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The Structuring of Products and Product Programmes

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Abstract

Structure means the way in which things are built up. A composed product does not exhibit one structure, but hides in its structure of parts several different structuring principles, which fit the product for production and service and make it a member of a product programme, where other family members may be created by variation.

The structuring of products and product families is a complex design task. This article aims at classifying the many structuring types, which are built into a product. The fact that different structures are superimposed in the final product, makes the design synthesis complex and raises a need for aids.

Among aids for structuring computer support seems feasible. The need for modelling the product and its structural aspects is eluciated. A modelling framework is proposed, and the need for modelling different structure types by use of an enhanced modelling is shown. This article has two substantial contributions to the theory of technical systems: Explaining the superimposed structures in products and proposing a modelling framework for support of structuring to be implemented in design support systems.

1. What is structuring?

The elements of a product and the way in which they are built together determine the behaviour or function of the product. So it is impossible to speak of an unstructured product, but it makes sense to speak about a weakly structured product, which we may reason from its properties "difficult to assemble", "difficult to repair", "unfitted for transport", etc.

Fig.1. The meaning of the concept "structure".

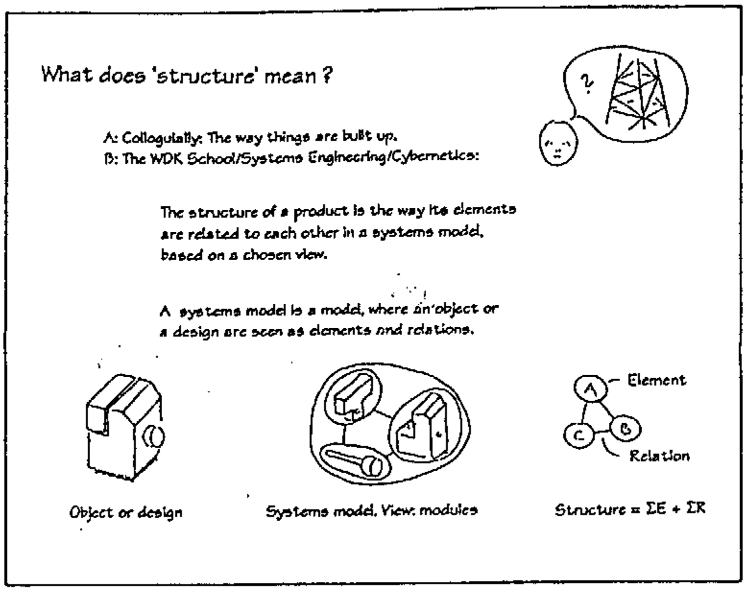


Fig.2. A product has more kinds of behaviour and more kinds of organ structures.

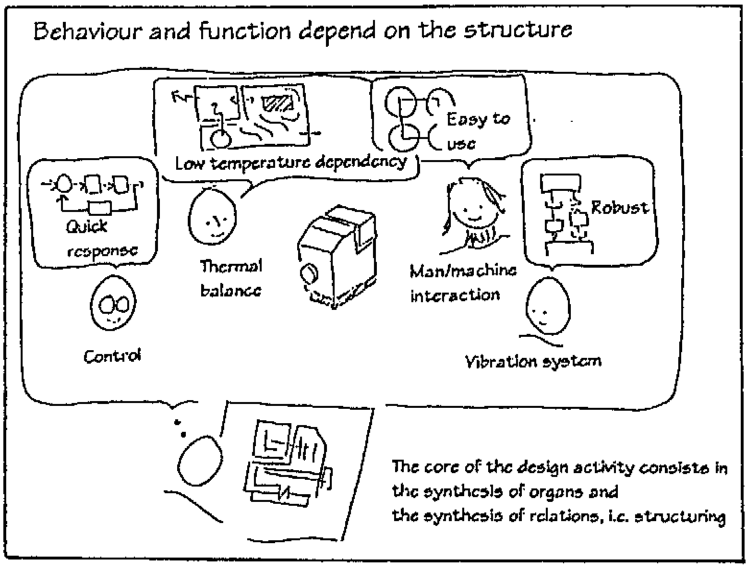
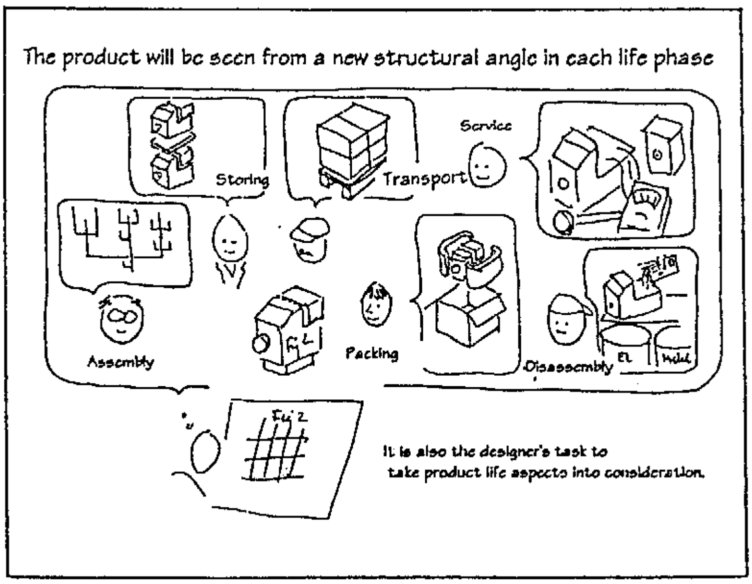


Fig.3. In each life phase we look upon the product from a specific point of view.



Determination of the product's elements and their structuring are called synthesis [1, 2, 3] in the field of design research. The design result may be seen as a system:

A system is a model of an object, viewed as elements and relations, described from an expedient angle and the theory of systems [4] and the cybernetics [5] may deliver a definition of structure, fig. 1:

> The structure of a product is the way in which its elements are related, seen from an expedient angle.

The viewpoint is decisive and unveils the ambiguity of the product. Fig. 2 shows four persons, each with his/her own viewpoint, who therefore each make a system model of the product. This means that the product carries more functionalities at the same time. The designer shown in fig. 2 therefore has to design based on multiple system and structure views. Structure viewed in this way we call *functional oriented structuring.*

The viewpoints in fig. 2 are related to the product itself and its primary purpose and use. In a similar way we find product life oriented viewpoints when different stakeholders in different life phases experience the fitness of the product for production, assembly, storage, packing, transport, repair, cleaning, and disposal, see fig. 3. The fitting between the product and its life phase activities is also closely related to the structuring and has to be treated at the design stage by the designer, see fig. 3. We will name the structural views for *product life oriented structuring.*

2. Synthesis

Products are designed or developed in different ways in industry. The design science aims at finding good theories, models, methods, and techniques for supporting the synthesis. A theory based on the so-called WDK-school and operationalised in our department, is the so-called Domain Theory [1, 2]. A product is seen from four system-oriented angles, see fig. 4:

- A process view, where the transformation of material, energy, and information of the product related to its use or function is central. This viewpoint leads to a description of *a process structure.*

- An effect view, where the desired functions or effects are in focus. These effects must be able to facilitate the necessary transformations. This viewpoints is related to *a function structure.*

Fig.4. According to the domain theory we need four structure types for designing the product.

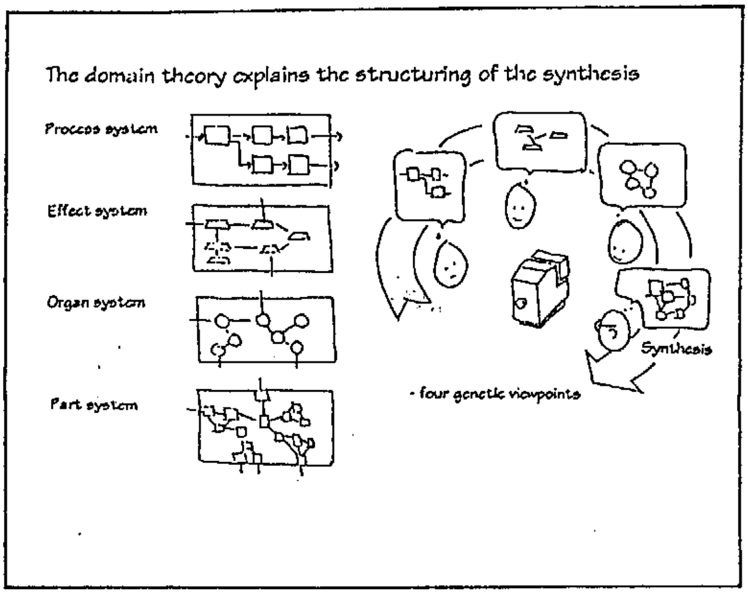


Fig.5. The real sequence of synthesis activities does not follow the ideal picture given by the domain theory.

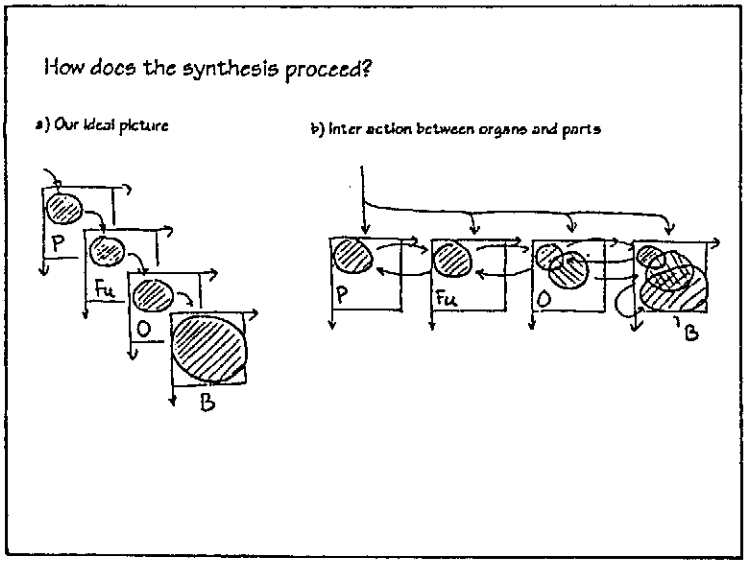
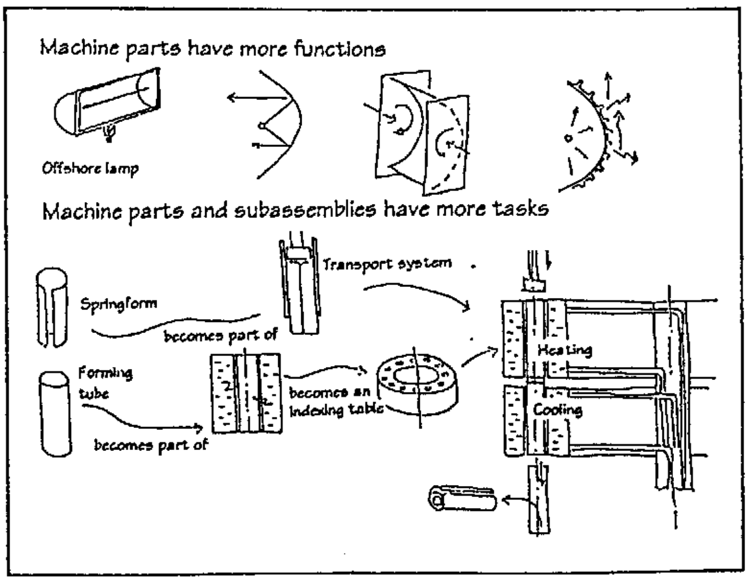


Fig. 6. The machine parts of a product often have more tasks or functionalities at the same time.



- An organ view, where the technical principles or means of the product are in focus. These principles or solutions are called organs (or function carriers) and by their functionality they create the mentioned effects. The result of the design considerations is *an organ structure.*

- A part view (or assembly view, German: Baustruktur), where we consider the machine parts of the product. By determining material, form, dimensions, tolerance and surface quality of each part and the inter relation of the parts, we create the necessary conditions for the organs and their functionality. We call this viewpoint *a part structure.*

From the above explanation it appears that these four views or system types are bound in a causal chain. Therefore, a procedure for synthesis of a product could be to determine the four systems of a product in a sequence following the four domains, see fig. 5a. In practise, the engineering designer is forced to perform several loops and jumps from domain to domain, fig. 5b. This fact is made visible by the description of the structuring task, treated in the following sections.

3. Superimposed functional structures

When we analyse a product, we recognise that the parts of the product normally solve more tasks at the same time. Fig. 6a shows an offshore lamp, in which the central mirror, which is made by an extruded aluminium profile, performs the tasks to reflect light, to create strength, and to lead away heat [6]. It means that the lamp holds (at least) three structures, that determine the behaviour of the product as light sourse, as a strength unit (casing), and as a thermal (heat transmitting) system.

The same situation is illustrated in fig. 6b. Here we see a machine for producing "egg sausage", i.e. a hard boiled egg in an extruded shape. The external shape is created by a springform which is closed into a cylindrical shape by being pressed into a tube. This tube also has to transmit the heat for boiling the eggmasses and it has to guide the movement of the form from the heating to the cooling zone. A chamber-like solution with circulating water is chosen for heating and cooling, which leads to the decision to let these chambers form the indexing table.

These examples indicate that a product carries superimposed functional structures. The designer is forced to alternate between various viewpoints, see fig. 7, and try to obtain high functionality and quality concerning each viewpoint or function, e.g. high yield, precise guidance, and efficient heat transmission for the hydraulic motor shown in fig. 7. It is not possible by organ considerations to determine superimposed functional structures. The engineering designer has to alternate between the organ and the part domains as shown in fig. 5b.

Fig.7. This hydraulic motor may be seen as four superimposed organ structures.

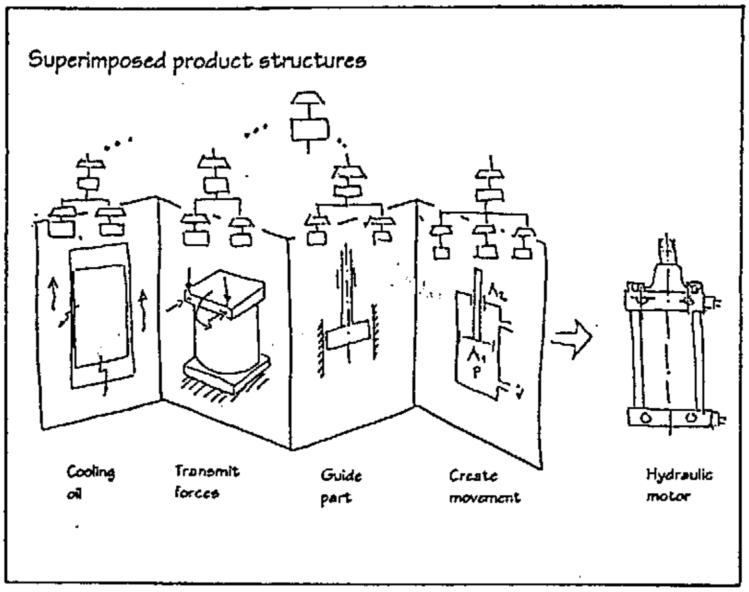
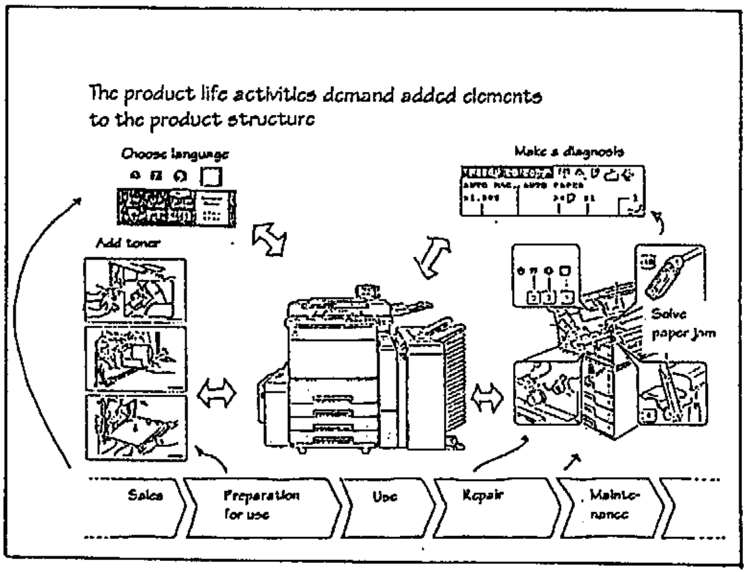


Fig.8. The life activities of the product demand more functionalities than those determined by basic use.



4. The influence of the product life on product structure

So far, we have only considered the functional aspects of the product and recognised the synthetization of superimposed functional structures. How does the fitting of the product to its life phase activities influence the structuring?

In the following we will try to demonstrate that the structure of the product is influenced in two ways:

- New elements in the structures of the product (process, function, organ and parts structures) have to be added due to the fitting of the product to the life phase activities.
- Certain structural principles may be superimposed to the functional structures for fitting the product to the life phase systems or activities.

From a superficial viewpoint, a product is only a passive object, a collection of parts, in most life phases, except in the use phase where it gets "life". But this observation is not correct; the product contains more or less active elements which add to functionality and quality in the life phases. Fig. 8 shows an imaginary example, the fitting of a copying machine to the life phases. Here we recognise the following:

- During sales, a change to another language on the display of the product may be utilised. This feature is realised by a (software) subsystem which is normally not activated during the use of the product.
- When preparing the machine for use, we may have to add toner. Therefore, the product should be easily opened and a swivel arm should lift out the toner cartridge thus allowing us to change it.
- When paper jams occur, the user should be able to set right the machine. Therefore the machine should able to open like a fan making the paper accessible; some rollers have to be turnable by hand, a safety system must switch off the current, etc., etc. All in all, a number of structural elements which are passive, when the machine is running normally.
- In situations, where the machine departs from its normal functions (lack of toner, lubrication, increased motor effect due to disturbances) a service operator should be called. Subsystems in the machine currently make a diagnoses and display messages about actions.

Fig.9. The fitting of the product and the production is made by structural fitting.

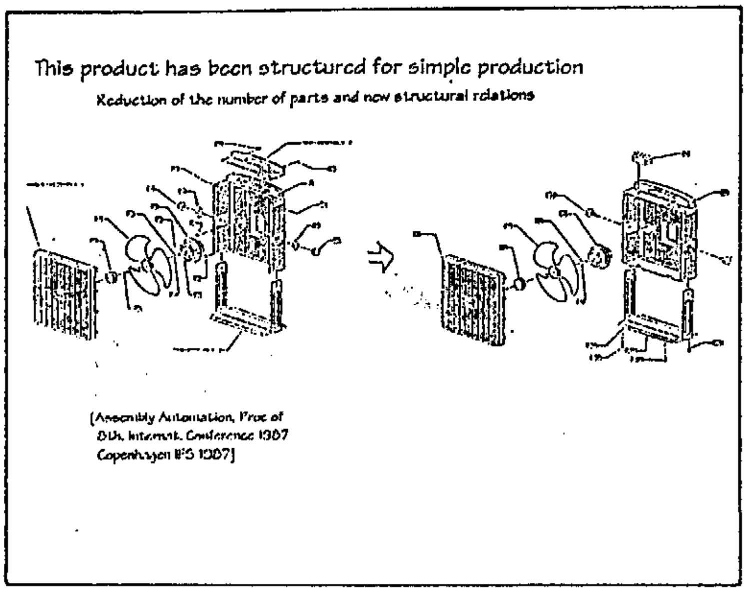


Fig.10. The fitting of the product and the life phase systems are made on four levels.

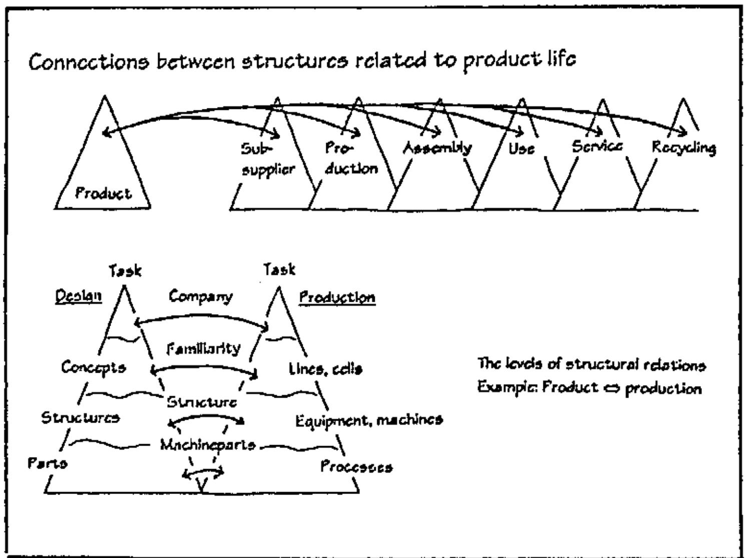
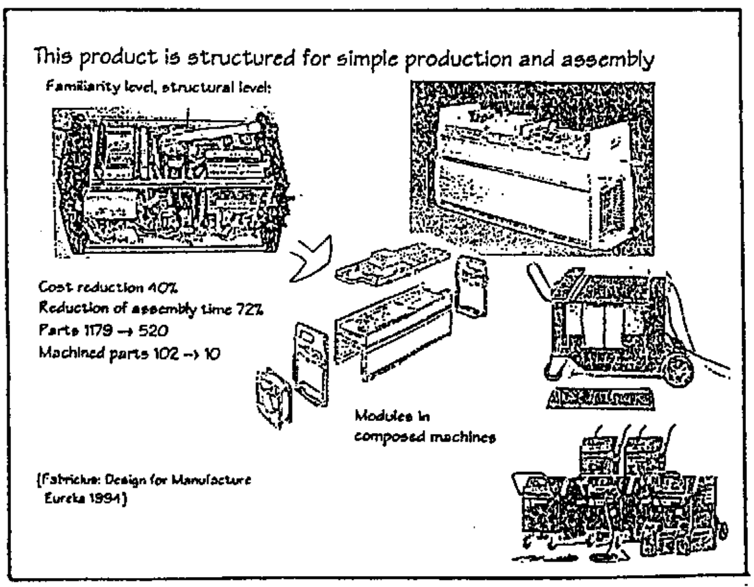


Fig.11. In the fitting of this product to production, several structural principles are used.



From this example we may recognise that the product does not have a structure determined only by its primary task; its range depends on accessories like mountable modules, safety guards for transport, transport pallets, spare parts, eyebolts, etc.

The second postulate that the life phases superimpose structuring principles is to a certain degree a known phenomenon. If we look upon the fitting of a product to an assembly system, the fitting may result in structural changes as shown in fig. 9. The fitting consists of spatial rearranging, but not changing the organs, differentiation or integration of machine parts, changing of connections for ease of assembly, etc. This restructuring does not mean a change in the effect or organ structure, but changes in the part structure. So the original part structures of the product is superimposed by an assembly oriented structuring principle.

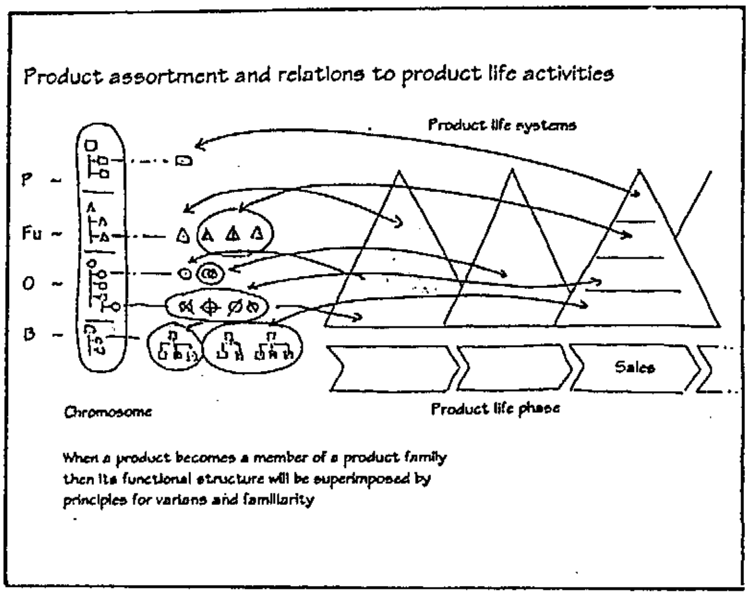
This recognition concerning structural fitting of product and life phase systems is made in several areas and by several researchers [7, 8, 9, 10, 11]. Symbolically it may be illustrated as shown in fig. 10. To the left are the four domains shown, which may be seen as design degrees of freedom according to Tjalve [12] and modelled as a pyramid. At the top we find the problem or the task, and gradually in the movement from top to bottom we determine the process, effect, organ, and part characteristics.

Fig. 10 shows the principal relations between the characteristics of the product and the characteristics of similar pyramids describing the product life systems: subsupplier, production, assembly, use, service, and recycling. It has been shown [8, 13, 14] that these relations may be categorised as relations on company, familiarity, structural and parts level.

Fig. 11 shows an example of the creation of a product with structural characteristics that fit it to the product life [8]. We see the old and the new design. The new design has a very simplified part structure with a strongly reduced number of parts. The assembly structure, i.e. the pattern which determines assembly sequence and methods, is now optimised to few, vertical assemblies and no wiring. This example is commented in the following section.

Another structural relation has to do with environmental effects. If for instance the lifetime of a television set is prolonged, its environmental effects due to production and disposal are reduced. The prolongation may be created by better cooling of electrical parts obtained by natural convection between vertical boards, it means a structural change of the part structure [10].

Fig.12. Here, a product family is illustrated on the basis of a chromosome and variants to the elements of the chromosome. Variants are utilised in sales, but demand familiarity in other life phases.



This section about product life oriented structuring leads to the recognition, that a product in the way it is built up may carry at the same time structural patterns related to for instance production, assembly, service, and recycling, which are superimposed and determine the product life fit and qualities of the product.

5. Variance oriented product structuring

The market demands for precise adaption of the product assortment to different market segments, users, and use situations lead to the building in of *variance* in the assortment of the product [15]. Such variance will normally be a cost driver for the company, because the benefit of high production volume disappears. But one may meet this problem by creating flexibility (i.e. unsensitivity against variance) in the production or by creation of such a familiarity between the products that they become identical to the manufacturing system.

Let us have a look at the range of the variance. What the company may recognise as its product assortment and the task for production may carry the following principal types of variance:

- Variance at process level: The company may have an assortment of process units, which may be combined in various ways for machine systems. Example: Process units in production machinery for chocolate candy.

- Variance at effect level: The company sells variance products for the same purpose, for instance flow measuring, but adds on different functionalities like supervision, registration, control, etc.

- Variance at organ level: The company supplies the market with products for the same primary purpose, but based on different principles, for instance different principles for flow measurement for fitting the products to different measuring tasks. There may also be variance conserning yield, size, interface, etc.

- Variance at part level: At this level there are many types of variance, for instance space structural, dimensional, and geometric interface variance.

Fig. 12 shows these aspects. To the left in the illustration a product model, the so-called chromosome [15, 16, 17] is shown, which contains the characteristics of the product concerning process, effect, organ and part structures. Some of these characteristics may be varied and in this way different products are created, belonging to the product assortment. The variance may create added costs in purchase, production, assembly, logistics, and storing if we do not try at the same

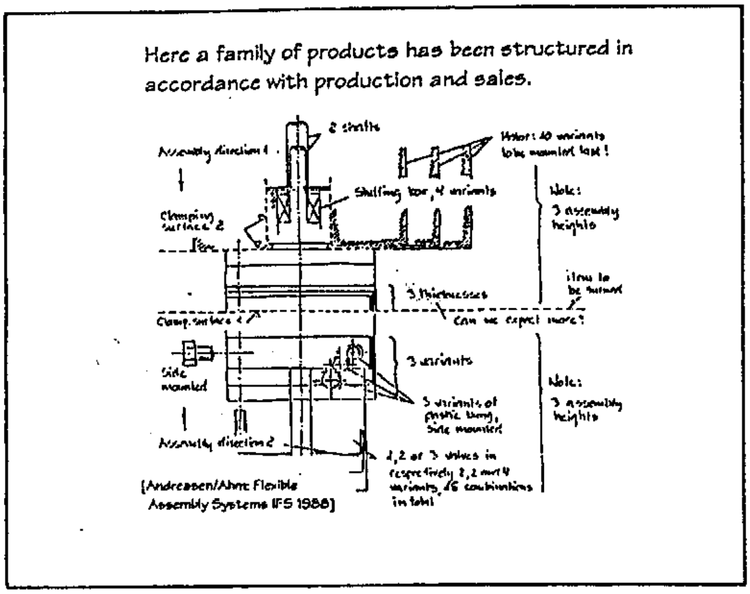


Fig.13. The structure of the product family is here predefined to ensure that the variants do not harm the production familiarity.

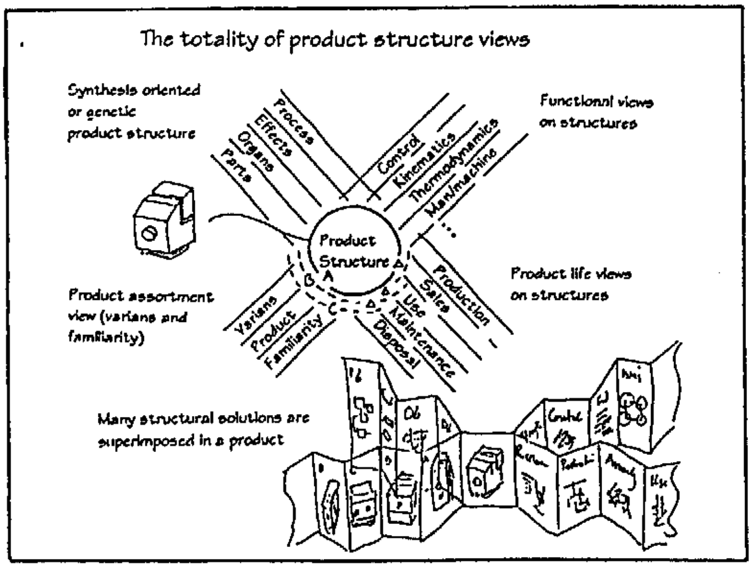


Fig.14. An overview of the four classes of structures of a product (a). The many structures of a product may be seen as a "centerfold"-pattern (b).

time to create familiarity. In the examples above we may utilize *familiarity* principles as follows:

- *Modularisation,* i.e. creation of physical subsystems with convenient inter faces, used for
  * Reduction of variance at process level: The process units may be given such interface (tube connections, transport lines, physical sizes..) that they may be combined in different ways. Hereby, the engineering and production costs are reduced for each customer order.

  * Reduction of variance at effect level: Added functionalities may be estab lished as"building blocks" with interfaces which allow independent and flexible assembly.

  * Reduction of variance at organ level: Central functional organisms may be designed as units with interfaces to the power supply, different functional building blocks, helping equipment, etc, so that different functional configurations optionally may be created by combination without added design and production costs.

  * Reduction of variance of parts level: Here we may create component modularisation, parametrization or use group technology principles, for ensuring identification of productive tasks.

- *Utilization of preferred numbers,* i.e. products where yield or productivity are fitted to a mathematical row of standard numbers in such a way that the best coverage of customer needs is created by as few sizes of products as possible. This principle is widely utilized.

Several additional types of principles for familiarity in processing, assembly, logistics, and sales exist, for instance creation of products which only by styling, colour, and text appear as different products.

Fig. 11 illustrates the modularisation, where the welding unit may be used as a module in bigger machines. The number of modules to be utilized is determined by a preferred numbers. Fig. 13 shows considerations concerning variance and familarity for an oil pump for heating systems. Here a modular system is created, consisting of basic units (with parametric variation), added functional units (control and safety valves). In order to simple fitting to the assembly system, the geometrical interface to the fixtures is unified for all variants [15].

In this section we have recognised that a product which belongs to a product family may have structural characteristics which determine the variance and the familiarity: more structural patterns may be superimposed in the same product.

6. A total structure picture

In the sections 2 to 5 we have seen that if we "read" the structure of a product, we get an ambiguous picture, and we have seen that the development of a product, which is a member of a product family, cannot be solved in a simple, progressing activity chain.

In symbolic form a total structure picture may be created, as shown in fig. 14a. The product in its primary situation of use and the hereto related structures are shown in the middle. This circle may vary due to structures related to product life fitting and due to variants (A, B, C..), which are related to the product family. Four basic views seem to exist [16]:

- *A domain or genetic view*: Here we see the four domain types proposed by the Domain Theory for synthesis of a product [1, 2].

- *A functional view*: Here we look at the different tasks of the product and the disciplines describing the product in different structures. Each view or discipline represents a theory based or at least engineering approach de termination of the structural model.

- *A product life view*: Here we recognize, seen from each single product life phase, the structure of the product and the elements to be added for fitting the product to the actual life phase activity.

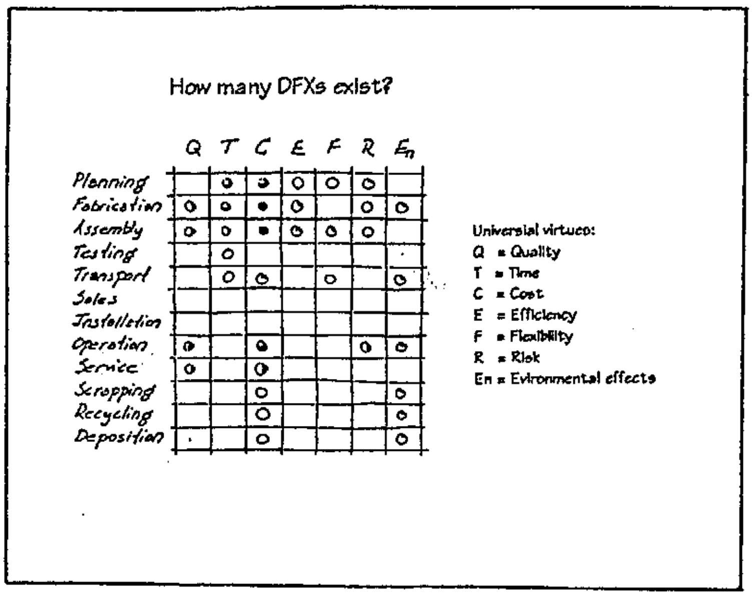
- *A product assortment view*: Here variance (related to the market) and the familiarity (for reducing internal costs) are in focus and explicit structural principles may be used.

Fig. 14b shows the same matter in a "centerfold picture", where each page represents a structure type which is recognized in the product.

7. Consequences of the superimpose picture

The insight into the nature of products and machines, illustrated above, is a contribution to the general theory of machine systems [1, 17]. Now the question may be raised: Where may this insight be of importance for engineering and design? We have selected two important DFX-areas (DFX: design for "something") for answering the questions.

Fig.15. Two types of DFX exist: product life oriented and universal virtue oriented.



7.1 Design for X for lifephases

DFX is activity patterns, methods, and knowledge serving to fit the product at the design stage to the life phase X, which may be purchase, production, assembly, use or disposal. In each DFX-area we are able to identify principles which point out ideal relations between the characteristics of the product and of the X-system. An example: If we use the structuring principle "a stacked product" [7] this will support assembly made by cheap pick&place units.

The designer's task is to build in good qualities, not only in primary use, but also in certain life phases of importance for the competitive power of the product. The superimposing nature of structuring is the reality the designer must relate to and learn how to master. The nature of structuring seems fitted for support by computer tools, "configuration support" [24, 35, 42].

The area Concurrent Engineering [18, 19] receives much attention today. Today many well functioning companies in Japan, USA, and Great Britain are using this pattern for product development, which in Denmark is known and utilized under the name "Integrated Product Development" [20]. The activities to be performed simultaneously, integrated and concurrent from a synthesis point of view are primarily the mutual fitting of the product and the systems for purchase, production, assembly, quality, control, logistics, etc., but also activities the product's company- external life: distribution, use, maintenance, disposal, and recycling.

A core activity here is to create the product in a way that it gets optimal yield and optimal support for all X areas. It means that multidimensional structuring must be mastered.

7.2 Design for X for the universal virtues

Universal virtues are such attributes for any company activity that are of concern for the person responsible for a specific area as costs, quality, flexibility, risk, time, efficiency, and environmental effects. Some of these attributes have a local focus, others, like leadtime, production costs, environmental effects, and total quality should be summarized for the total product life phase.

Design for Cost and Design for Environment as examples have the nature that the structural characteristics of the product highly influence the relevant product life phase activities. Therefore, the mastering of multistructuring also here is a condition for the creation of good results.

Fig.16. The domain theory leads to this so-called chromosome, which may be seen as a genetic and defining product model.

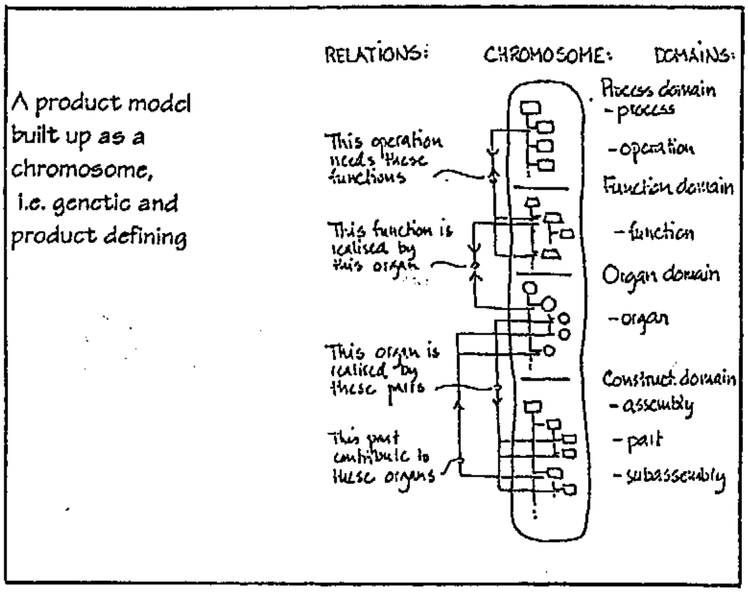


Fig.17. The theory and the model are closely related.

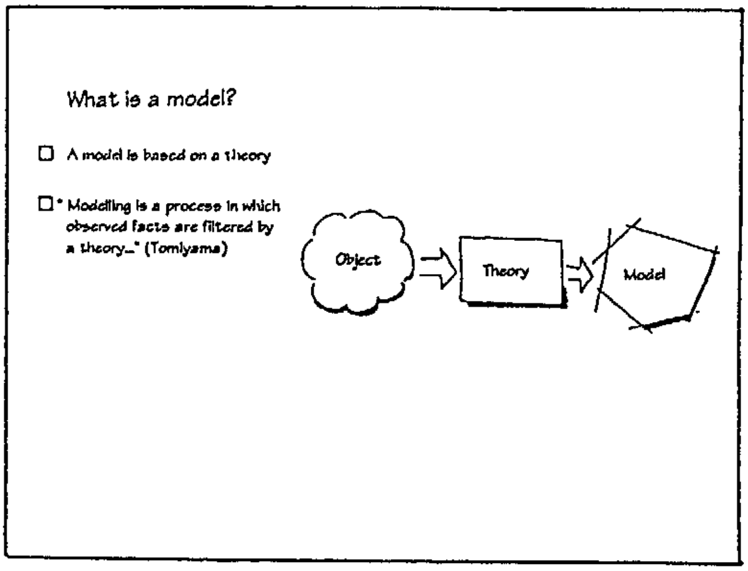
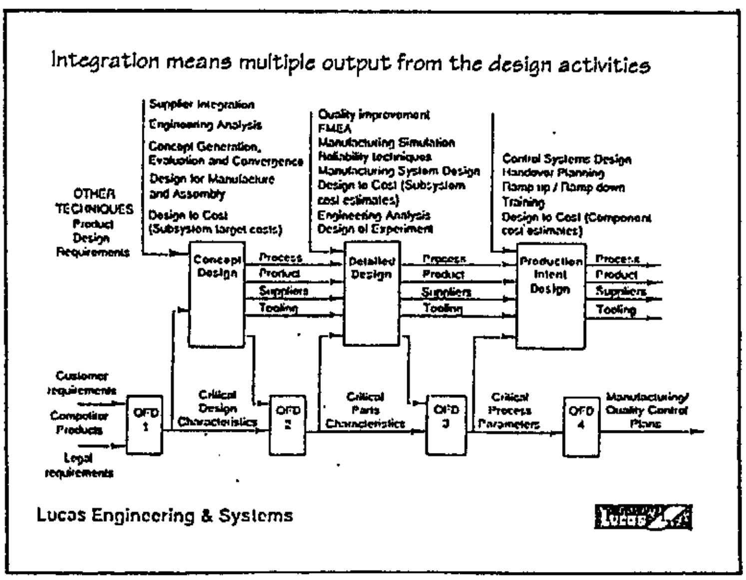


Fig.18. In this integrated product development process, the product, production process, tooling, and subsuppliers are determined in the early phases.



The two types of "Design for X" mentioned in section 7.1 and 7.2 are related in the so-called DFX matrix [21] shown in fig. 15. Each of the product life oriented views may be measured by the universal virtues.

8. Methods for structuring

The designer's structuring tasks vary in the whole range from a single product with unambiguous functionality and focus on the primary use situation to a complex product assortment with a high degree of superimposition and many product life aspects to be integrated. More over, the task may be independent from a familiarity point of view or belong to a defined system of products.

Especially for the task of configurating complex systems into a planned creation of variants and use of structuring principles (for instance modularisation), the computer support offers benefits. Many institutions are working on such support software [22, 23, 24]. The results are most visible in design of electrical circuts and pneumatic/hydraulic systems, but many companies have created special configuration systems for instance for bidding on industrial plants and for configuration of sound systems and consumer electronics. But it is characteristic that the system relations are quite simple and may be expressed by logic.

A condition for handling structuring and the data related hereto is product modelling. Below this area will be treated with special focus on structuring.

8.1 What is product modelling?

Product modelling may be seen as a high level concept for all types of modelling created in relation to the development of a product for obtaining insight, for specifying, or for communicating specific characteristics of the product [25, 26, 27]. But today the concept of product modelling also has a specific interpretation: a computer carried model containing product data. Or more specific: a product defining model (specifying product characteristics) with related data of importance for design choices made or of importance for the right use of the product (application data).

A broad spectrum of viewpoints and definitions concerning product modelling exists [28], most of these without theoretical justification as a basis. In the authors' department we see the product model as a chromosome, i.e. a set of data expressing the constitual characteristics of the product, defining the product, see fig. 16. The chromosome model mirrors the domains in fig. 4, but you may ask what structural aspects the chromosome mirrors, only one or all relevant?

Fig.19. This so-called score model is a mental picture, that support product life thinking in product development.

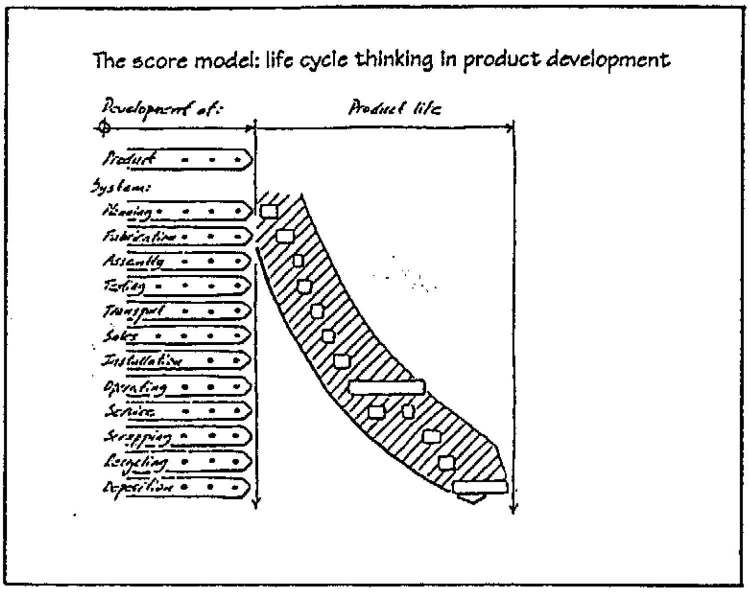
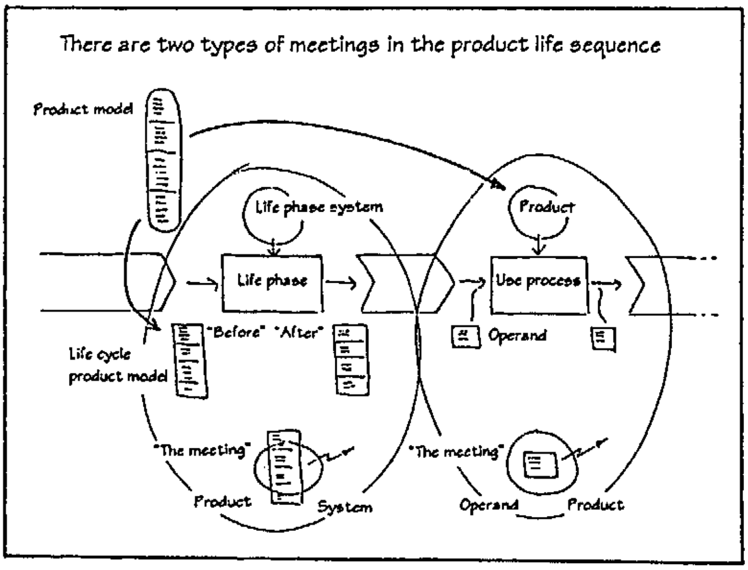


Fig.20. The relational properties of the product are determined by the meeting of the product with a life phase system. The relevant characteristics of the product are carried by the life phase product model (view model).



As shown in fig. 17, the connection between the object (i.e. the product) and the model is determined by the applied theory or way of observation. The object and the model have common properties. Tomiyama [29] defines that "modelling is a process in which observed facts are filtered by a theory". Many aspects of the product, even very concrete aspects like modularity and part structure, may be described in more ways depending on the theory which is the basis of the modelling.

We may therefore conclude that there is no *one* way of modelling a product, not even in the domain in which we model machine parts and their relations. It does not mean that the modelling is ambignous, but it means that we cannot expect a standardisation, not even in a branch area or a specific machine area.

8.2 Industrial needs made visible

The purpose of creation of a product model in a computer support system like for instance a Designer's Workbench [30, 31, 32] is to establish an operational model of the product, so that all contributions of definition of the product may be added to a common structure. Once such a structure is established, one may relate all types of information, which are the basis for reasoning or verification during the work. But we need this viewpoint expanded as shown in the following examples.

The company Lucas Engineering is utilizing an Integrated Product Development process as shown in fig. 18 [33] controlled by the QFD approach and characterised by four outputs from the design activities: product (subassemblies, parts), production methods, tools, and subsuppliers. Based on this fact we need to link data together concerning these four aspects, but neither the subsupplier, nor his production system or the tools are product characteristics, but belong as characteristics to something independent that may be related to the product.

The model of Integrated Product Development [20] shows in a similar way the need for relating set of data conserning market, product, and production in a product model. An expansion of this idea to all product life phases is found in the so-called score model fig. 19 [13] where the team during the design activity considers and decides about all aspects concerning lifephases and fitting to the systems that the product will meet during its life. In this way we recognise a need for coping with a complex set of data related to the product life sequence, the life systems, and their relations to the product.

We therefore recognize that a product model ideally should be able to handle all aspects shown in the model concerning structuring, fig. 14.a.

Fig.21. A genetic model system (GMS), i.e. the system of models necessary for carrying the results of synthesis and property modelling.

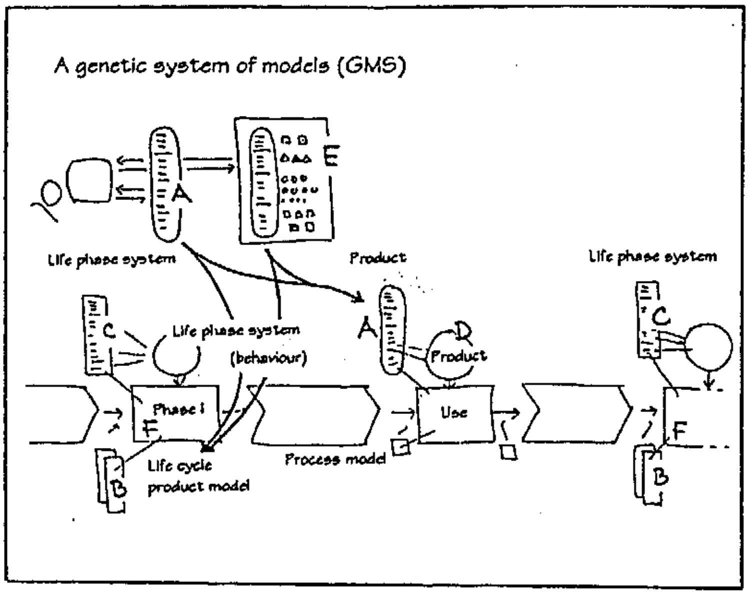


Fig.22. The GMS model with indication of property models and data.

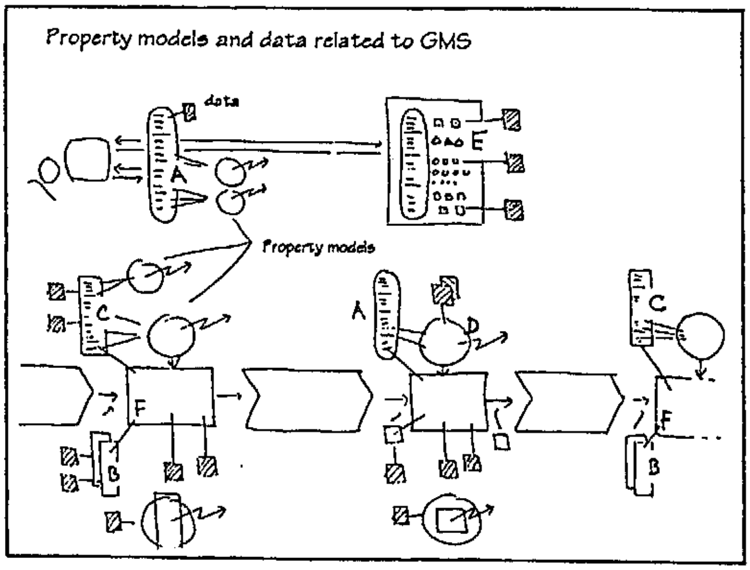
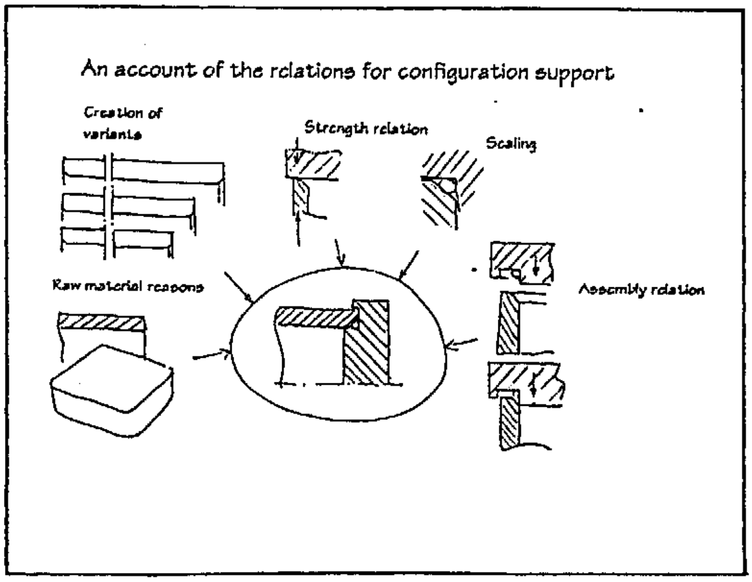


Fig 23. An example of accounting of relations for several structural models.



The modelling of the properties of a product is an area closely related to product modelling. During the design activity we need to model several properties of the product like strength, total form, costs, flow resistance, dynamic response, heat transmission, ease of use, etc. Some of these properties are solely dependant on the characteristic of the product, whereas others are dependant on the *relation* between the product and life phase system, see fig. 20. For instance production cost is a relational property dependant on both the product and the characteristics of the production system. Fig. 20 shows how characteristics are picked up in the chromosome for the modelling of properties and how characteristics from a specific life phase-oriented product model ("view model") together with characteristics from a life phase system are picked up for the creation of a relation property model.

When we consider the functionalities of a product model, it is important to consider how it interacts with these property models that may be seen as an important purpose of product modelling.

8.3 A framework for design models

The authors' department is working with the creation of a Designer's Workbench [3, 30, 32, 35] and related to this the question of how to establish a product model [36]. Because of the lack of sharpness of the concept of product modelling and because a product model of the kind presented above not primarily models the product, but the design (a genetic model explaining the route and the reasons), we propose the word *design model* as more appropriate for a Designer's Workbench related product model.

We have seen the necessity of working with a system of models based on the reasons found in the text above. A superior principle is that we want data to be related only to the object(s) which carry data or from which the data may be derived. This implies that we need to model several objects:

A. The product and the way it is designed (i.e. chromosome model or genetic model).

B. The product as it appears in a certain life phase (a life phase product model or view model). There exist as many view models as relevant life phases.

C. The life phase system, at least as far as what relates to defining and model ling the aspects of the system, that are relevant for the fitting of the product relative to the life phase system and for establishing relation property models.

D. The behaviour of the product in its primary task: the use situation.

E. The product assortment, it means the total product family and its internal relations.

Fig. 21 shows a proposal for a framework of design models, "a genetic model system" (GMS) [36]. At the top we find the designer in interaction with the product or design model A, with relations to the product assortment model E, relations to each of the life phase product models B and the life phase system models C. Based on these models we are able to establish several models as shown in fig. 22:

F. The product properties, derived from A or C, in form of property models F1 or relational property models F2.

The behaviour model D plays a special role in the use phase where properties related to use and man/machine interaction are in focus.

9. Structuring and design modelling

The picture of the dimensions of the structuring of the product fig 14a and the framework for design models have the same four dimensions, because the need for determining structural aspects (design characteristics) is mirrored in the need for modelling types.

The designer's tasks to structure the product need support from suitable models and techniques:

- What elements seen from what view are part of what structure?
- What relations must be established for this structuring?
- What are the overall relations to be established in the chromosome model of the product to ensure clarification of all structural aspects?
- Opposite: What structure does a certain relation belong to?

These aspects are illustrated partly in the example in fig. 23. Each single relation has its own "designer's intent", i.e. its argumentation, documentation, and verification.

The structuring task has a very high complexity. The aids for structuring may not show themselves beneficial when first used, but highly beneficial in situations with reuse of solutions and knowledge and creation of a database with experience on quality and costs.

10. Practical experience

The uniqueness of the authors' theory of machine systems is the fact, that it explains the chain from the purpose of the product to the role of details of the product and its quality contribution.

Based on this clarification effect, the department has established activities related to structuring and design modelling:

- A final year student's project for feasibility study of a database system, which links product assortment to development, production, sales and use of a product [37].

- A final year student's project for development of a new system structure (variance and familiarity) for a range of flow measuring equipment based on new ideas for production and man/machine interaction [38].

- A research project for SkanAluminium concerning the development of a knowledge system for aluminium technology in products and processes [39]. The system is launched for industrial use.

- A Nordic cooperation project concerning "Life cycle engineering support" with focus on environmental effects and costs [40]. The system will be based on the GMS model.

- A research project under the national research programme Integrated Pro duction Systems concerning development of a Designer's Workbench based on product modelling facilities.

- Submissions of EU applications for research on configuration support by computer systems [41, 42].

Today, these activities constitute too limited experience for evaluation of the ideas on product modelling of the department, but the signals obtained so far are promising.

11. Conclusion

This article has pointed out important aspects of structuring of mechanical products and it is shown that many products contain several superimposed structures.

Determination of the structural characteristics of the product for reaching good properties is essential in engineering design. It has been made probable that it is necessary to work based on a framework of models to be able to cover all aspects and the high complexity of design modelling. Such a framework is proposed .

This article has launched two important contributions to the theory of technical systems, namely a contribution concerning the superimposed nature of several basic types of structures, and a contribution concerning the types and relations of models in a general structure of design models.

Hereby, we believe that important conditions for a better understanding of complex designing is established and a theory basis for development of support systems for configuration and product modelling in design support systems has been established.

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