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DEVELOPMENT OF MODULAR PRODUCTION LINES

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Abstract

Keeping and improving the competitiveness on the market of machine building depends on effectiveness, lead-time, flexibility and the process-quality of manufacturers. Companies providing design and build production lines can choose two different methods for machine design. First method is the application of earlier designed up-builds of production line, and the usage of those as a fitted construction according to the market demands. Second method is to develop an own machine-family, containing standardized elements, based on variation of constructional principles. The main advantages of this second method are predominating mainly when high number of orders has to be fulfilled. The goal of this paper is to introduce the modular system, and to compare conventional design method and this modular one.

Keywords: modular machine family, design for modularity, flexible machine, element-library.

1. Introduction

Due to demands of mass-product, which nowadays owns a huge slice of product activities, modular products have appeared in the market. In other words, producer companies are building their products in higher rate from standard and modular elements (e.g. automotive or mobile-phone industry). Producing of modular products has led very quickly to the modularly connectable technological steps (think e.g. of *SMD*-technology, which has these properties in electronics industry), and also to the modular machines. On the other hand these mentioned machines are also products of many specialized companies like Bodine, so these kinds of machines have been forced from both sides towards modular structure.

A very important criterion of flexible application is the suitable design of standard connections of all modules. Just it can ensure the ampleness of variations, what increases the number of available cases [1]. Flexibility also plays an important role, because market demands (and therefore the products) are changing very often, hence a really quick and easy conversion of product line components is required. In addition, today there is also a real and frequent demand to accomplish quick changeover between similar product-versions.

2. Principle of Modular Structure – Theoretical Bases

First of all, we would like to overview the theoretical bases of modular technology. The combination of two determinant design principles is required to create a modular machine-family. One of the principles is the *principle of product models* [2], which at first divides the design steps to model-groups, then solves the groups, and finally merges them. The other principle is the *principle of building blocks* [3], which is actually the methodological base of the design of a modular build-up machine family.

2.1. Principle of Product-models

The *requirement model* (*RM*) of a modular build-up production line contains customer demands, which are the base of a design process. Based on this, the *specification model* is easily defined. Hence we have elaborated the *specification database* (*SDB*), which will help to make quicker and more standardized specification of a production line (or any element of that). Naturally, the parameters collected in *SDB* are connected to the *element-library system* (*ELS*) of the modules. The *SDB* is a very global database, so designers will be able to handle in standardized form the customer, technological and modular limitations and possibilities. Next step is the making of the *concept model*, which is provided after classifying and abstracting of collected machine types and element types. Final step is the creation of a *construction model*, what actually means the design of concept-level modules. Connections of the four models are illustrated in *Fig. 1*.

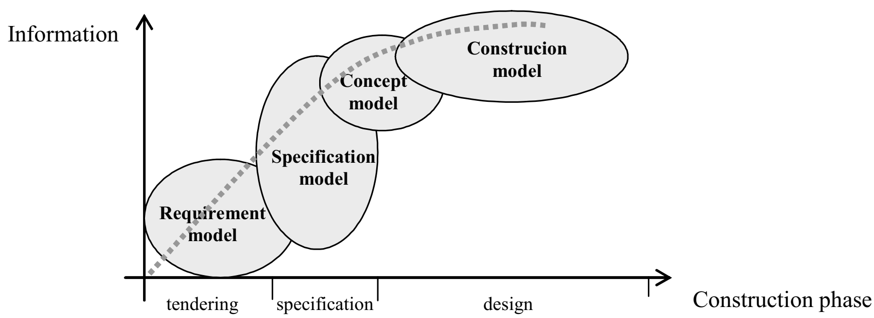

Fig. 1. The product-models

Actually, these models are representing the four main phases of a design process, and it can be seen, that we cannot define a sharp boundary between them (so we cannot determine the beginning and the end of a model-type).

2.2. Principle of Building Blocks

The first step of this method is the separation of modules for basic, auxiliary, special, fitting and non-building elements. The second step is the determination of parameters (and the value range of that) of the elements. The definitions of element-types are in *Table 1*.

Table 1. Element-types of modular machine family and their properties

Function	Element-type	Properties	Level
Base-function	Basic-element	Non variable, always repeat	Always required
Auxiliary-, connecting and switching function	Auxiliary element	General connector and bonding units	Usually necessary
Special or specific function	Special element	Depends on task, special accessories of base-element	Available
Fitting function	Fitting element	Required for adaptation to other system or boundary condition (in case of non-anticipated events)	Necessary available
Order-depending function	Non building- element	Depends on task, in case of specific and individual demands	Available

2.3. Properties of Modular Machines

Standardized and modularized machines differ significantly from conventional ones. The differences are illustrated in *Table 2*, also indicating the advantages and limitations of a modular system, from the aspects of the user (customer) and the manufacturer (GE – Machinery Plant) [4, 5, 6].

Element-set established according to modular-principle ensures high level of flexibility in case of every design and production steps. Replicated appliance of developed modules is a guarantee for quality by continuous solving feedback of problems and issues. By this process, elements of a modular system will be more and more perfect. In addition, this kind of modular system supports very well the application of design based on earlier cases. Storage of earlier solutions in an electronic database makes this procedure more effective.

Table 2. Advantages and bounds of modular machines

	MANUFACTURER	USER
ADVANTAGES	• ready capability documents • design is required only in the case of very special equipments (significantly shorter construction time) • easy to make a hybrid system by combining of the building and non-building elements • preparation of work is more simple • shorter turnaround time (because of the parallel manufacturing of the building-elements) • in case of computerized design, making of a new version is quick and simple • more simple calculations • good assembling conditions because of the well designed structural units (pre-assembled units) • the building blocks can be made in the best quantity according to the manufacturing (independently from orders) • it is advantageously adaptable in all phases of a production process (specification, design, technology, manufacturing and assembling) • easily adaptable for any kind of special machines	• short delivery time • lower cost • better part-sparing and maintenance capability • better supply of spare parts • changeable construction according to the further demands • matured product almost has no defects (low risk investment, better quality) • flexible structure and system (easily developable, suits to changing market demands) • a lot of problems of a production line are reducible (line balancing, optimizing, setting-up problems)
LIMITATIONS	• lower flexibility (e.g. in cases of special demands) • preparation demands bigger investments (at once) • changing of the product is not too economical • the manufacturing cost is higher • higher quality is required (there is no way for additional manufacturing, accurate manufacturing is necessary) • it demands more attentive assembling	• accomplishment to special demands is limited • certain qualitative properties can be more disadvantageous than some special purposely built constructions • enlarged weight and volume (bigger space demand and fundamental cost)

I have to underline that modularization has a lot of advantages and also disadvantages (for example: standardization bounds free creativity of designers), so the primary purpose is to define the optimal application of a modular machine-family.

3. Development Steps of Modular Machines

3.1. Practical Steps

First step of modular design is the elaboration of the modules, which are required to a special (product-specific) machine [7]. Primary purpose of this development is not the substitution of special machines, but developing of a modular machine-family. By using this machine-family, designers can up-build approximately ninety percent of a production line, which is able to manufacture the given product-family (in quicker and much more cost-effective way than the non-modular). Later, after choosing the suitable modular elements and the design-specific (individual) parts, follows the fitting of all modular and non-modular parts and subassemblies. And finally, as a result of this method the required special machine is completed.

Development of a design-system based on modular structure can be divided into two main parts. First is the *process of the development steps*, what means the determination and design of the modular elements. Second is the *tool-system*, which supports the modular-principle. It contains the definition, the creation of design-tools and the theoretical background which supports the elaboration of a modular system. *Fig. 2* helps to overview all of these steps and tools, where one can see the tools supporting the modular-principle inside of the ellipse, and the steps according to the modular-principle are shown outside.

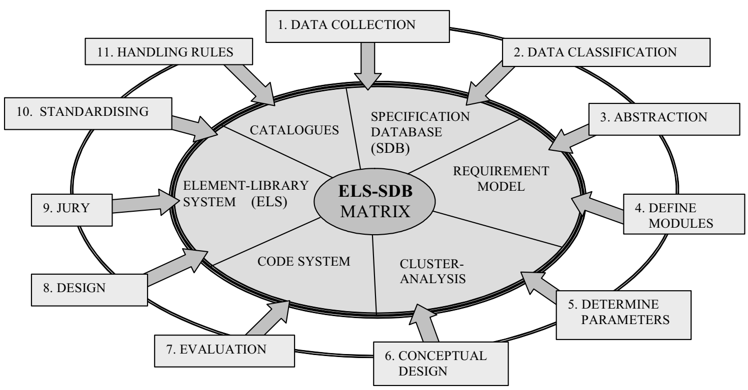

Fig. 2. Practical steps and developed tools of a modular machine-family

We would like to introduce in next pages the practical steps of the modular design method we have built and the developed auxiliary tools of this method.

3.2. Steps Developing Tools Supporting Flexible Design

As one can see it on *Fig. 2*, the *first step* is *data collection*, which means collecting data of several earlier tenders, specifications and surveying of machines and units to standardize. Data collection should be a bit extended than it is usually demanded, because later a data can easily become important, which was inconsiderable at the beginning of the process. Data collecting and later data processing can be supported on higher level by standardized and expediently made electronic surveying sheets. An example of these kinds of sheets is illustrated on *Table 3*, in which one can register the part-movement combinations of manipulators, which execute the technologically required movements of a production machine. With these sheets we can register data in standardized form, and by classification of data we can get the most important sub-units, which can substitute almost all of the units of earlier cases.

Table 3. An example of surveying sheet

Name of machine:		Exhaust machine	Production line:	GLS 2600	
Drawing number:		NM12	Type of machine:	Conventional	
ps.	manipulation	handled part	movements (mm)	pmc.*	drawing no.
1	loading	lamp	X30 X-30	1	NM12-1520
2	loading	tube	↑Y-90+X100 ↑Y90X-100	2	NM12-1780
3	bending	wire	X30↑Y-90 Z30 X-30↑Y90 -Z30	3	NM12-1580
1	measuring	wire	Z10 Z-10	1	NM12-1430
1	unloading	lamp	Z20 Z-20	1	NM12-1790
…	…	…	…	…	…
Notes, description:					
The task of this machine is to exhaust the sealed lamps, and to fill them with inert gas and finally to close the exhaust tube.					
Surveyor person:		John Smith	Date:		17/09/2004
* part-movement combinations					

Second step is *data classification*, which is analysing and processing of collected data to help easier and quicker appliance later on.

Third step was generalization of specific data, so called *abstraction*. It is needed because development of modular units and their hierarchical system happens based only on the main properties of earlier cases, but the abstraction is originally required to create new and independent solutions.

Fourth step was *definition of modular elements*. These elements generate the modular system. During this step, *ELS* is developed, what one can realize by choosing of units which cover up to ninety percent of the whole range [8]. Bigger and complex elements can be divided according to functional parts to get the modules, but smaller units can be the modules themselves. On the next tables you can see an example of classification of surveyed units. On *Table 4*, one can see the main modules of a production line, and the properties.

Table 4. A possible classification for the main modules of production lines

Group	Code	Modular element	Element type	Parameters
Production line	MBP	Production line	*Assortable element group*	Velocity, product properties
	MBB	Base-machine	*Assortable element group*	Velocity, head-no.
	MBPC	Conveyor	Fitting element, auxiliary element	Velocity, up-build
	MBPF	Feeder	Fitting element	Process, product properties
	MBPP	Puffer	Special element	Capacity, up-build
	MBPM	Measuring, checking unit	Special element	Accuracy, velocity
	MBPC	Controller unit	Base-element, special element	Handling of data
	MBPX	Accessories	non-building element	Specific

By forwarding the classification of modules we can get a level lower (and so on). On *Table 5*, you can see it as an example, actually in the case of the base-machine.

Table 5. A possible classification of the main modules of the base-machine

Group	Code	Modular element	Element type	Parameters
Base-machine	MBB	Base-machine	*Assortable element group*	Velocity, no. of heads, execution
	MBBS	Structure of machine	Base-, auxiliary or specific element	Up-build type, geometry
	MBBD	Driving system	Base-, auxiliary or specific element	Velocity, performance, indexing
	MBBP	Part handling	Base-element, fitting element	Product properties
	MBBA	Actuator	Base-element, auxiliary element	Demand of movement, velocity
	MBBM	Manipulator	Special element	Sub-movements, intervals
	MBBX	Accessories	Non-building element	Specific

Fifth step was *clarifying of parameters*. During this step we have determined the main parameters of the modules, and their working range. In addition we have to divide units to fixed and alternate parameter-value types to create module-versions.

Sixth step is *conceptual design* of modules, hence it is needed to elaborate some preliminary-design versions for all modular units.

Seventh step is *evaluation*, what is choosing the most suitable elaborated versions. This step is executed by a developer-team. We suggest this team has to be defined at the beginning of the development process, and has to contain one competent expert from all fields.

Eighth step is *design*, what is final elaboration of the chosen module-versions. During this step all of the elements have to be redesigned according to the modular demands (e.g. variability, standardized connections etc.).

Ninth step is *accomplishment of juries* (by a competent team), what means the realization of required smaller modifications and finally the acceptation of designs.

It leads us to the *tenth step*, which is *finalizing the accepted modules*, this is called standardization. In the future the alternation of finalised modules can happen only in very reasoned case. This is a fundamental-condition of building from standardized elements (so called principle of building-blocks). And last but not least, *eleventh step* was *determination of the handling rules*. These rules contain the access rights and the application conditions of the flexible tools and the modular elements.

3.3. Flexible Design Supporting Tools

In this chapter we will introduce the flexible design supporting tools (in accidental order). *Requirement model* (*RM*) is the collection and systematization of demands and requirements of flexible system, which are precedents during developing of flexible tools. The sources of RM are illustrated on *Fig. 3*.

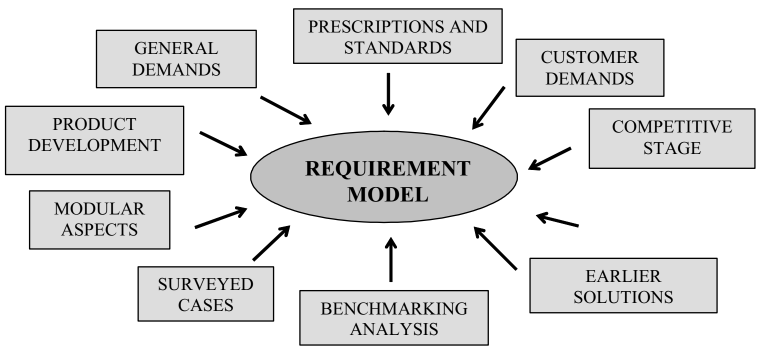

Fig. 3. The sources of RM

RM is a very important tool, because modular properties often conflict other important requirements, so during the development process, a competent team has to decide that in given product-environment which properties are more important.

Specification database (*SDB*) is a result of surveyed specifications, and provides high level of help in the following cases, for example in the specification phase of newer machines. The structure of SDB is illustrated on *Fig. 4*. To establish *SDB*, studying of several earlier specifications is suggested to create a database, which consider (almost) all parameters. By using of *SDB* designers always are able to create a suitable specification, which is the base of the whole design process [9].

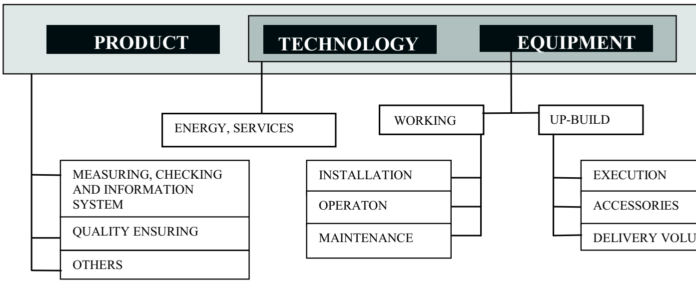

Fig. 4. Structure of specification database

Element-library system (*ELS*) contains the modules of the flexible system in hierarchical layout. The code-system helps to handle all elements in an easier and more definite way. The result of the module-classification is illustrated on *Fig. 5*.

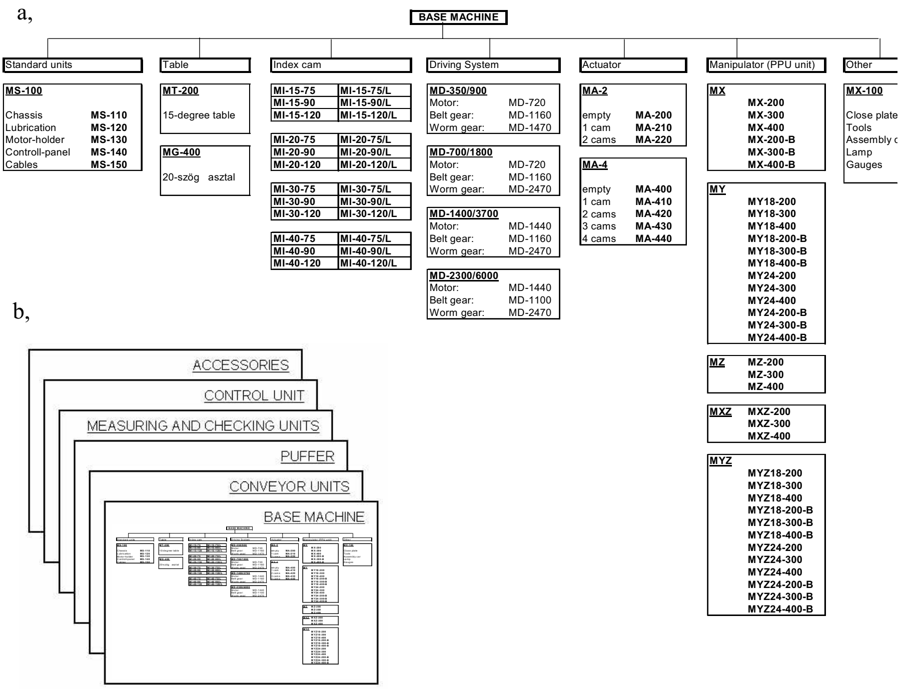

Fig. 5. Structure of ELS (a, modular production line; b, modular base-machine)

By combining these two systems (*SDB* and *ELS*) one can get the *ELS-SDB matrix* – which is illustrated on *Table 6*. This matrix helps to define and connect parameters of modules and specification activities – in both directions. First direction, if we are searching the parameters, which have to be specified to design a unit (reading along rows). Second direction is, when we want to define which properties of which modules depend on a required (and specified) parameter-value (reading along columns). One can see that the *matrix* can be used in any direction and level.

			SDB																	
			PRODUCT				TECHNOLOGY					EQUIPMENT				…	SERVICES			
		Parameters / Units	size	type	material	…	principle	description	prescribe	property	…	no. of heads	capacity	up-build	…		electricity	gas	cooling	…
ELS	BASE-MACHINE	actuator	■		■	■	■			■			■	■				■	■	■
		manipulator		■	■	■	■		■	■		■			■		■	■		■
		…	■	■	■		■	■	■	■	■		■	■	■			■	■	
	PUFFER	anaconda	■										■							
		gug			■					■					■			■	■	■
		…			■										■					
	…																			
	CONVEYOR UNITS	chain		■						■				■						■
		belt			■	■	■													
		…			■	■							■					■	■	

Table 6. Structure of matrix ELS-SDB

Cluster-analysis is a well-known method [10], which can help us to define the overlaps of the created specifications and the accessible module-set by appliance of the matrix. The main parts of bi-phase cluster-analysis are illustrated on *Fig. 6.*

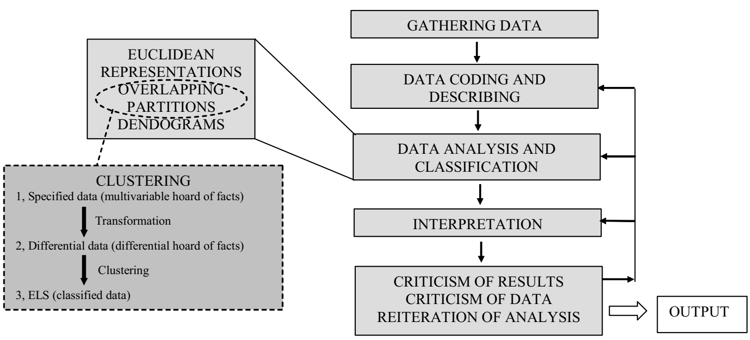

Fig. 6. Main steps of the Cluster-analysis.

And finally, *catalogues* make the handling of the established system easier and quicker. To accomplish all the demands, three types of catalogues are needed. First type is the *design catalogue* of the modular machine family, which helps the work of developer-team and contains the steps and phases of the development in fully detailed form [11].

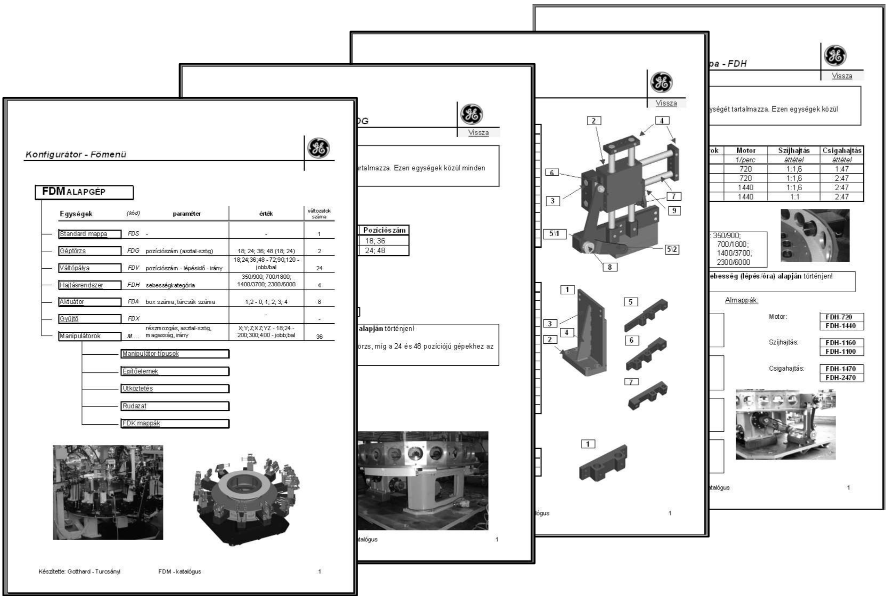

Fig. 7. Some sample-pages from the element-catalogue of the modular machine-family

Second type is a *catalogue of ELS*, which presents the modular elements of the flexible system (with the properties and detailed descriptions of those) and introduces the whole system (see *Fig. 7*). It has been made for designers who will use modules during their design activities. And the third type is a *commercial catalogue*, which shows the modules as standard products for that kind of machine-builder companies, which would like to order ready-made modular-units, and use them according to their own goals.

4. Introduction of Developed Modular Machine-family

Modular system means an element-set consisting of modular units and sub-units, which (besides the special elements required by actual demands) help designers to build a production line, which is able to make products, which contain more elements by realization of production and assembly operations [12]. As an example, *Fig. 8/a* illustrates a fictive production line in which we have indicated some typical units. The hierarchical system of a modular machine-family can be divided into sub-modules and accessory modules. The group of main-modules contains the special machines (task of these is to execute a technological operation-group), the auxilliary units (e.g. feeders, conveyors, puffers) and the modules, which are needed for the operation of the whole production line (e.g. services, information system etc.). The group of sub-modules became by forwarding-division of main modules, like for example the sub-modules of a special machine is chassis, driving system, actuator units, manipulators, accessory units and so on (see *Fig. 8/b*). By forwarding-division we can get the level of modular units (*Fig. 8/c*) and finally the level of modular building-blocks (*Fig. 8/d*).

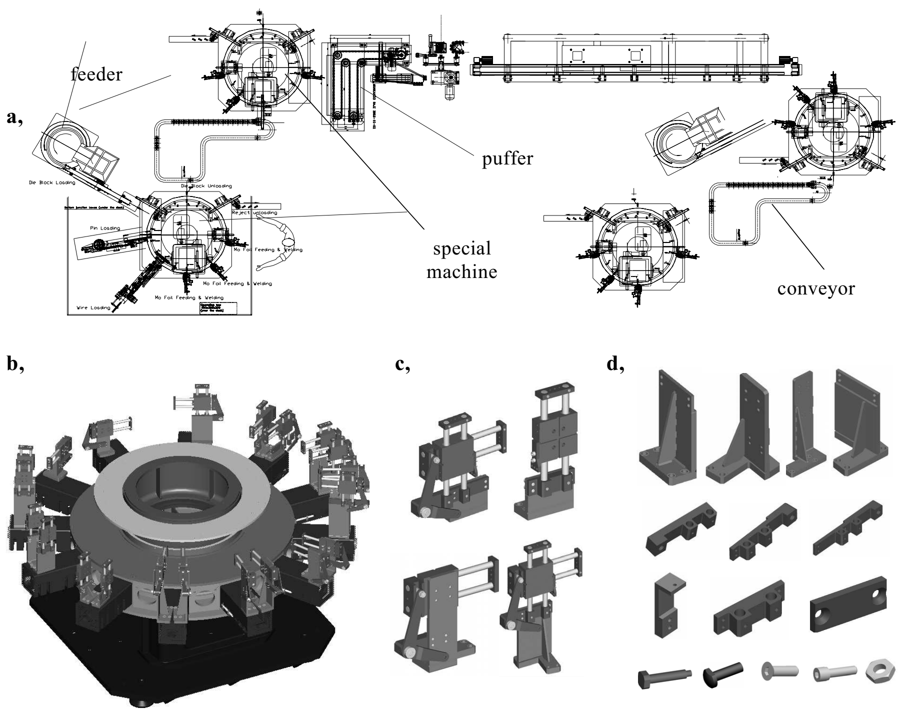

Fig. 8. Some example for typical modules of a modular production line (a, modular production line; b, main module; c, modular units; d, modular building-blocks)

5. Computerized Tools of Modular Systems

Computerized tools are required to use the developed modular system. These tools make interactive connection between developed auxiliary tools of the modular system, ready to use modular units and the demands and requirements of the user. To collect all of these computerized tools we have developed an auxiliary-software, the so-called Modular Design Software (*MDS*).

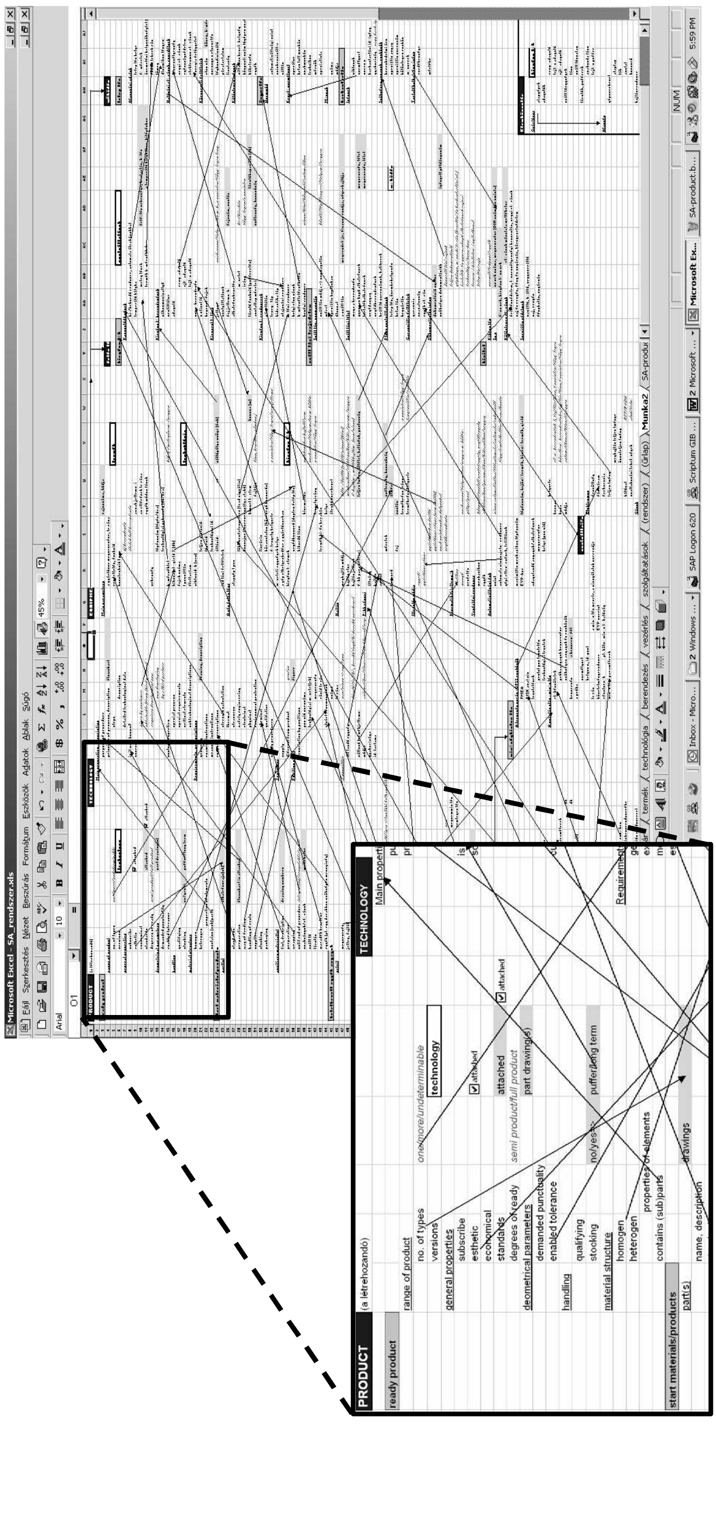

Fig. 9. Structure of SDB

5.1. The Specification Module of MDS

As one can see on *Fig.9*, there are several connections between elements situated on different hierarchical levels of *SD*B. It seems, that these connections realize a very difficult system. To handle this connection-system, the Specification Software was developed, which has several advantages. The hierarchy of this software is the same as the hierarchy of *SDB*, and in addition by appliance of Cluster-analysis, it realizes connections between *ELS* and *SDB* (based on the matrix). See *Table 6*.

Hence, the software is based on the matrix, it can be used in the same way, so towards both directions, on any hierarchical levels. The interactive catalogue of *ELS* helps to orientate in the system and to choose the most optimal solution. See *Fig. 10*. The output of this software is a document, which is equal to a standard specification, generally used to specify all of demanded technical parameters. The structure and the user interface of the software are illustrated on the next figures. 3D-models of chosen modules are collected to a given folder. Ready 3D-models

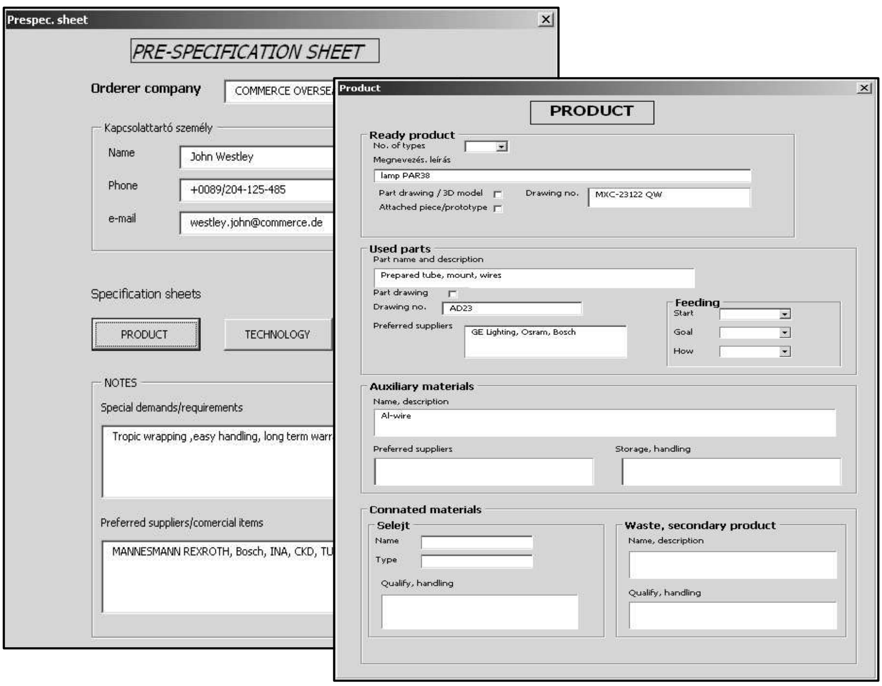

Fig. 10. The user interface of the auxilliary programme

and drawings of modular units ensure quick and simple design and alignment. Beside of these it is also important, that by multiple applications of modules and by continuous feedback of information, the manufacturing process of modular units is also ready and optimized.

5.2. Morphology of MDS

According to the specification, choosing of suitable modules and the realization of their different combinations are also executed in a computerized way [13, 14]. To make a decision for the most suitable solution, an integrated cluster-analysis processor supports the combination. A code-system (*CS*) supports the symbolic description of the elements, which help to realize cluster-analysis (*CA*) in a simple and perspicuous way. All combinations get the code lines, which describe their properties, the contained modules and their properties.

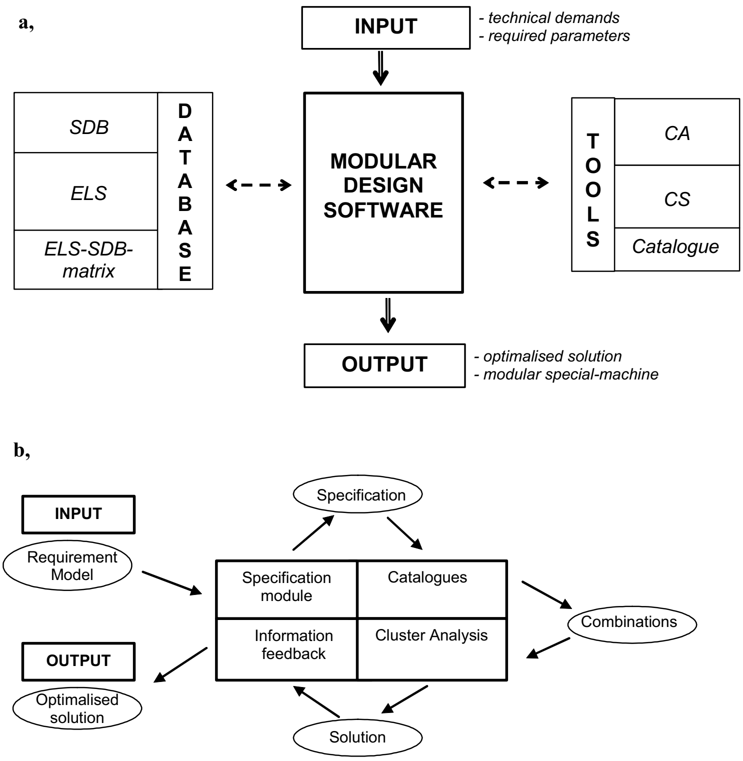

Fig. 11. Introduction of MDS (a, structure; b, operation)

5.3. Information Feedback

To feedback opinions, critique and suggestions of the executed modules, we have developed an interactive questionnaire, which has several surveying sheets. It is suitable for inner usage, so to collect information about the production of modules (sourcing, machining, assembling etc.). On the other hand, we have worked out the registration way of the collected experiences of outer users (customers of modular machines). Surveying sheets filled by outer users are also stored in an electronic database. This information get to the developer-team of the modular machine to overview and use notifications frequently.

6. Phases of a Machine-building Process

In this chapter, I will introduce the application of the developed modular machine-family. To give a clear picture about the main design steps, we have divided the whole process to four main phases of a machine-building process see *Fig. 11*.

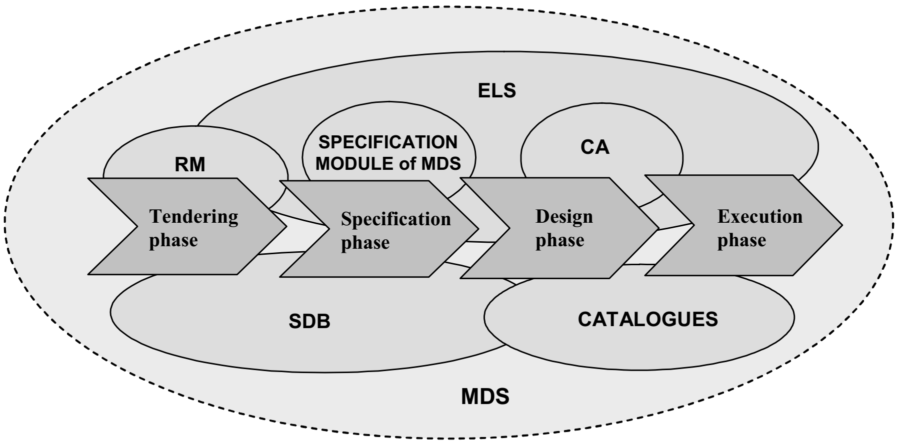

Fig. 12. Phases of a machine building process, and the supporting tools

First is the *tendering phase*, when the customer asks for a proposal for a machine, which is able to execute the required tasks (conditions and deadline for delivery is given). As a response for it, the machine-builder company creates a rough bid (which contains the needed sources). If it is acceptable for the customer, the contract will be signed, and the partners do the next step, but if the conditions are not acceptable the business fails. Second is the *specification phase*, when the partners clarify the required parameters, their values, and the allowed tolerances. This specification generally contains all of the technical and other kinds of parameters. The result of this phase used to be the specification of the machine, which is a technical document, determining all required parameters and following steps (of all partners). Third is the *design phase*, which is based on the specification and contains three main parts. First is searching for and adoption of earlier similar machines (or sub-units) according to the actual demands (case-based design), second is construction of special parts needed by individual requirements, and third is the fitting of the elements of these two groups. Fourth is the *execution phase*, which contains the production of the designed parts, the supply of the commercial items, and the assembling of all. Finally tests and trial-run closes the execution phase.

These four phases are occuring in cases of machine design and manufacturing processes (naturally with different intensity), also in case of a modular system, when several special tools (originated by in house standardizations) support all of these phases.

6.1. Tendering Phase

During tendering phase, clarification of questions "What? – When? – How much?" is needed. Answering of these questions in case of conventional design happens by analysis of earlier solutions and analysis of data. But in case of a modular system, there is an element-library system, and we know the required data about all of the elements – as time goes, by repeated application of elements more and more exactly.

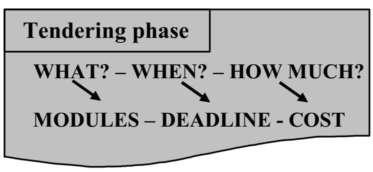

Fig. 13. Questions and answers of tendering

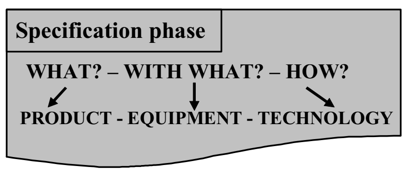

Fig. 14. Questions and answers of specification

The answer on the question *„What?"* is the definition of a suitable production line (and its elements), which is given by a *modular element-set*, by modular elements and their allowed combinations. The answer on the question *„When?"* is a feasible *deadline*, for their determination, whose manufacturing time of parts, the sourcing time of commercial items and the assembling time of these have to be known. For preliminary estimation of these time-demands, we have to define, which activities can happen parallel and which are building on each other – it is actually the network plan of the project. Determination of these items is the more simple and exact, the higher rate of production line can be designed by elements of modular element-set, because detailed capacity-demand of these elements is known. The answer on the question *„How much?"* also can be estimated properly, because costs of the modular elements are known, so we have to estimate only the costs of the actually special elements.

6.2. Specification Phase

The creation of specification in case of a conventional design process happens by searching for earlier similar solutions and the determination of the required parameter-values. During this phase, answering of questions *„What? – With what? – How?"* is needed.

The answeron the question *„What?"* is actually the *product*, fabrication of which is required by the designed production line. Determination of the geometrical, physical and other parameters of the product (and the types of the product) is needed. Answer for *„With what?"* is the *equipment*, and its properties (e.g. service-demand, velocity, number of positions etc.). And the answer on the question *„How?"* is the definition of the *technology*, what is actually the technological tooling chart of the production steps.

The auxiliary-programme makes collection and determination more simple and quick. This auxiliary-programme connects the properties of the modular elements with a database (*SDB*), which contains several specified parameters of earlier built machines.

6.3. Design Phase

Design phase consists of three main steps [3]. The first step in the case of conventional design is *searching for similar earlier cases*. In the case of modular system it is substituted by identification of the suitable modules. Naturally to help this step, the analysis of earlier modularly constructed machines also can happen, what can be divided into two main sub-steps. First sub-step is searching for earlier similar modular production line, and second sub-step is based on the principle of building-blocks. Actually we have to change the non-required modules for newly required ones. Next step is to *overlap differences* between existing earlier cases and the actual demanded one. In case of a conventional design process, this overlapping can happen by redesign (modification) of an already designed machine, and the design of individual elements. But in the case of a modular machine-family, it can be solved only by design of special elements. Third step is *fitting all elements*, what in conventional case happens by suitably created connections of sub-units. But in the modular case fitting of elements happens automatically (by standardized connections), and the connection of individual elements has to be established according to the pre-designed (and given) module-elements. It is also advantageous, because in this way executed individual elements will later be easily connected to our module-elements.

6.4. Execution Phase

First step of the execution phase is producing the modules, chosen in early-time of design phase. Second step isthe producing of individual ("freshly" designed) parts. Sourcing of commercial items can concurrently happen, and finally comes assembling of all units. Information needed by this execution phase is also known and fixed to modules. In addition, machining and assembling operations should be done by a competent professional-team. As time goes, this team will be able to do their tasks much more quickly and with less fault. When the whole modular production line is ready, machine delivery-receipt activities (e.g. test runs, *EVP*, *PVP* etc.) also can be established quickly and simply by previously created sheets of modular elements.

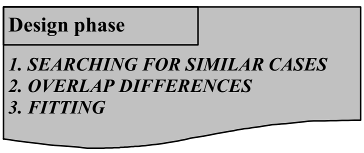

Fig. 15. Main steps of design

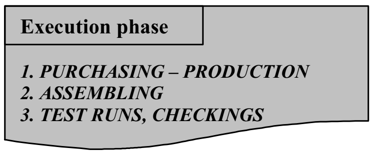

Fig. 16. Main steps of execution

7. Summary

Finally, I would like to summarize the main results of this research. At first we will overview the main properties of the developed modular machine-family, then I write some words about our reference prototype-machines.

7.1. Is this System Really Flexible?

We have to ask a question: *Does this modular system really fulfil the requirements?* We think, the answer on this question is in the following five facts:

- Modules of element-set which contains modular units is *flexible changeable,* so several combinations of elements can be created.
- Parameter-values (e.g. positions of manipulators, velocity…) of a flexible machine can be *flexibly alternated* during test run. It can happen even by setting of units or even by changing of modules.
- When the equipment already works, an often repetitive demand is the type-changeover, what (opposite earlier conventional solutions) also *can be solved flexibly* with the help of the element-set */short-term modification/* [15].

- The whole modular element-set and their parameter-values stored in electronic form by a database and handled by an auxiliary-program. Hence the parameter-values and the modules can be *flexibly changed* according to the alternate market-demands */long term modification/*.

- *Flexibility of the system* appears also after disassembling of the equipment, by repeated usage of several modules. It ensures a very high level of *recycling-rate*.

7.2. Pilot-machines

Till today several special machines have been built, using this modular system. These machines are working excellently in different factories in the world. In addition we are continuously feedback the information of these prototype-machines to achieve the main purpose: building reliable, cost-effective and qualitating machines and production lines based on this modular element-set.

7.3. Conclusions

Based on our research, we would like to highlight the main steps of building up a modular machine-family. At first, the correct survey of special machines and equipments is needed. The develop-team has to determine the functions, and later, based on this function-structure, has to generate conceptual solutions for modular units. This can happen by using specifications of earlier equipments. Than, according to modular and other special requirements, choosing of the most optimal conceptions is needed. In this phase of the modular development, the team has to design all of the modules. During all of these development steps, computerized supporting background (hardware and software) has to be created. It has to fulfil all of today's requirements and demands. The main purposes are: standard units, high compatibility rate, easy handling, quick application and design, up-to-date computerized tools and database. We have to underline, that standardization has its limits. According to our experience there are several special-units, whhose standardization is not suggested. There is determined limit for the occurrence of individual machine: about 70% can be up-built from modular units, hence 30% are special, so have to be designed in all cases. For easier and quicker design, all of these special parts should be collected in a database, and if there are any of special parts, which are used more times, than the team has to think over to put these units into the modular units. Another very important advice is to collect the users' opinions and suggestions about the modular elements, and to feedback these information.

List of abbreviations

SMD	Surface Module Device
RM	Requirement Model
SDB	Specification Database
ELS	Element-library System
MDS	Modular Design Software
CS	Code System
CA	Cluster-analysis
EVP	Equipment Validation Process
PVP	Product Validation Process

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