Materials and Process Selection at Conceptual Product Design Stages

ABSTRACT: The main aim of this research work is to draw up a framework proposal for integrated materials and process selection in product design. Following an in-depth review of existing studies and the factors that influence decision-making, the flow of reasoning in the process is defined and the relations among the parameters of the whole life cycle to be considered in the conceptual design phase are established. This analysis is then used to define a workflow that breaks the work down into stages and gates, as well as specifying how the preliminary selection is to be performed.

Keywords: product design and development, materials selection, manufacturing process selection, product lifecycle, stage-gate

1. Introduction

Product design necessarily involves accomplishing the goals that stem from the analysis of an idea that arises after detecting or creating needs in the consumer. The feasibility of the design is the result of evaluating the technology and the current status of the issue. The voice of the customer is used as the basis to define the design characteristics and the product is detailed as a series of functionalities.

From the point of view of the materialisation of the product, both manufacturers and engineers are constantly searching for new materials and manufacturing processes that allow them to maintain a competitive advantage and maximise their profit margin.

The process of selecting appropriate materials requires a solid definition of the specifications of the whole, the components and the relation of compatibility between them.

Yet, the path from abstraction to concretion or from creativity to focalisation is not independent of the procedure or process adopted, which is what will make it possible to obtain more or less optimised solutions. This is due to the fact that the number of materials and new manufacturing processes is constantly on the rise, thereby making it more difficult to detect an innovation and apply it.

Hence, there is a need for a strategy to translate a new idea into detailed information that can be applied in manufacturing and which transforms requirements and specifications into material-manufacturing process alternatives, as in a transfer function. This strategy leads to models for developing new products that can be descriptive, prescriptive or managerial and which fit different solutions. For example, design methodologies for manufacturing and assembly reduce the total number of parts, thereby improving the costs, reliability and quality of the final product, since it has fewer components. This therefore makes them better suited to product optimisation or innovation.

Further still, materials and process selection requires an interdisciplinary effort, duly documented information and tacit knowledge, which is not easily made explicit. Support methods are therefore needed. It is for this reason that, in many cases, they are often selected by means of "trial and error", the most widely used argument being that they were used in the past and lived up to expectations.

Other procedures that can be a source of knowledge for coming up with ideas and selecting are suppliers' design guidelines, sectorial studies or the knowledge acquired through quality systems and customer service. Many components are manufactured by external suppliers and exclusive rights to knowledge are therefore disappearing because suppliers or competitors can easily reuse them.

In the case of product design, it can be said that the whole is always greater than the sum of its parts and products will have functionalities, characteristics and a value that are higher than those of their components. Nonetheless, appropriate manufacturing with the correct material for each of their components is critical if these premises are to be fulfilled.

In order to define a model for materials and process selection it is necessary to abstract oneself to the point where the whole life cycle of a product can be visualised, thereby allowing all of the implications in the selection of materials to be taken into account (Fig. 1).

The selection of materials, geometry and manufacturing processes is not independent from the product development model that is adopted. A broader view will lead us to observe the life cycle of the product as a whole.

It is essential to establish differentiated stages, since this facilitates management and the improvement processes as a cyclical activity, that is, each new product provides the basis for some future development.
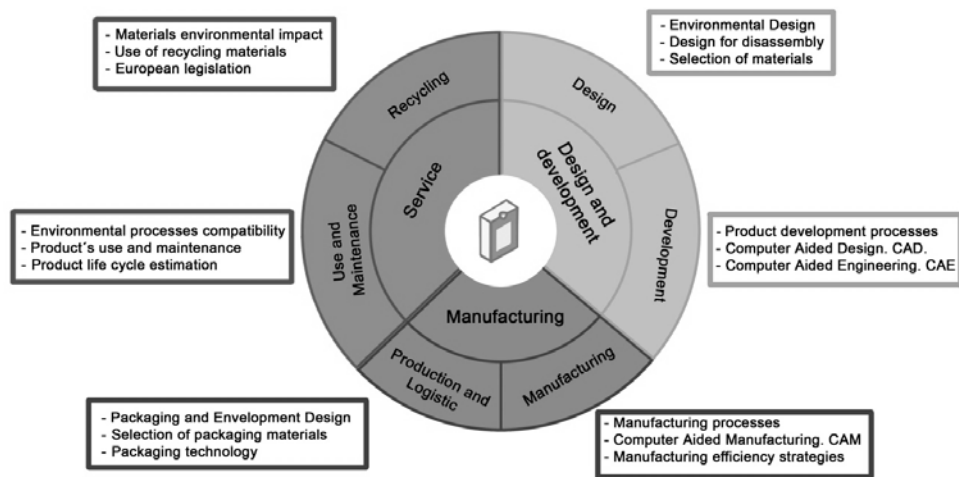

Fig. 1. Product lifecycle proposed framework.

This work comprises the following parts: analysis of the current status of the issue, the framework proposal and the selection strategy for the conceptual design phase.

2. Related Work

Product design and development necessarily entails the task of gathering knowledge, which is essentially a description that tells us how things are related to experience. This description needs to be reflected by means of a model that is in fact a simplified representation of a phenomenon. A set of models together offers a holistic view for a larger system of phenomena that is called its "*theory*". From a theory and a set of predefined rules we obtain a methodology.

Researchers, on the one hand, attempt to describe what things are like (descriptive research) and, on the other, they work on ways to alter things, which is known as normative research. When the latter involves *improving* the object and includes practical operations that are part of the life cycle of a product, then we are talking about development projects.

If we take into account the degree of universality, then a distinction can be drawn between intensive studies (specific cases represented by means of ideographic knowledge) or extensive ones (knowledge that is common to all or most of a class of products).

A scenario of limited resources and a sustainable economy allows for the concept of ecological development of products and their production.

The development of new products is affected by the surrounding environment and pressure from the market and this will determine the degree of success, recognition and competitive advantage obtained by those products.

Incompatibility between materials and manufacturing processes can affect decisions regarding the geometry.

The designer establishes the geometry, the materials specialist searches for functionalities and limit values, and the person responsible for production ensures producibility.

The earliest work carried out in this field dates back to the early 1970s with Arimoto's evaluation of producibility (Producibility Evaluation Method, PEM), which focused only on modelling and evaluating machining processes and operations [1].

Later, Jacobsen addressed design by always taking the function of the component as the starting point [2]. Then Alting and Haudrum defended the selection of the manufacturing process by means of process/material incompatibility matrices [3].

Boothroyd and Dewhurst also developed the design for manufacture and assembly (DFMA) methodology, which focuses on eliminating inefficiency in design, simplifying the structure, cutting costs and quantifying improvements [4]. On the other hand, Swift and Booker [5] proposed a methodology based on costs, by means of models of manufacturing processes called PRIMA (Process Information Maps).

Ashby [6] was the first to develop a methodology focused exclusively on materials selection aided by screening based on limit values ("Screening") and property indices to establish comparisons by maximising or minimising ("Ranking"). At present, the CES (Cambridge Engineering Selector) system also takes into account the geometries for parts, manufacturing processes and selection functions with Eco-audit criteria.

The Brinell Centre in Stockholm developed MATOP in 2003. This involves integrated materials selection, by mathematical optimisation, with the aid of algorithms of the behaviour in terms of functionalities and use [7].

Arizona State University developed a tool for analysing producibility, with a database, knowledge management of the material, manufacturing resources, processes and design components. The database interacts with two different user interfaces for design and engineering [8].

In nearly all the studies carried out on integrated materials and process selection, there are both generic methods and methods that are dedicated to particular products in very specific sectors. The generic methods contain indications about the steps to be taken and help to achieve a global framework by translating ideas into industrial design products and establishing the design phases and the stages of selection in parallel [9]. In these generic methods we find two phases: screening and ranking. The screening methods make it possible to discard certain elements in accordance with a set of specific rules, whereas ranking methods evaluate the different solutions by means of parameterised functions or algorithms and rank them in terms of the degree of compliance.

Tools for selecting materials in samples of products [10] include aspects of user-process interaction and help to specify requirements that are difficult to quantify, such as sensory properties.

Catalogue-based methods allow the user to see the personality of designs, forms and combination of materials. Attributes that are difficult to convert into numeric values need to be compared with others to be able to make the selection.

In questionnaire-based methods functional requirements are classified in two categories: rigid (complies or does not comply) and soft (or relative). Edwards proposed a structured questionnaire consisting of checklists in order to improve the probability of optimum design by exploring the design both before and

during the process of materials selection [11], [12], [13], [14]. Pedgley, on the other hand [15], gathered real needs from the interaction of automated questionnaires and transferred them to process selection.

Most selection systems are implemented through search engines that interact with databases. One of the best-known is the CES (Granta Design).

Sectoral databases such as CAMPUS (Plastics Computer Aided Material Preselection by Uniform Standards), the global network for professionals in materials, minerals and mining, the International American Society of Materials – ASM or the National Resource Center for Materials Technology USA offer advantages when the manufacturing process is known.

The University of Arizona has developed a platform of databases for knowledge about materials, manufacturing resources, processes and design components that interacts with two different user interfaces for design and engineering.

The latest trends are aimed towards methods based on artificial intelligence that are capable of processing the large number of materials that are generated each day using intelligent agents that can perceive their surroundings, process them and give a response by maximising or minimising the result of a specific function, geometry, material and process. These systems are capable of solving problems that require knowledge and reasoning thanks to the information from one or more experts in a specific area, together with predefined rules that constitute this knowledge base [15], [16] and [17].

There are essentially three main types: those based on previously established rules, those based on cases – or CBR (Case Based Reasoning) – and those based on networks.

The rule-based expert systems are not limited to just the screening task but also participate in the ranking process, in interpreting results and in proposing solutions [18].

Case-based expert systems address new problems by using information from solutions to previous problems, which is an application of analogies. An example of networks is to be found in the use of neural networks that imitate biological systems through mathematical models.

Multi-criteria decision-making methodologies are an attempt to take into consideration all the parameters that affect materials and process selection. They highlight conflicts that appear when trying to optimise them all at the same time and allow a compromise to be reached. For example, Chau and Parkan [20] used

the RMS (Response Surface Methodology) method to analyse direct costs in the attributes and proposed a systematic approach to the process of selection by means of neural networks.

Jee and Kang [21] used the concept of entropy to evaluate the weighting of each property of the material and the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) technique to classify materials by means of multi-criteria evaluation.

Shanian and Savadogo compared the results of TOPSIS and VIKOR MCDM (Vikor Multi-Criteria Decision-Making) so that "Outranking" relations could later be used in materials selection by means of ELECTRE IV [22].

Chan and Tong used grey analysis for materials selection. Situations for which there is no information are defined as black while full information is white; intermediate situations between these two extremes are described as grey, cloudy or fuzzy [23]. Edwards and Deng proposed materials selection through a combination that takes into account the multiplicity of optimal indicators [14]. Manshadi developed a numerical method focused on the weighting of two factors, namely, non-linear normalisation and digital logic [24]. Khabbaz developed a simplified fuzzy logic approach with Manshadi's method [25]. Fayazbakhsh used the Z-transformation for the statistical normalisation of the properties of materials. The same author compared the Z-transformation with the MDL (minimum description length) method of normalisation and concluded that the Z-transformation yielded better results [26].

Finally, Chuu developed a decision support method based on fuzzy logic (FMS – fuzzy multiple attribute decision-making selector method) for selecting the manufacturing process on the basis of multiple attributes [27].

Important examples of studies focused on the multi-criteria application include Rao and Parnichkun [28], who used combinatory mathematics to evaluate alternatives in flexible manufacturing systems and proposed a multi-attribute method (MADM) that uses subjective preferences for materials selection [29]. Gyurova [17] used the OBS (optimal brain surgeon) method to streamline the neural networks method and eliminate unnecessary nodes. Maniya and Bhatt [30] used the preference selection index (PSI) method, the Graph Theory and Matrix Approach (GTMA) and TOPSIS. Cicek and Celik used the fuzzy logic axiomatic model (Generic Framework of the Fuzzy Axiomatic Design - Model Selection Interface,

FAD-MSI). Sapuan and Mujtaba [18] analysed the uses of neural networks in Composites. Tuzkaya [31] used Analytical Network Process (ANP) and PROMETHEE to perform the selection.

Examples of methods with a clearly defined design objective include Johnson and Kirchain, who focused on cost methods for materials selection [32], or Zhou [33], who took into account the environmental factors in the life cycle by means of neural networks (ANN) and genetic algorithms (GAs) for the multi-objective optimisation of materials selection.

Finally, there are also studies that review developments in the field and help us to gain an overall vision of the current status of the issue. These include the work of Jahan [34] or Chatterjee [35], who compares the new decision support methods VIKOR MCDM, ELECTRE, COPRAS (Complex proportional assessment method) and EVAMIX (Evaluation of mixed data method).

As we have seen, the need to define methods that bring us closer to correct decision-making when it comes to materials and process selection has given rise to a vast amount of research in this field. This has allowed new lines of work to be opened up, since the level of complexity of products and their components requires rigorous management in all aspects of the life cycle, and materials have the greatest specific weight.

Accordingly, and to be able to make a proposal after analysing the work carried out to date, we need a framework with a general vision that allows us to define a method with appropriate tools to match each phase of the life cycle, with special attention being given to the conceptual design.

The following table summarises the current status of the issue in the literature and the contribution made by each work from different aspects.

PROPOSAL	DESCRIPTION	CONTRIBUTION
1978 Alting & Haudrum	Methodology Morphological model of process design	Process/material incompatibility matrices used as a starting point to develop the geometry and the selection of material
1989 Jacobsen	Methodology for design Interrelation of geometry, material & manufacturing process	Establishes six different ways of addressing the design, always taking the function of the component as the starting point
1989 Materials Matter	Databases of the UK Department of Trade and Industry programme	Different selection solutions in a variety of sectors
1992 Ashby	CES	
1992 Boothroyd & Dewhurst	Software interfaces. Design methodologies for manufacturing, facilitating the manufacture of parts and design for making assembly easier	Design model. Guidelines for orienting design in concurrent engineering in order to simplify the structure of the product, reduce manufacturing and assembly costs, and quantify improvements
1996 Chalmers University of Technology	Software interfaces and consultancy system based on databases – Life Cycle Assessment, Life Cycle Inventory	Software tools for drawing up reports and offering advice on the life cycle of products
1997 Swift & Booker	Methodology for design. Methodology for cost-based process selection	Analogy by graphs and correlation coefficients
1997 Fuzzymat Bassetti FuzzyCast FuzzyGlass	Free search in multi-criteria manufacturing processes and materials databases using a fuzzy logic algorithm	Screening phase using preset values within limits Genetic and fuzzy logic algorithms
1998 Astek expert Lae	Analogy based on reasoned cases. Selection of optimal methods of joining based on existing solutions	Approach by means of a decision tree
1999 Sandwich selector Lemoine	Free search. Optimisation of materials selection and suitable dimensions for structural sandwiches	Genetic algorithm and mechanical modes of selection for creating possible solutions
2000 CAMD Landru,	Free search and questionnaire. Expert system for developing the set of requirements by means of coupled equations and value analysis	Screening phase using a recursive algorithm
2000 MAPS Landru	Free search. Identification of possible applications of a material based on its properties / in-service behavioural profile	Screening
2001 R. Amen, P. Vomacka	IVF - Swedish Institute of Production Engineering Research	System of materials selection by means of case-based reasoning
2002 Failure expert Bouget	Analogy. Guidelines for analysing faults and possible solutions from a database of typical cases	Reasoned practical cases
2002 Fuzzy extrude Heiberg	Questionnaire. Optimisation of the selection of extruded aluminium alloys, including extrusion and the form through an expert system	Screening phase using preset values in a questionnaire
2003 MATOP Brinell Centre, Stockholm	Development of tools for the integrated optimisation of materials Software interfaces	Mathematical optimisation by means of algorithms of the behaviour of the materials in terms of selection and use

PROPOSAL	DESCRIPTION	CONTRIBUTION
2005 ASU-DFM framework development procedure	Layer-independent domain for DFM and its application to die-stamping and injection moulding (Material and process based on CAD geometry) Interface between designer and knowledge engineering	Databases and management of knowledge about material, manufacturing resources, processes and design components This database interacts with two different user interfaces for design and engineering
2006 Zha et al.	Models of product families	Generation, evaluation and personalisation of product families
2006 – 2009 Shanian et al.	Expert systems based on "Outranking" relations	Materials selection by means of ELECTRE IV and comparison with TOPSIS and VIKOR MCDM
2007 Chan & Tong	Grey and fuzzy logic analyses	Provides selection techniques that fit the real situation
2007 Edwards & Deng	Selection of materials in combination	Contributes to optimal indicators in configuration and structural components
2009 Pedgley	Process selection by means of questionnaires	Automated questionnaires
2009 Fayazbakhsh et al.	Z-transformation for the statistical normalisation of the properties of materials	Compares the Z-transformation with the MDL (minimum description length) normalisation method
2009 Chatterjee et al.	Multi-criteria methods	Compares VIKOR, ELECTRE and reviews the current state of the issue
2009 Chuu	Decision support method by use of fuzzy logic (FMS), the "fuzzy multiple-attribute decision-making selector method"	Selects the manufacturing process on the basis of multiple attributes
2009 Zhou et al.	Uses environmental factors in the life cycle by means of neural networks (ANN) and genetic algorithms (GAs)	Multi-objective materials selection
2009 Rao & Parnichkun	Evaluation of alternatives in flexible manufacturing systems	Multi-attribute method (MADM) that uses subjective preferences for materials selection
2010 Gyurova et al.	OBS (optimal brain surgeon) method	Streamlines neural networks and eliminates unnecessary nodes
2010 Maniya & Bhatt	Preference selection index (PSI) method	Selection by means of GTMA and TOPSIS
2010 Tuzkaya et al.	Selection by analytical network process	Uses ANP and PROMETHEE
2011 Chatterjee et al.	Decision support methods	Compares COPRAS and EVAMIX

Table 1. Literature review.

3. Integrated material and processes selection framework

In its most creative phase, the design process offers a wide range of possibilities. For this reason development teams encounter many sources of fuzzy knowledge that is difficult to collect and interrelate.

Moreover, the first critical factor in planning a project is the difficulty involved in setting up multidisciplinary teams and often the geographical separation between expert members in specific fields.

These issues make the work inefficient. To optimise resources and focus planning, a good breakdown of the concept is crucial.

Once the concept has been defined and delimited, we can determine whether, in some way or another, the product exceeds the capabilities of the organisation. In those cases, to be able to undertake it, it will be necessary to arrange alliances or set up other temporary virtual organisations.

In the development of products that requires collaboration among different organisations, life cycle and knowledge must be managed in such a way as to produce Win-Win relations that have repercussions on the competitive advantage for all the collaborators.

Management of the life cycle of the product implies structured decision-making in design.

Decision-making covers different areas and adapts to the life cycle model that is adopted. In the framework proposal, a process of reflection is used to conclude the relation between these areas of selection and obtaining competitive advantage.

First, decisions can be classified as technical, economic and strategic.

Technical decisions are the backbone of engineering processes and, therefore, design. For this to be possible, organisations must have facilitating elements, such as an efficient system of knowledge management.

Together, economic and engineering decisions provide creativity, reliability, repeatability, cuts in access to market time and, in short, an increase in the value indicators of companies.

Strategic decisions harmonise business processes and provide the basic resources for managing the life cycle of the product.

All the above factors have an effect on excellence and allow competitive advantage to be obtained.
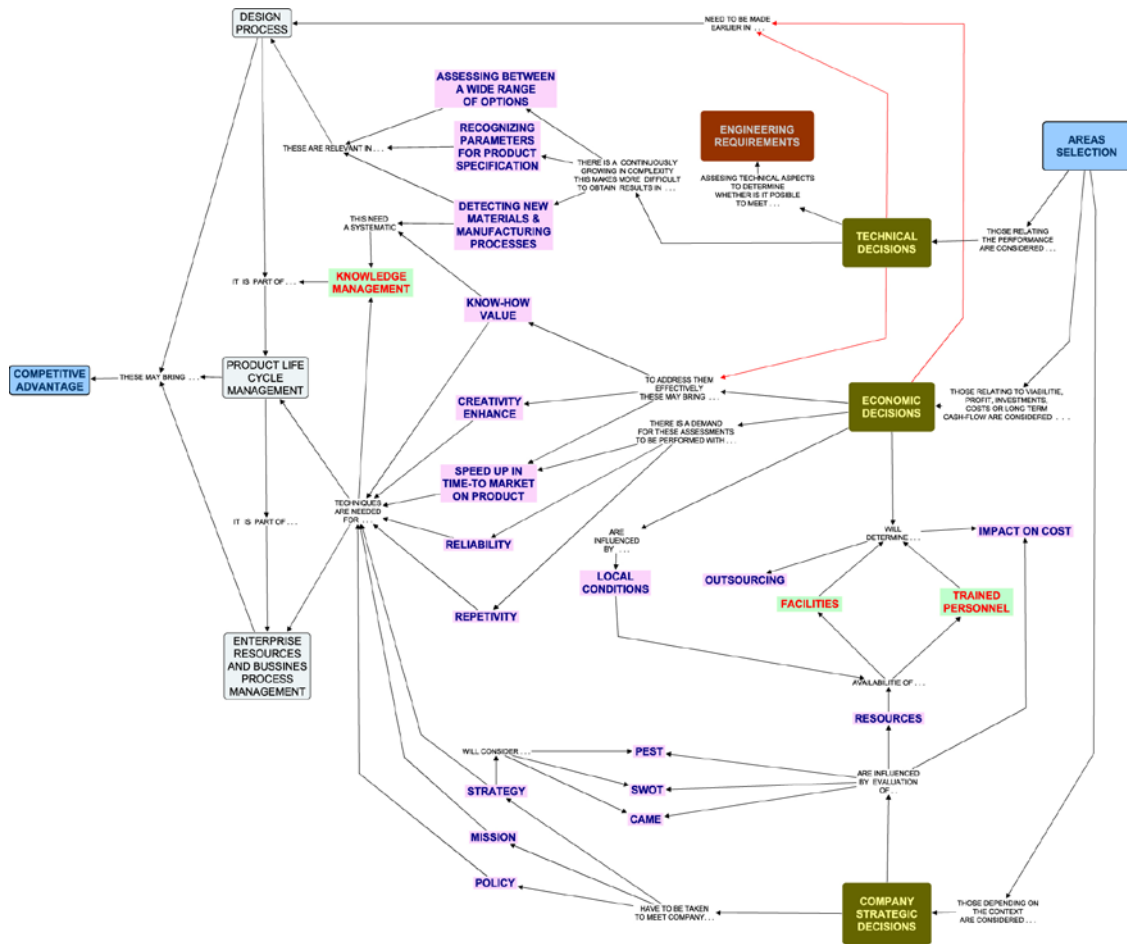

Fig. 2. Relationship between the selection areas and life cycle and competitive advantage through knowledge management.

Any life cycle model that is adopted in the life cycle includes a process for identifying requirements and functionalities.

The effective identification of requirements and functionalities requires a system both for collecting information and for evaluating its importance.
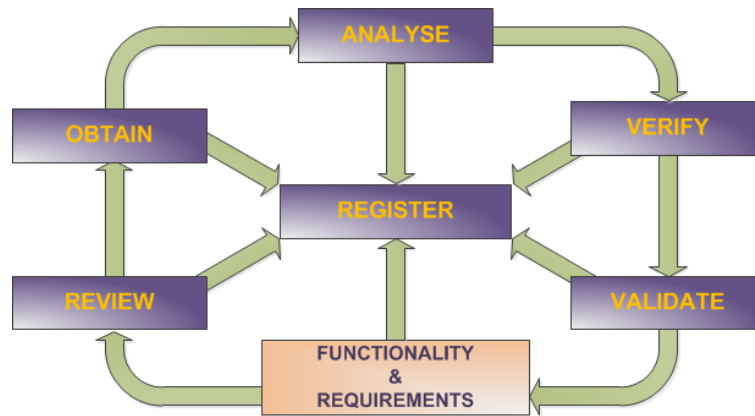
Fig. 3 The preliminary process of selecting requirements and functionalities.

Needs, specifications, aesthetics, preferences and restrictions go to make up the voice of the customer, which can be used to establish a rough model of the concept.

The design team will have to focus on the aspects that are vital for quality (Critical to Quality, CTQs).

In conceptual design, the level of detail is not high enough, but the decisions that are adopted will condition future development. A correct decision will lead to a reduction in all the costs involved.

The tools proposed to facilitate selection processes are the following:

1. Documentation management that allows ideas to be translated into industrial design.
2. Matrices that relate incompatibility between materials and manufacturing processes.
3. Matrices that relate typical properties to specific requirements.
4. Models of manufacturing processes PRIMA, which take into account limitations as regards the geometry of parts.
5. Multi-criteria analysis techniques.
6. Screening preselection techniques.

For organising selection in conceptual design, a "Stage-Gate" validation model is proposed (Fig. 4). The purpose of this model is to verify the technical and economic viability, optimise the selection as regards the use of the product, its performance, durability or costs and, finally, to validate decisions and to approve plans and their budget for the next phase.
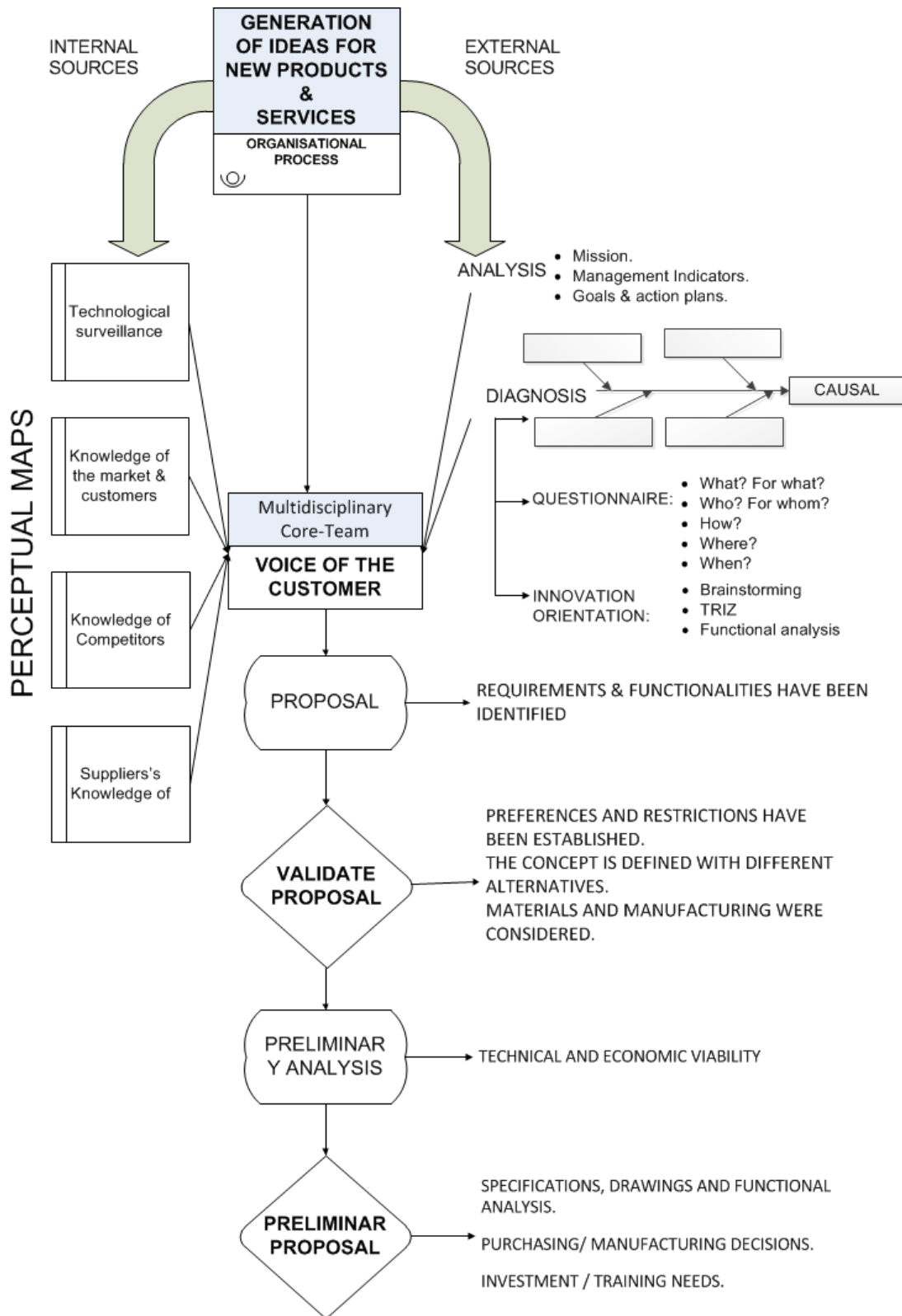
Fig. 4. Stage-Gate process for approval of the conceptual design.

This model makes it possible to ensure that the CTQ requirements and functionalities have been met.

4. Proposed selection strategy

Administering a product development project involves detecting and solving conflicts concerning criteria, requirements and functionalities.

Each product requirement is a documented need regarding a characteristic or capability appreciated by users. This source of knowledge will be used as input data to establish WHAT must be done.

Preferences and restraints help to maintain the requirements within a range of values and facilitate decision-making about HOW to do it (concept definition).

The documentary material obtained and generated by the development team will be structured on different levels that range from the most general down to the most specific.

Concept / Property / Quality	Material	Manufacturing process
What is it? Definition	What identifies it?	What does it consist in?
How is it measured / tested?	How is it obtained or transformed?	How is it executed and controlled? Tools, implements, equipment, control parameters
What can we relate it to? Physical laws it complies with, analogous phenomena, etc.	Family of materials that is similar to the one it belongs to	Variants of the process
Top-down approach: Start out from the general concept to end with specific details	Qualities of interest	Capacity & productivity

Table 2. The documentary material structure

Organisational knowledge increases the number of intangible assets and presents an opportunity to gain competitive advantage.

The main function offers a way to eliminate materials and processes that are not technically or economically viable and to carry out the process of screening.

The main function provides a number of ways to identify a requirement:

- It defines a property of the material, which may be electrical, mechanical, thermal, etc.
- It is related to movement: support, motorisation, transmission, etc.

- It is related to compliance and reliability: robust design, failure modes, maintenance, etc.
- It derives from the value perceived by the user and may be ergonomic, about the user, etc.
- It is linked to the life cycle: durability, sustainability, etc.

The geometry of the parts can be classified in three broad groups that cover the different industrial sectors:

- Structural or rigid geometries: Solid of revolution, rectangular prism and thin-wall or thin-section components.
- Elastic or deformable geometries (which should adapt to another rigid element or allow for a certain amount of deformation): viscoelastic amorphous materials, laminas and thin walls, and tissues, fibres, cables, belts, etc.
- Microgeometric: microstructures and micro-electromechanical systems

Manufacturing processes are to be classified in accordance with the specifications set out in DIN 8580.

The following framework, (Fig. 5). is proposed as a way to relate the selection processes with the management models and product development:
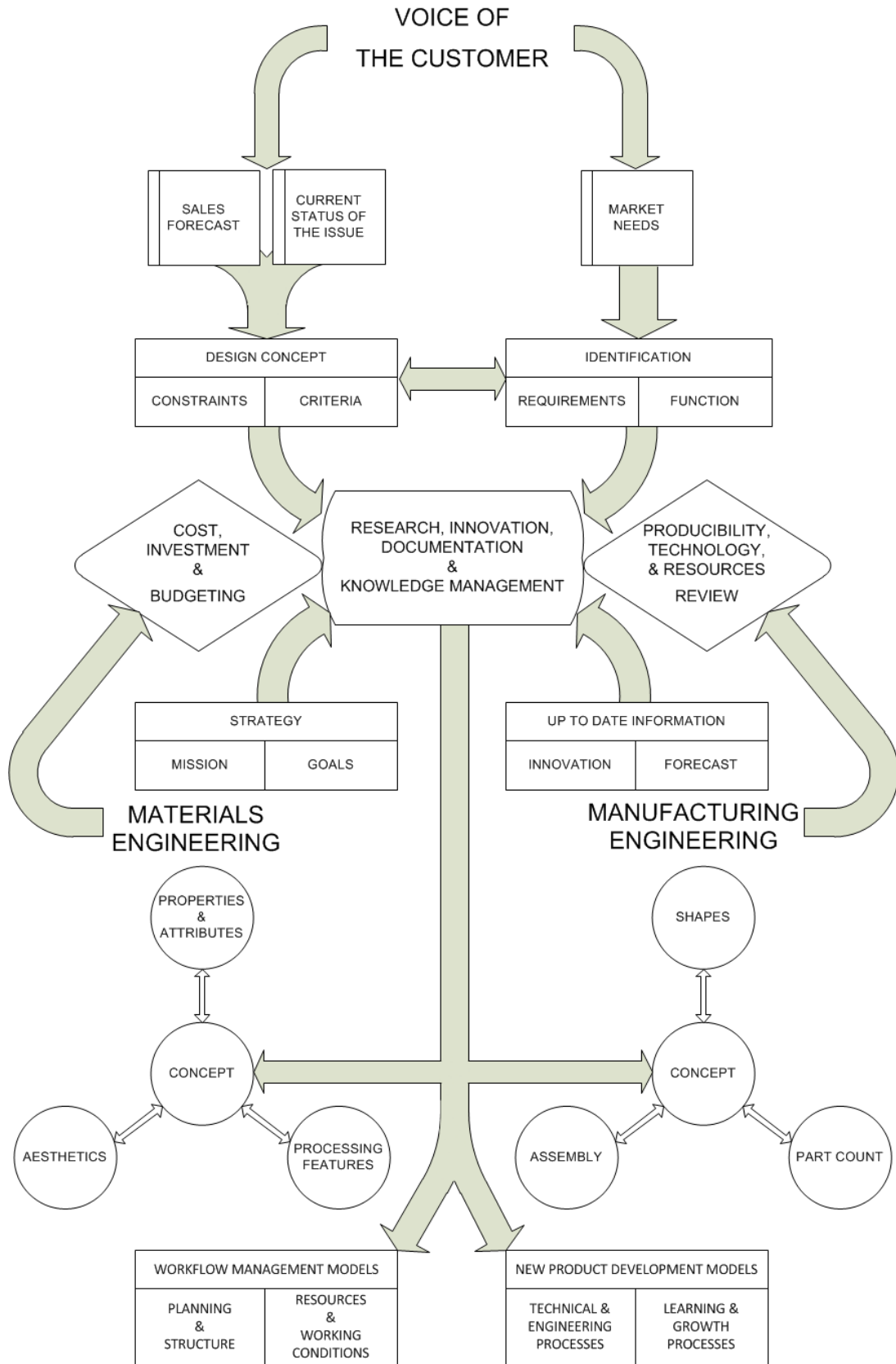
Fig. 5. The preliminary process of selecting materials and manufacturing processes.

The following steps are proposed for generating ideas for new products and services within the context of the selection process in conceptual design:

1. Acquire knowledge from internal and external sources.
2. Analyse data.
3. Break down the product.
    a. Identify requirements and functionalities.
    b. Establish preferences and restraints.
    c. Identify critical-to-quality factors.
4. Manage knowledge.
    a. Preliminary evaluation of technology and resources:
        i. Functionality, properties and attributes.
        ii. Producibility, geometries, assemblies.
        iii. Technical viability.
        iv. Economic viability.
    b. Initial selection. (Screening).
    c. Preliminary evaluation of cost / investment:
        i. Forecast and batches.
        ii. Initial selection of candidate Material / Processes.
        iii. Cost analysis and maximisation of preferences (Ranking).
5. Establish development model.
    a. Selection of the design model.
    b. Selection support tools, according to methodologies and design model.
6. Establish management model.
    a. Work breakdown and mapping of the processes involved.
    b. Establish project plan and revision stages.
    c. Approve financial plan.
7. Document the conceptual design.

The assessment of the concept must evaluate the impact of the product. The PESTEL methodology offers this evaluation in the following factors:

1. Political factors.
2. Economic factors.
3. Sociocultural factors.
4. Technological factors.
5. Environmental factors.

6.Legal factors.

A deeper analysis will take into account topics such as the usefulness of the functionality, its importance, maintenance, reparability, consumable spare parts, aesthetics and ergonomics.

At the strategic level, the following points must be taken into account:

- Accessibility and continuity in the supply of raw materials
- The occupational framework and the availability of qualified employees
- Energy resources and their availability
- The means of production available and, if necessary, the acquisitions needed

In sum, we can conclude that the best solution in design is part of an iterative process between the different areas of selection, (Fig. 6). The first approach in selection can come from a cost-based point of view or from the actual operating behaviour of the final product.

The cost-based point of view aims at the use of commercial forms and the reduction in the total number of parts. This is where a decision is made as to whether to use simple or complex geometries and between modular or specific manufacturing.

The requirements used in the individual selection for each part give rise to interactions and conflicts in the final product. All this leads to a narrowing of the margin in the limit conditions of the whole process.
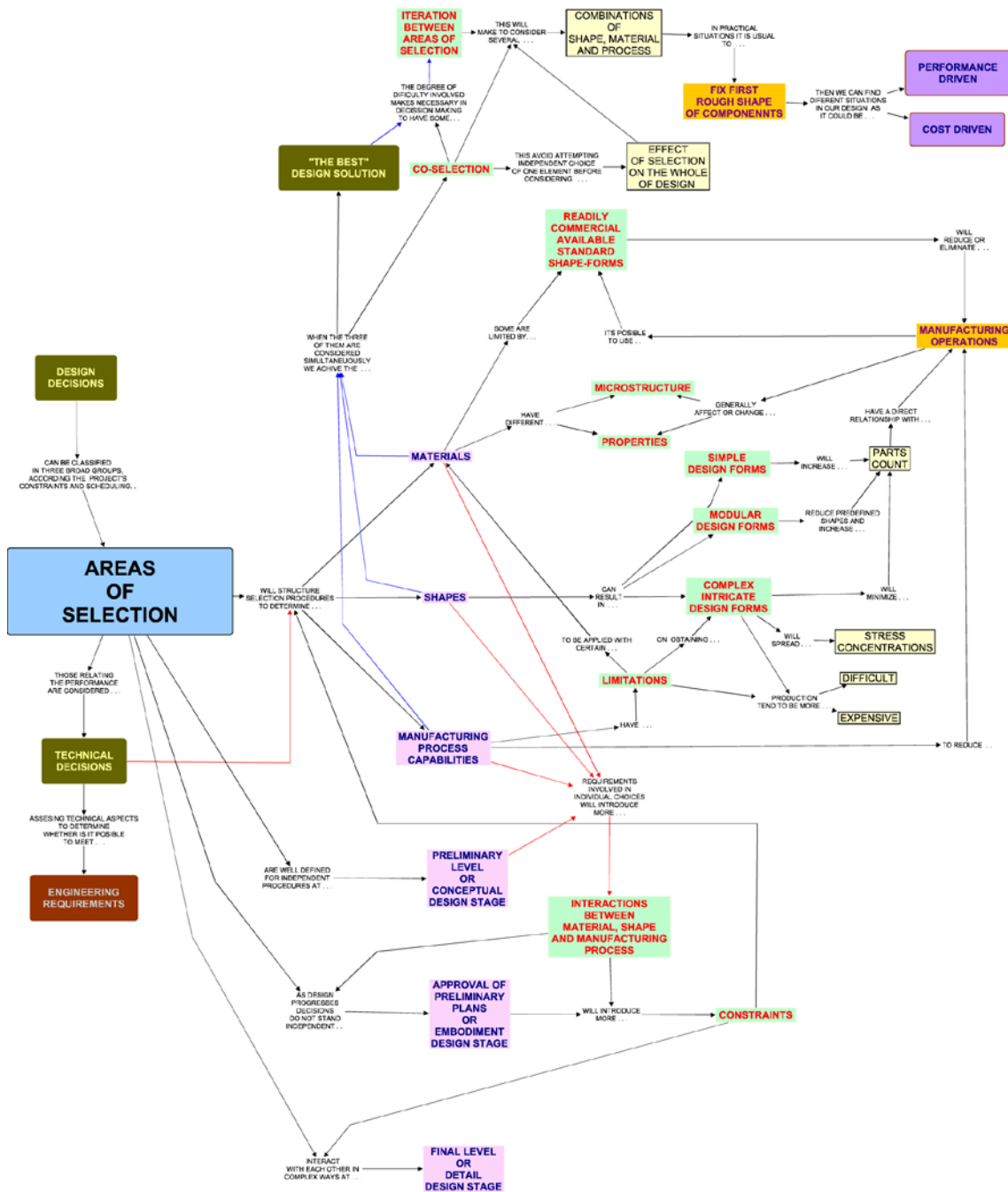
Fig. 6. The areas of selection in conceptual design.

Product breakdown is in fact a design in its early stages that is mature enough to be able to apply certain validation tools, such as questionnaires, which evaluate the user's decision to purchase, (Fig. 7).
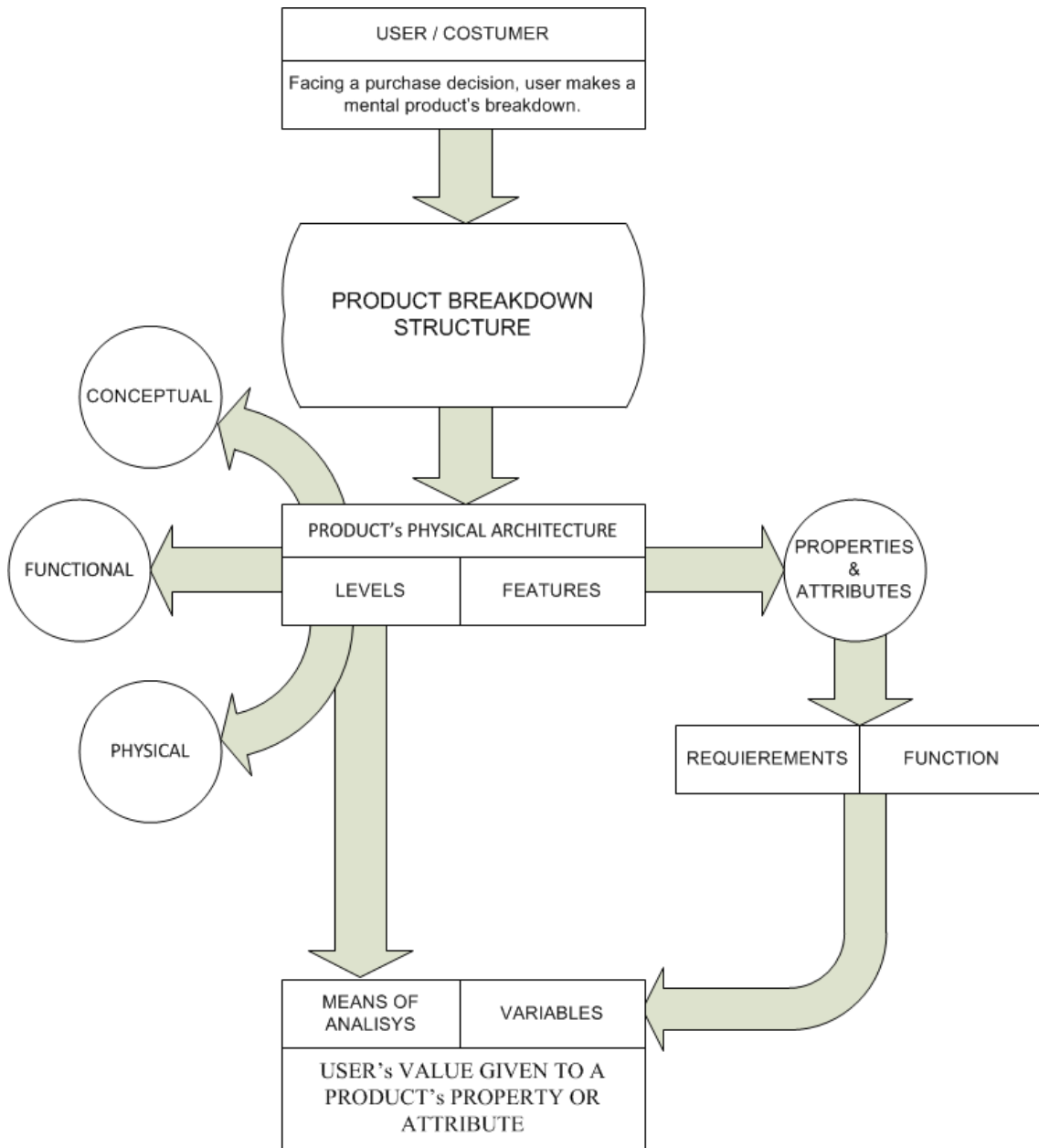

Fig. 7. Product breakdown structure.

To finish it is important to bear in mind that:

- It is not always possible to identify all the requirements
- Viability is conditioned by scientific and technical progress
- If the technology, processes or materials are unknown, then training and experimentation should be carried out
- If a project is excessively complex, the best strategy is to divide it into phases

5. Conclusions and future work

Design detects or creates needs in consumers and turns them into products or services. Manufacturers and engineers are constantly searching for new materials and manufacturing processes in order to maintain a competitive advantage.

The definition of the concept offers a wide range of possibilities for exploring the selection of materials and manufacturing processes. A structured process of reasoning offers a framework that does not restrain novel materials and processes.

This paper analyses the most notable works in the field and offers a framework for reasoning and a process for approving the selection of materials and manufacturing processes.

Technological surveillance and knowledge management have become essential elements for organisations that intend to innovate. This is the reason why materials and process selection has been related to business processes, the life cycle, workflow management and methodologies for the creation of new products.

Finally, it should be noted that the most appropriate choices in the conceptual design will result in greater effectiveness throughout the whole project. It is vital for all the knowledge obtained in the creation of a new product to be structured and made available for use in future developments.

6. Acknowledgements

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