blocks of the product. The purpose of the product architecture is to define the basic physical building blocks of the product in terms of what they do and what their interfaces are to the rest of the device.

Decisions about how to divide the product into chunks and about how much modularity to impose on the architecture are tightly linked to several issues of importance to the entire enterprise: product change, product variety, component standardization, product performance, manufacturability, and product development management. The architecture of the product therefore is closely linked to decisions about marketing strategy, manufacturing capabilities, and product development management.

Product Change: Chunks are the physical building blocks of the product, but the architecture of the product defines how these blocks relate to the function of the product. The architecture therefore also defines how the product can be changed. Modular chunks allow changes to be made to a few isolated functional elements of the product without necessarily affecting the design of other chunks. Changing an integral chunk may influence many functional elements and require changes to several related chunks.

Product Variety: Variety refers to the range of product models the firm can produce within a particular time period in response to market demand. Products built around modular product architectures can be more easily varied without adding tremendous complexity to the manufacturing system.

Component Standardization: Component standardization is the use of the same component or chunk in multiple products. If a chunk implements only one or a few widely useful functional elements, then the chunk can be standardized and used in several different products. Such standardization allows the firm to manufacture the chunk in higher volumes than would otherwise be possible. This in turn may lead to lower costs and increased quality.

Product Performance: We define product performance as how well a product implements its intended functions. Typical product performance characteristics are speed, efficiency, life, accuracy, and noise. An integral architecture facilitates the optimization of holistic performance characteristics and those that are driven by the size, shape, and mass of a product. Such characteristics include acceleration, energy consumption, aerodynamic drag, noise, and aesthetics.

Manufacturability: In addition to the cost implications of product variety and component standardization described above, the product architecture also directly affects the ability of the team to design each chunk to be produced at low cost. One important design-for-manufacturing (DFM) strategy involves the minimization of the number of parts in a product through component integration. However, to maintain a given architecture, the integration of physical components can only be easily considered within each of the chunks.

Product Development Management: Responsibility for the detail design of each chunk is usually assigned to a relatively small group within the firm or to an outside supplier. Chunks are assigned to a single individual or group because their design requires careful resolution of interactions, geometric and otherwise, among components within the chunk.

6.What is industrial design? Examine the impact of industrial design.

The Industrial Designers Society of America (IDSA) defines industrial design as "the professional service of creating and developing concepts and specifications that optimize the function, value, and appearance of products and systems for the mutual benefit of both user and manufacturer".

Impact of Industrial design:

Managers will often want to know, for a specific product or for a business operation in general, how much effort should be invested in industrial design. While it is difficult to answer this question precisely, we can offer several insights by considering the costs and benefits. The costs of ID include direct cost, manufacturing cost, and time cost.

• **Direct cost** is the cost of the ID services. This quantity is determined by the number and type of designers used, duration of the project, and number of models required, plus material costs and other related expenses. In 2011, ID consulting services in the United States cost $75 to $300 per hour, with most of the work being done by junior level designers in the lower half of this price range and senior designers contributing relatively few hours of more strategic work in the higher half of the range. Additional charges include costs for models, photos, and other expenses. The true cost of internal corporate design services is generally about the same.

• **Manufacturing cost** is the expense incurred to implement the product details created through ID. Surface finishes, stylized shapes, rich colors, and many other design details can increase tooling cost and/or production cost. Note, however, that many ID details can be implemented at practically no cost, particularly if ID is involved early enough in the process (see below). In fact, some ID inputs can actually reduce manufacturing costs—particularly when the industrial designer works closely with the manufacturing engineers.

• **Time cost** is the penalty associated with extended lead time. As industrial designers attempt to refine the ergonomics and aesthetics of a product, multiple design iterations and/or prototypes will be necessary. This may result in a delay in the product's introduction, which will likely have an economic cost.

7.How to assess the quality of industrial design? Discuss in brief.

Assessing the Quality of Industrial Design Assessing the quality of ID for a finished product is an inherently subjective task. However, we can qualitatively determine whether ID has accomplished its goals by considering each aspect of the product that is influenced by ID. Below are five categories for evaluating a product:

1. Quality of the User Interface: This is a rating of how easy the product is to use. Interface quality is related to the product's appearance, feel, and modes of interaction.

• Do the features of the product effectively communicate their operation to the user?

• Is the product's use intuitive?

• Are all features safe?

• Have all potential users and uses of the product been considered?

2. Emotional Appeal: This is a rating of the overall consumer appeal of the product. Appeal is achieved in part through appearance, feel, sound, and smell.

• Is the product attractive? Is it exciting?

• Does the product express quality?

• What images come to mind when viewing it?

• Does the product inspire pride of ownership?

• Does the product evoke feelings of pride among the development team and sales staff?

3. Ability to Maintain and Repair the Product: This is a rating of the ease of product maintenance and repair. Maintenance and repair should be considered along with the other user interactions.

• Is the maintenance of the product obvious? Is it easy?

• Do product features effectively communicate disassembly and assembly procedures?

4. Appropriate Use of Resources: This is a rating of how well resources were used in satisfying the customer needs. Resources typically refer to the dollar expenditures on ID and other functions. These factors tend to drive costs such as manufacturing. A poorly designed product, one with unnecessary features, or a product made from an exotic material will affect tooling, manufacturing processes, assembly processes, and the like. This category asks whether these investments were well spent.

• How well were resources used to satisfy the customer requirements?

• Is the material selection appropriate (in terms of cost and quality)?

• Is the product over- or under designed (does it have features that are unnecessary or neglected)?

• Were environmental/ecological factors considered?

5. Product Differentiation: This is a rating of a product's uniqueness and consistency with the corporate identity. This differentiation arises predominantly from appearance.

• Will a customer who sees the product in a store be able to identify it because of its appearance?

• Will it be remembered by a consumer who has seen it in an advertisement?

• Will it be recognized when seen on the street?

• Does the product fit with or enhance the corporate identity?

8.Explain the different phases of industrial design process.

Industrial design process consists of the following phases:

1. Investigation of Customer Needs: The product development team begins by documenting customer needs by identifying Customer Needs. Because industrial designers are skilled at recognizing issues involving user interactions, ID involvement is crucial in the needs process.

2. Conceptualization: Once the customer needs and constraints are understood, the industrial designers help the team conceptualize the product. During the concept generation stage engineers naturally focus their attention upon finding solutions to the technical subfunctions of the product. At this time, the industrial designers concentrate upon creating the product's form and user interfaces. Industrial designers make simple sketches, known as thumbnail sketches, of each concept. These sketches are a fast and inexpensive medium for expressing ideas and evaluating possibilities.

3. Preliminary Refinement: In the preliminary refinement phase, industrial designers build models of the most promising concepts. Soft models are typically made in full scale using foam or foam-core board. They are the second-fastest method—only slightly slower than sketches—used to evaluate concepts.

4. Further Refinement and Final Concept Selection: At this stage, industrial designers often switch from soft models and sketches to hard models and information-intensive drawings known as renderings. Renderings show the details of the design and often depict the product in use. Drawn in two or three dimensions, they convey a great deal of information about the product. Renderings are often used for color studies and for testing customers' reception to the proposed product's features and functionality.

5. Control Drawings or Models: Industrial designers complete their development process by making control drawings or control models of the final concept. Control drawings or models document functionality, features, sizes, colors, surface finishes, and key dimensions. Although they are not detailed part drawings (known as engineering drawings), they can be used to fabricate final design models and other prototypes.

6. Coordination with Engineering, Manufacturing, and External Vendors: The industrial designers must continue to work closely with engineering and manufacturing personnel throughout the subsequent product development process. Some industrial design consulting firms offer quite comprehensive product development services, including detailed engineering design and the selection and management of outside vendors of materials, tooling, components, and assembly services.

9.How does industrial design establish a corporate identity?

Corporate identity is derived from “the visual style of an organization,” a factor that affects the firm’s positioning in the market (Olins, 1989). A company’s identity emerges primarily through what people see. Advertising, logos, signage, uniforms, buildings, packaging, and product designs all contribute to creating corporate identity.

In product-based companies, ID plays an important role in determining the company’s identity. Industrial design determines a product’s style, which is directly related to the public perception of the firm. When a company’s products maintain a consistent and recognizable appearance, visual equity is established. A consistent look and feel may be associated with the product’s color, form, style, or even its features. When a firm enjoys a positive reputation, such visual equity is valuable, as it can create a positive association with quality for future products. Some companies that have effectively used ID to establish visual equity and corporate identity through their product lines include:

• **Apple Inc.:** The original Macintosh had a small, upright shape and a benign buff coloring. This design purposely gave the product a nonthreatening, user-friendly look that has since been associated with all of Apple’s products. More recent Apple designs have striking lines and innovative styling in silver, black, and white finishes.

• **Rolex Watch Co.:** The Rolex line of watches maintains a classic look and solid feel that signifies quality and prestige.

• Braun GmbH: Braun kitchen appliances and shavers have clean lines and basic colors. The Braun name has long been associated with simplicity and quality.

- **Bang & Olufsen a/s:** B&O high-fidelity consumer electronics systems are designed to have sleek lines and impressive visual displays, providing an image of technological innovation.
- **BMW AG:** BMW automobiles, known for luxury features and driver-oriented performance, display exterior styling features that have evolved slowly, retaining the equity associated with the brand.
- **Motorola, Inc.:** The original MicroTAC and StarTAC mobile phones were recognized as Motorola's leading-edge flip-phone innovations. The later RAZR model also used a folding clamshell concept in a much thinner form factor, emphasizing Motorola's leadership in a rapidly evolving industry.