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Towards a Tool for Computer Supported Configuring of Machine Systems

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Synopsis
An engineering designer designing a product determines not only the product's component structure, also a set of different structures which carry product behaviour and performance and make the product suited for its life phases is determined. Whereas the elements of a machine system are fairly well known, the relations and their characteristics are only partly known and vaguely identified.

1. Introduction

An engineering designer designing a product determines not only the product's component structure, also a set of different structures which carry behaviour and performance and make the product suited for its life phases, e.g. production, sales, and use, is determined. Therefore, a product does not possess one product structure, but a set of superimposed product structures. According to the Domain Theory, Andreasen (1980), a product can be seen as a system from four different system views: Process, function, organ, and part. Whereas the elements of each system view are fairly well known, e.g. for machine parts an element is characterized by form, dimension, material, tolerance, and surface quality, the relations and their characteristics are only partly known and vaguely identified.

Our long-term research goal is to develop a computer-based system that is capable of supporting synthesis activities in engineering design. Such a system must contain a product model, which allows definition of and operations on machine system relations and elements. In this presentation we focus on machine system relations. We seek to identify types of machine system relations and the characteristics of the relations, and we discuss functionality of a computer tool to support configuring.

2. Product case: A tumble Dryer

A tumble dryer has been analysed in order to identify functional relations and organ relations. We have set up a function/means-tree and a state diagram for the tumble dryer. Based on the function/means-tree and the state diagram we see:

- that the purpose functions are active depending on the state of the machine system,
- that the relation between two purpose function seems to be of type logical "and". For example: When the functions "create air flow" *and* "lead air through clothes" *and* "tumble clothes" are realised then the functionality for a state of the tumble dryer is realised,
- the relation between two organs can be solved by an organ, and thereby a relation between two organs can be broken down and change type.

Andreasen, Duffy & Mortensen (1995) propose that a relation can be expressed by:

R (#A, #B, type, value, deviation).

For some of the organ relations we have tried to express relations this way and it seems to be possible.

3. Computer Supported Configuring

Mortensen & Andreasen (1996) has described the application of a computer based design support system, a Designer's Workbench (DWB), based on a metaphor: The engineering designer places certain bricks (design units) on a blackboard, and the composite set of bricks on the blackboard constitutes a complete product description. Mortensen & Andreasen define three types of brick: Specification or function, organ, and part. The designer puts the bricks on the blackboard when he designs, and he connects the bricks by threads. Following this metaphor some of the threads between the bricks on the blackboard are relations.

For an organ design unit we recognize relations to the function and part domains, and relations within the organ domain. According to the analysis of the tumble dryer the following set of operations seems to be suitable when designing on a DWB:

- define relation name, type, #A, #B
- show relation of type XX
- show all relations
- modify relation
- search solutions & relations.

4. Conclusions

The analysis of the tumble dryer shows that there exist various types of relation. Although the result of design work can be seen as a description of the product's components structure and all components, it is probably beneficial for the engineering designer to apply various system view points.

For the organ domain the following types of relation have been identified: Coupling, time, arrangement, realisation, drive, support, and control. Does there exist other types of organ relation?

It seems to be possible to express a relation by:

R (#A, #B, type, value, deviation).

In order to set up a classification of relations more work is needed.

The design unit metaphor has been applied to outline the requirements for a DWB to support configuring. A classification of relations will be a valuable step towards the definition of a formal design language based on the Domain Theory.

References

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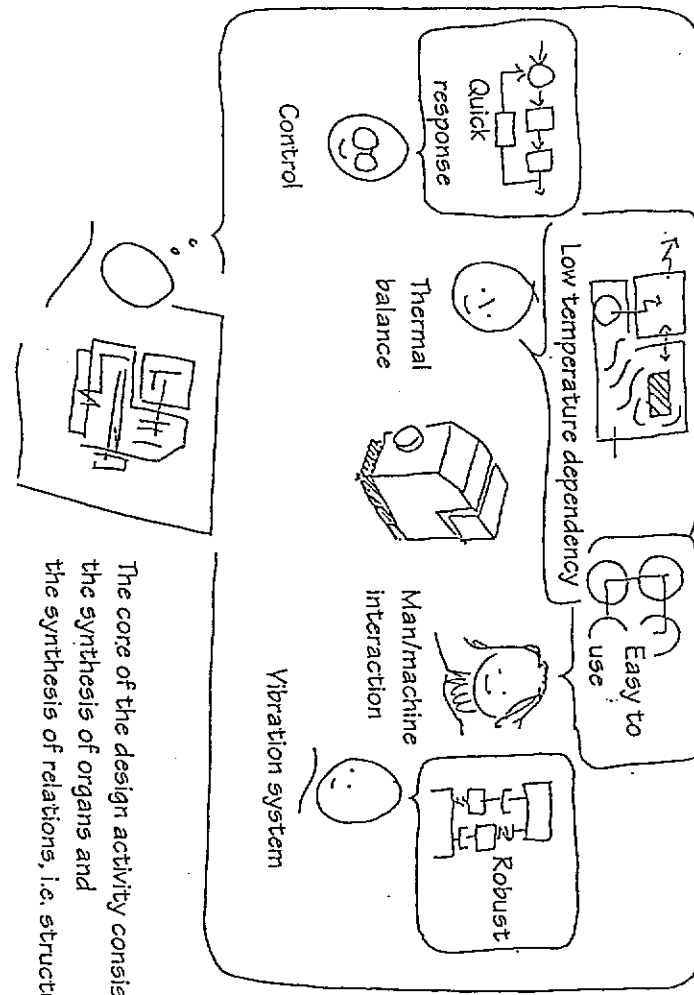
Towards a Tool for Computer Supported Configuring of Machine Systems

Claus Thorp Hansen

1. Introduction

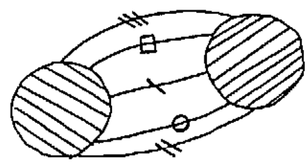
Behaviour and function depend on the structure



The core of the design activity consists in the synthesis of organs and the synthesis of relations, i.e. structuring

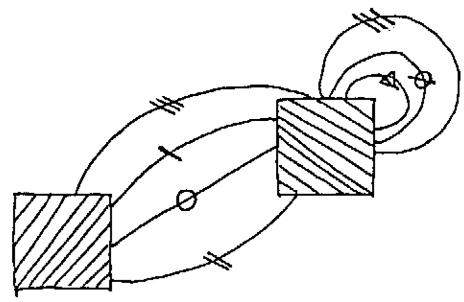
[Andreasen, Hansen, Mortensen]

Types of organ relation:



- // coupling
- o time
- / arrangement
- □ realisation
- /// more types ? ? ?

Types of part relation:

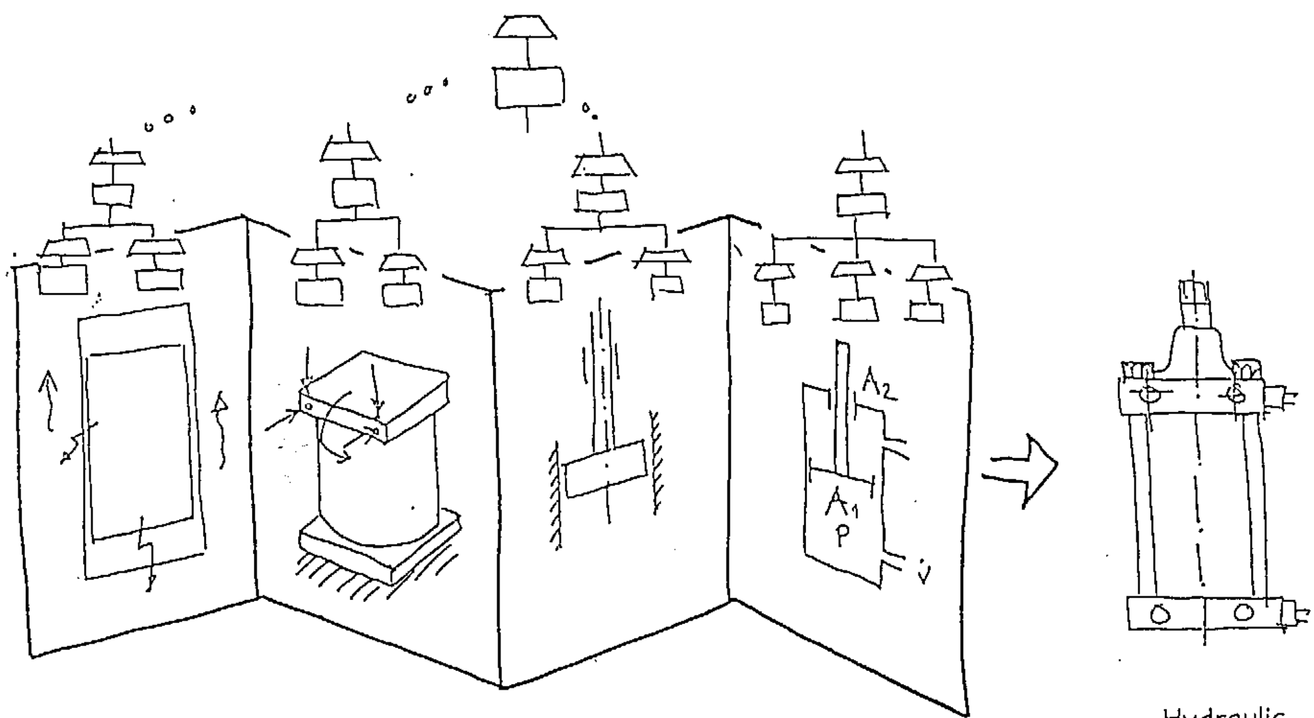


between parts:
- // assembly
- o organ
- / build up

in a part:
- ø functional surface
- ✗ contribution to two organs

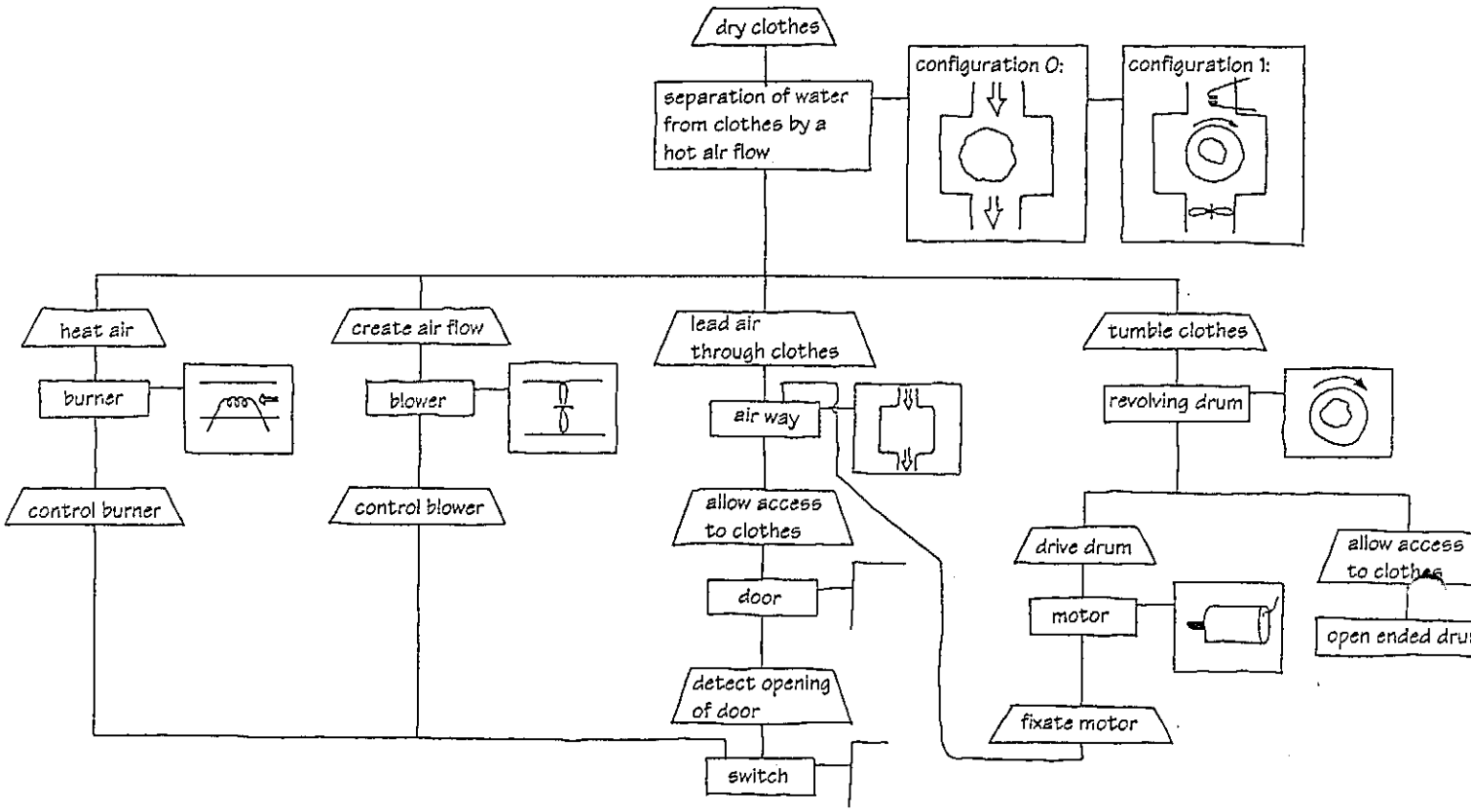
/// more types ? ? ?

Superimposed product structures



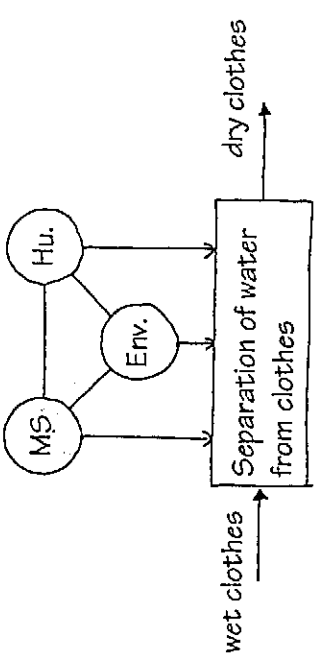
[Andreasen, Hansen, Mortensen]

The function/means-tree

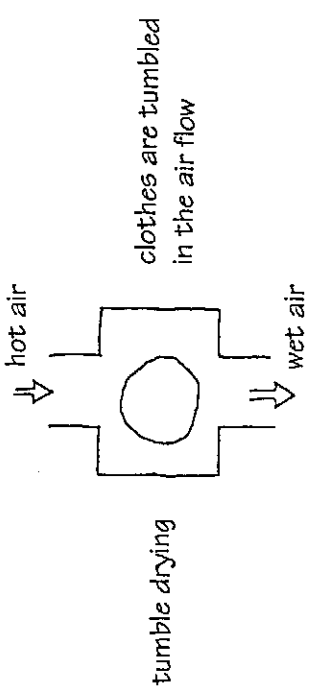


2. Product case: A Tumble Dryer

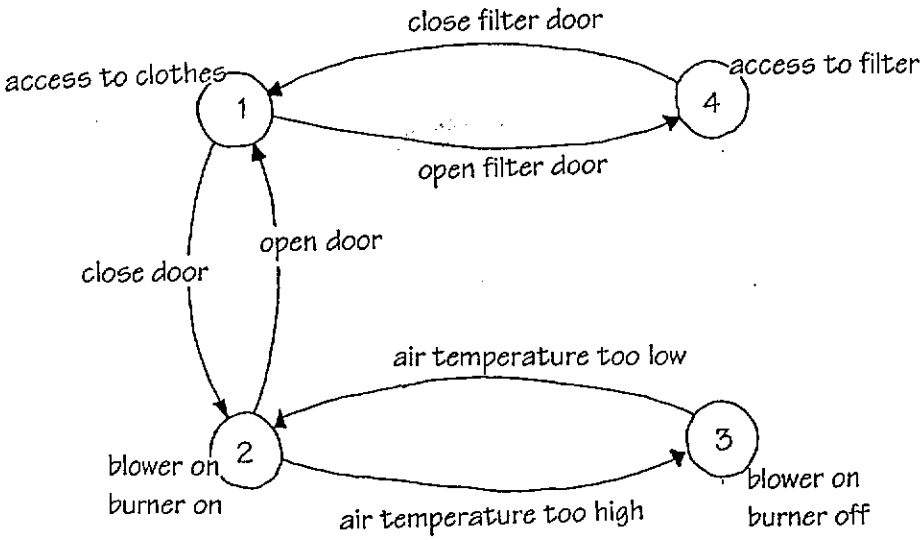
The process:



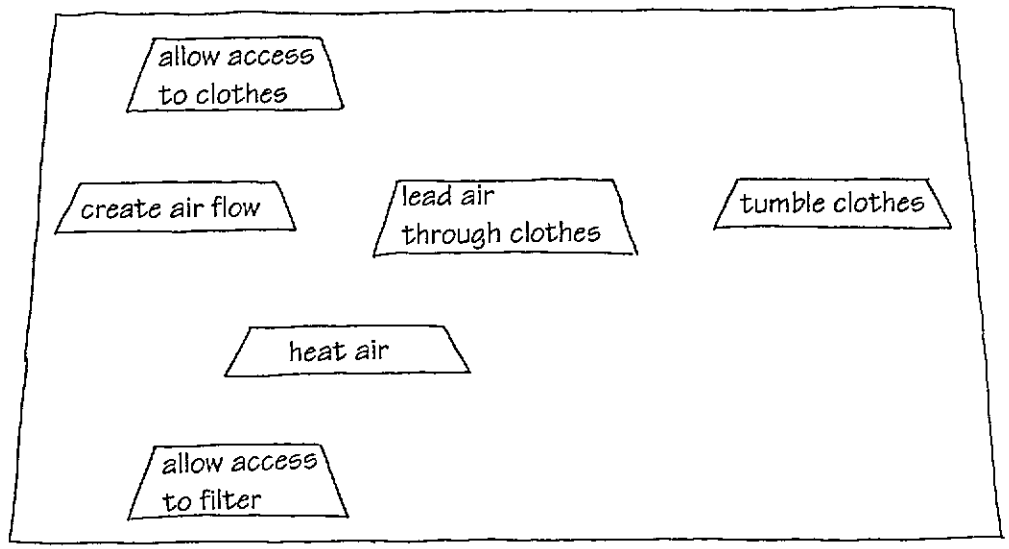
The technological principle:



The states of a tumble dryer



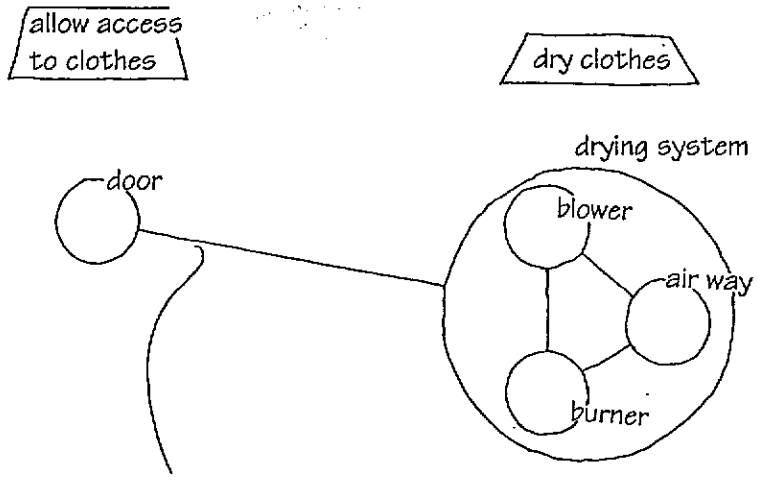
The purpose functions



The purpose functions are active depending on the state of the tumble dryer.

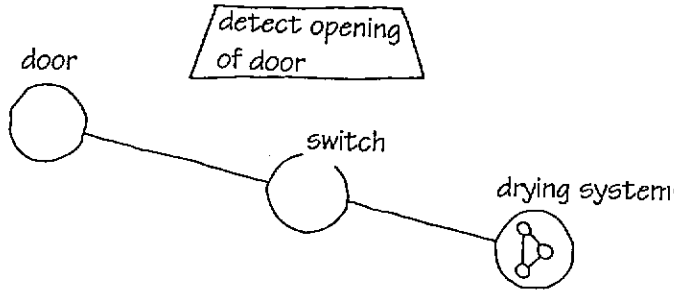
The relation between two organs can be solved by an organ.

Example 1:



Relation: When the door is opened the burner and blower must stop.

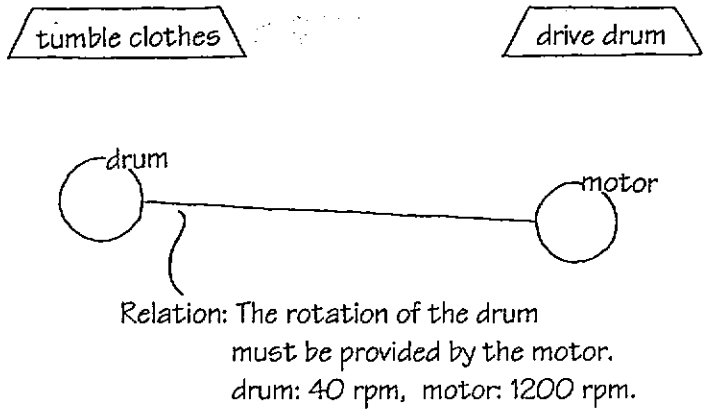
The relation is solved by a switch.



A switch interpreted as an organ creates a control effect. A control effect changes the state of a machine system.

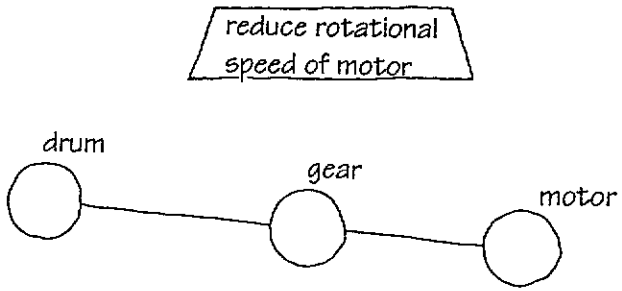
The relation between two organs can be solved by an organ.

Example 2:



Relation: The rotation of the drum must be provided by the motor.
drum: 40 rpm, motor: 1200 rpm.

The relation is solved by a gear.



Relations between organs to create functionality

R(#A, #B, type, value, deviation)

Drive relations:

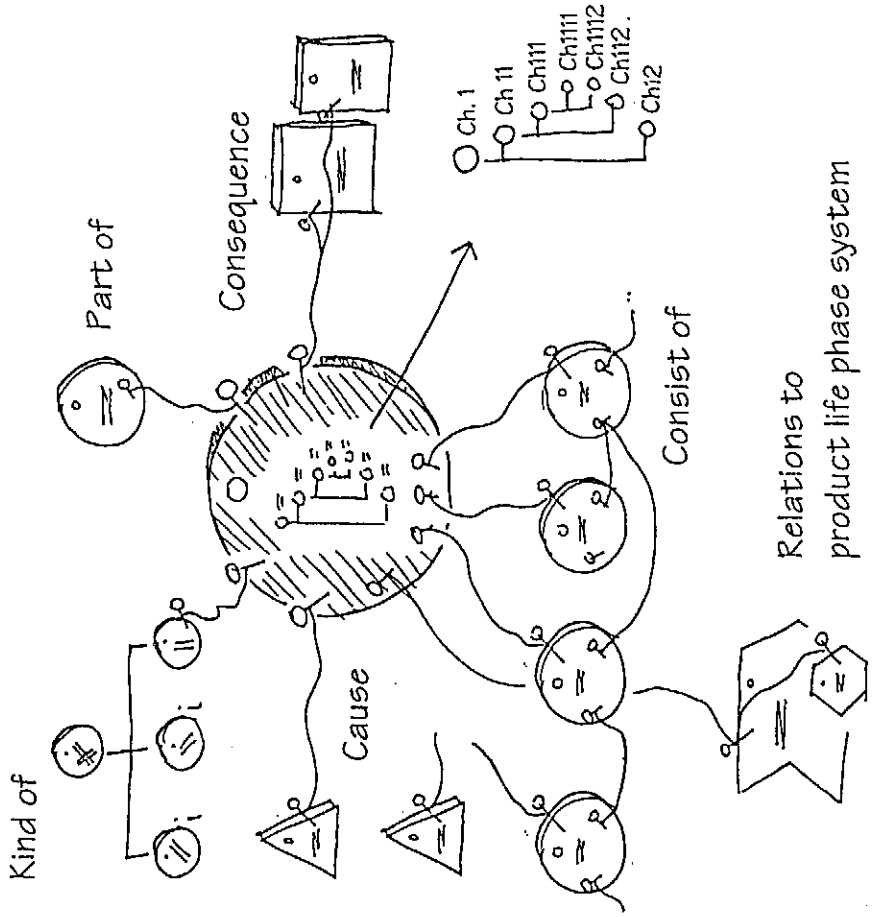
R(blower, air way, performance, suitable air flow, ?)
R(burner, air flow, performance, suitable air temp., ?)
R(motor,drum, performance, drum speed, ?)

Control relations:

R(door, motor, control, on/off, ?)
R(air temp., burner, control, on/off, accept. temp. range)

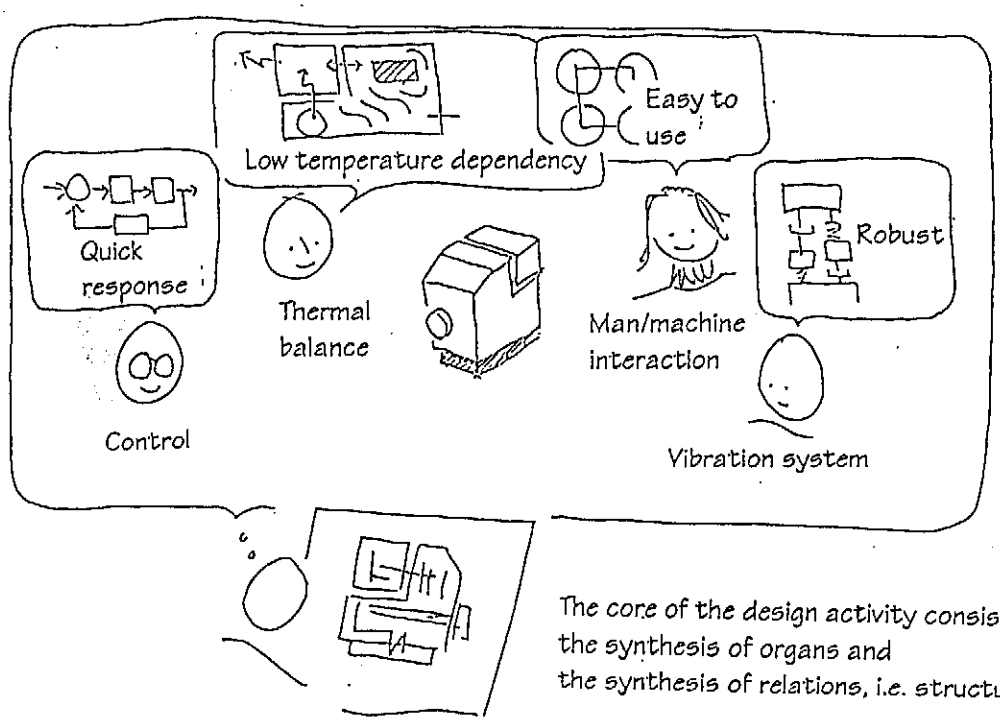
Support relations:

R(drum, bearing, support, ?, ?)
R(bearing, housing, support, ?, ?)



3. Computer Supported Configuring

No pre-defined design sequence



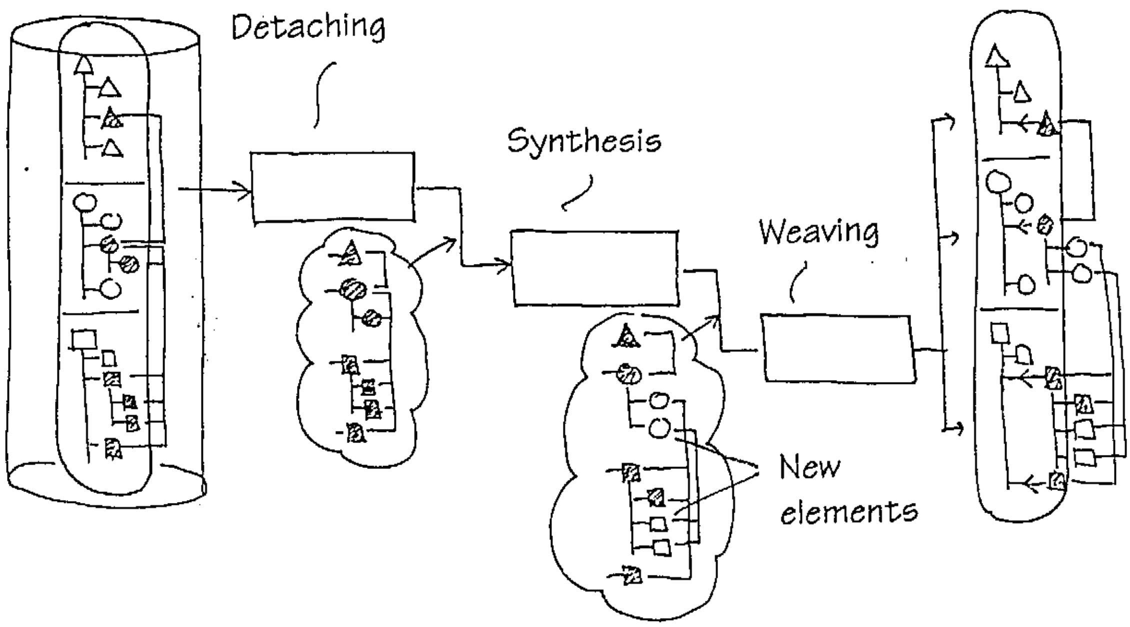
The core of the design activity consists in the synthesis of organs and the synthesis of relations, i.e. structuring

[Andreasen, Hansen, Mortensen]

Handling relations in a Designer's Workbench

Necessary operations:
- define relation   name, type,#A,#B
- show relations of type XX
- show all relations
- modify relation
- search solutions & relations.

Composing re-use elements



[Mortensen, Andreasen]

4. Conclusions

* Various types of relations

The work presented shows that there exist various types of relations:

- function, organ, part domain
- organ: coupling, time, arrangement, realisation, drive, control, support, ? ?

in a complex pattern.

It seems to be possible to express a relation by:

R(#A,#B,type,value,deviation).

More work needed to set up a classification of relations.

* Computer supported configuring

Requirements for a DWB to support configuring has been outlined:

- A set of operations
- The product model