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GEOMETRICAL MODELLING TECHNIQUES TO DEVELOP A METAL STRUCTURE DESIGN SPACE

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Abstract:*The objective of the work is the development of an integrated object-oriented environment (design space) for the computer-aided design of a metal structure. We call as metal structure design space the object-oriented collection of the following elements: 1. a platform - CAD/CAM/CAE system, for creating parametrical 3D models of details and assembly units, and also to save them in a database. 2. The user applications - the programs realizing additional opportunities of designing and operation which simplify frequently used actions for a class of products.3.A database – which containing typical parametrical models of details and assembly units for metal structure. 4. The knowledge base – which containing relations between objects parameters and a condition of their inclusion into assembly units. 5. Rational methods of creation of geometrical models for the given class of products (metal structures). The metal structure is designed on the basis of a formerly prepared structure of a product by association of complex parts and items, typical for the given group of geometrical constructions to original objects composed of the previously developed standard parts and assembly units. The generalized structure of product is or-and graph. The techniques of rational filling of databases and knowledge bases are offered.*
Key words:*CAD, geometrical modeling, metal structure design, integrated design environment.*

1. INTRODUCTION

Metal structure is a significant part in building constructions and machine-building products. As the application of the metal structure is extensive, it should meet a great number of technical and operation requirements. Metal structures are used in carrying farms, pillars and complex space constructions, such as frames, pontoons and working under pressure bunkers. Quite frequently the constructions consist of a combination of various rolled products (metal profiles and leaf hire of different width). Welded connections require preliminary grooving. Most frequently the constructions have large overall dimensions. While manufacturing large parts it is difficult to maintain accuracy of the exact dimensions and to assemble parts with incorrect sizes. As a result on an assembly area a lot of time is spent on correction of the reject. It is possible to avoid the errors of manufacturing using modern technologies, applying more exact equipment, tools of control, also introducing compensatory units into a construction. It is necessary to eliminate designer errors on all stages of designing by methods, permitting to minimize possible defects. One of the ways is of the implementing of solid modeling with the development the integrated object-oriented environment (design space) for the computer-aided design of a metal structure. This makes design cost-effective and efficient, increases manufacturing productivity, reduces the overall cost of manufacturing and reduces the time of new production development.

The computer environment of the designer (Design Space) is a collection of programs and objects ensuring intellectual activity of the person in the field of scientific and technical creativity, taking of from many routine operations.

As the yield of information process engineering's design space must be

- specialized knowledge base,
- specialized database,
- disk drive of outcomes of the user,
- personal teacher of the user,
- examiner (tool of self-checking),
- personal research laboratory,
- specialized designed system with a universal mathematical means,
- the tool of preparation and issue of designer and text documentation.

It is natural, that for automation of preparation and issue of design documentation design space should also have and CAD/CAM/CAE component. This component is a platform and used for creating parametrical 3D models of details and assembly units, and also to save them in a database.

Design space is created on Windows- applications: SolidEdge, MechSoft for SolidEdge, EXCEL and Word.

One of vital issues of creation of the database and knowledge base is the problem of redundancy. Redundancy affects not only because limitation of resources of personal computers, not only because of appreciation designs space, but, first of all, because of complications in use it by the simple user. The knowledge base of too large sizes generate at the user some shyness and uncertainty in success, that contradicts a criterion of "friendliness". On the other hand, the size of a knowledge base should be sufficient for solution of all tasks of auxiliary assignment design space. Thus, we collide with two contradictory criterions: than more size of knowledge's, the more probability of solution of the new task, but that less is "amicable" the system.

The significant acceleration of the designing process is achieved by application of the integrated object-oriented environment for computer aided design of metal structure, in which the database and the knowledge base should be created with the allowance of designing features for a specific type of constructions. We must to develop “user applications” - the programs realizing additional opportunities of designing and operation which simplify frequently used actions for a class of products. These programs are written in application language for the platform. A database contains typical parametrical models of details and assembly units for metal structure. The knowledge base - relations between objects parameters and a condition of their inclusion into assembly units. It is carried out by tools of a platform or in the programming language (for example, VBA in EXCEL). We need to choose rational methods of creation of geometrical models for the given class of products (metal structures). Besides, the techniques of creation of the design space and designing of the items in the developed design space can differ.

The metal structure is designed (Fig. 1.) on the basis of a formerly prepared generalized structure of an item by association of complex parts and items, typical for the given group of

geometrical constructions to original objects composed of the previously developed standard parts and assembly units.

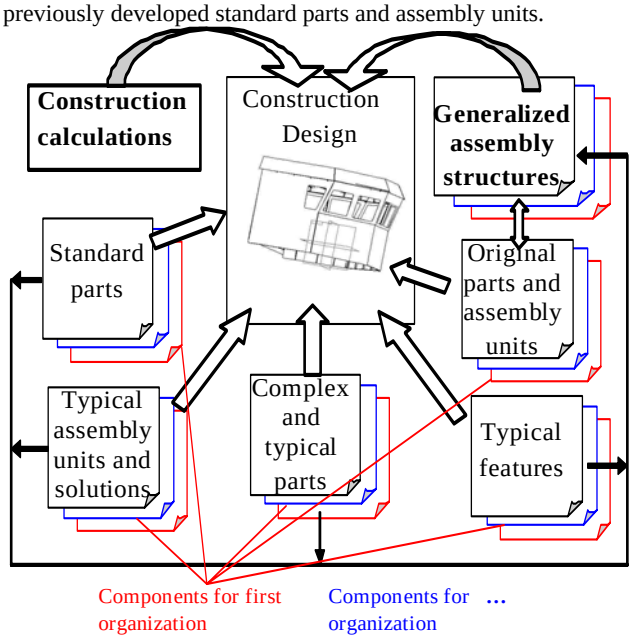

Fig. 1. The schema of metal structure design space.

2. GEOMETRICAL MODELLING TECHNIQUES

The design space should support the following procedures:

2.1. Input and employment of parametrical models of standard parts and assembly units (Fig. 2.)

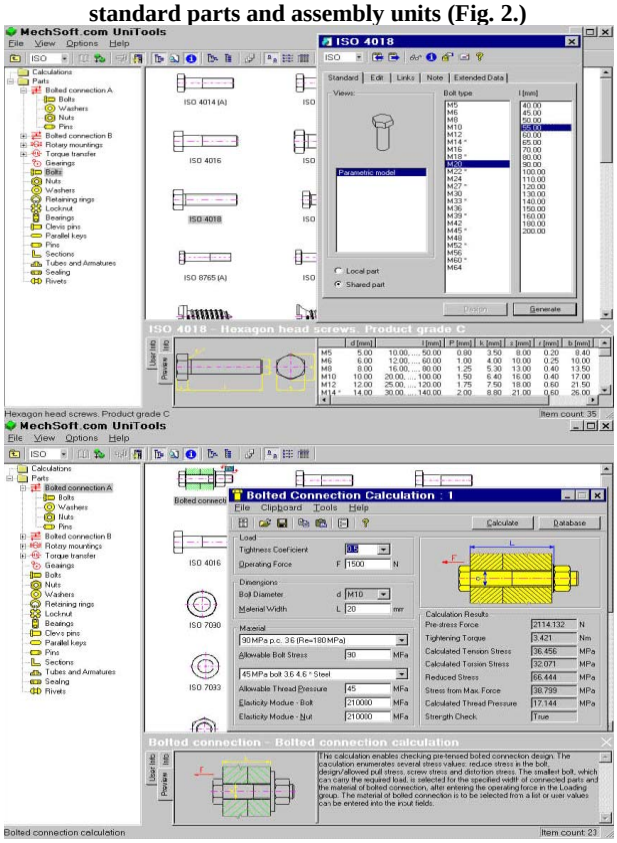

Fig. 2.The library of standard parts and assembly units in MechSoft.

The models may be taken from MechSoft, however they are not modified. New models can be added only to the user library. In metal structures such models play an insignificant part. In most cases it is impossible to pre-define the length of a standard configuration of the profile of a part, or to describe the form of extremities of the parts, to be welded under some corner.

2.2. Input and employment of models of complex and typical units

The models are taken from a special library, created by SolidEdge

We can create the family of parts (Fig. 3.), in which some surfaces, may be missing and possible sizes may be given in special tables.

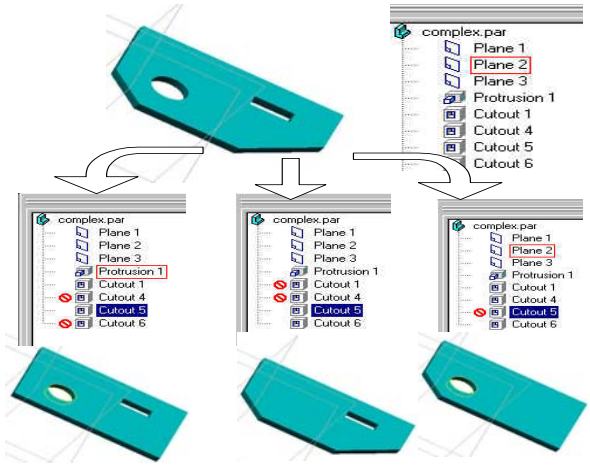

Fig. 3. The family of parts.

The method of creation of libraries of parameterized typical parts with a support of correlation between their parameters is offered (Fig. 4.).

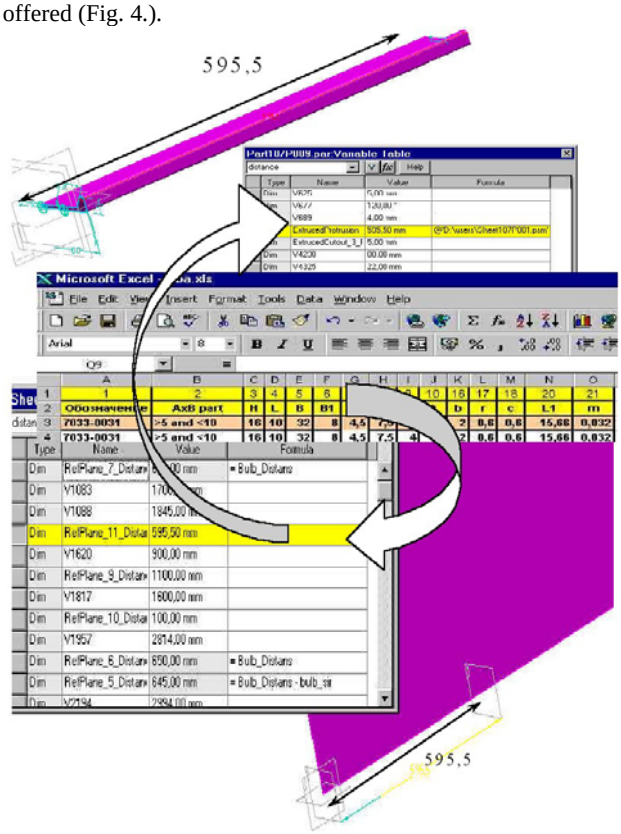

Fig. 4. Using "Variable Table" for link dimensions.

For such approaches in designing the introducing sizes correlation between a typical part and the base parts, on which these parts are placed, is defined. It is necessary to take into account these links so that with the size changing for a number of typed parts and base parts all the appropriate models of these parts are modified automatically. In the system Solid Edge similar modification can be carried out by means of models

parameterization and operation with the Excel-tables. The values of the introducing sizes for typical parts and base parts are recorded in the Excel-table and the link in the table Variable Table is defined. Solid Edge generates changes of a model automatically.

2.3. Input and employment of models of original parts and assembly units.

- An approach to creation of leaf parts is offered for the metal structure (Fig. 5.). The construction is originally produced as a mockup of a solid part, and the models of sheets are designed on assembly using Inter-Part Manager, which links the sizes of the mockup with the obtained sizes of leaf parts. Thus created model leaves of parts automatically vary when the mockup is resized.

Besides, in the knowledge base the information on the structure of a fragment of an item and mutual layout of interlaced parts is saved.

- The right extremities of profile parts can be received, using Multi-Part Cutout.

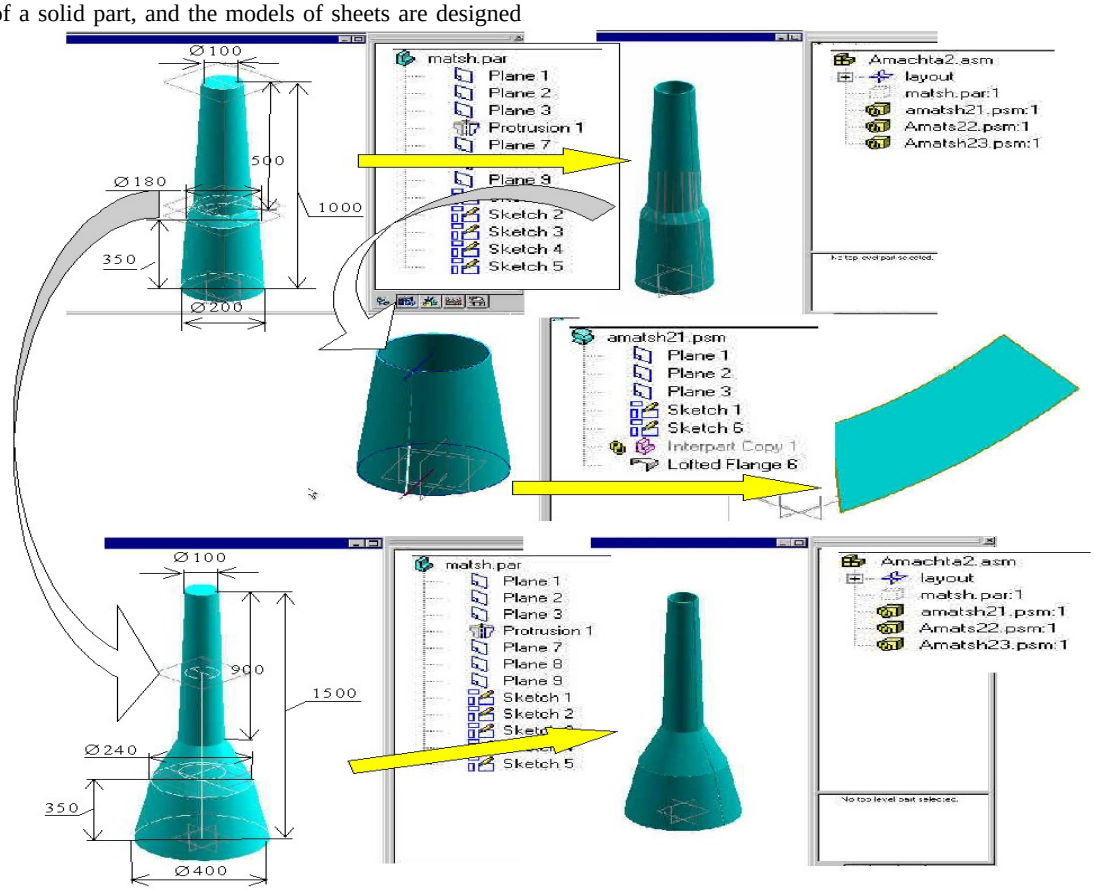

Fig. 5. Lead parts design with mockup and resizing of the mockup.

- Frequently large details cannot be made of the whole sheet. Then they are welded from separate sheets (Fig. 6).

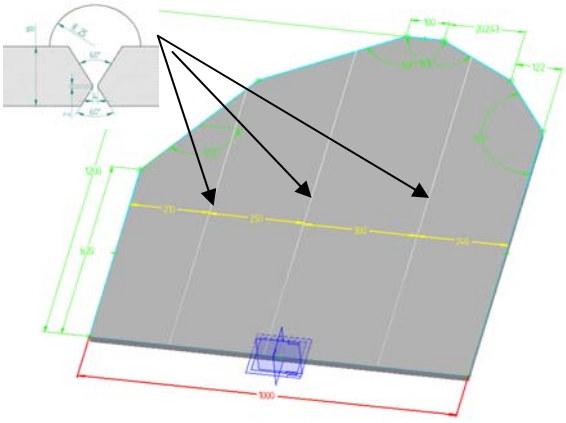

Fig. 6. Operation of division of sheets.

For maintenance of welding it is necessary to prepare edges for welding. The sum of the sizes of making sheets not always corresponds to the desirable size of a received detail.

Traditional approach for designing such details demands additional calculations. It is offered to project such details from top to down. The detail created to the correct form segments with maintenance of the correct sizes and preparation of edges for welding. For this purpose in system complex operation of division of sheets is added.

In Fig. 7 other developed variant of division of details for maintenance of the passing of one detail through another is shown.

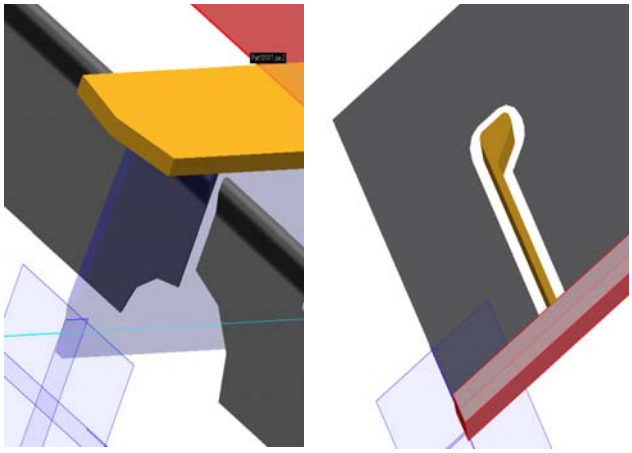

Fig. 7. Passing operation.

For use such operation it is necessary to change structure of assembly units. Some parts from divided assemblies separately.

Technological assembly units which need to be shown in structure of a product are created. For change of a tree of structure associations and divisions of assembly units operation moving parts are created.
The technique of geometrical modeling of frames is offered (Fig. 8). It is based also on creation of a mockup of a solid part on which rods are located. Rod system calculation of strength gives the necessary moments of inertia and the area for the given rods. Further the user can choose structures from a database and specify a place of their installation

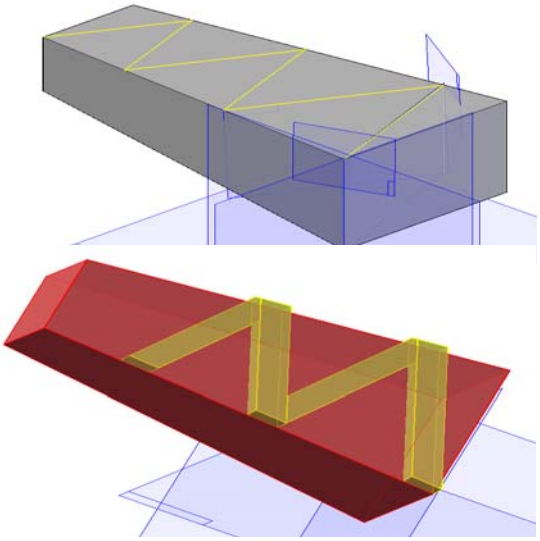

Fig. 8. Geometrical modeling of frames.

- The models of parts are made with the use of standard units, which are kept in libraries as a construction. These units can be solid features as well as various kinds of notches (window, grooving edges for welding).

2.4. Creating a model of the assembled construction.

It may be created by association of required parts and assembly units, taking away 6 degrees of freedoms. More rational simulation is executed with the use of the knowledge base about the structure of an item or its fragments (Fig. 9.).
A great number of repeated units, previously joined into a fictitious assembly unit, which is not the output in the bill of material, are characteristic for the metal structure. Further the fictitious assembly unit is repeated through the pattern.
The way of connecting parts (welding, bolt joint...) superimposes supplementary claims to the construction of the parts. These connections can be calculated by MechSoft and are added to the construction from the library of standard units or using Multi-Part Cutout.

Using the model of an item it is possible to make:

- the various variants of the specification, which can be transferred to information systems for their further use;
- required drawings of parts and assembly units.

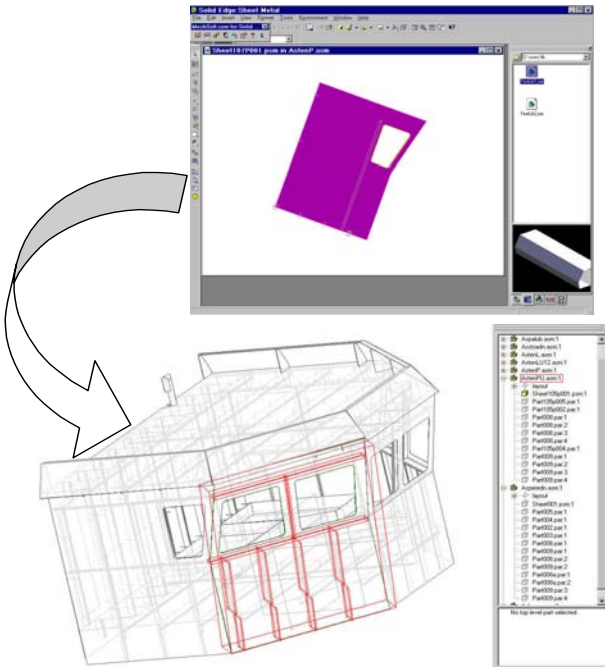

Fig. 9. Assembly unit design.

3. CONCLUSION

Results of this work are used in the test phase for student course work at TTU. This study is a part of a larger project for the development of concurrent engineering support environment for the technological equipment design.

4. REFERENCES

S. M. Kannapan, D. G. Bell Structuring information and co-ordinating teams in product development. DE-Vol-53 Design Theory and Methodology. ASME,1993.Pp.233-242..

R. Küttner. Techniques for development an integrated environment for supporting of product development in SMEs. Proceedings of 2nd International Conference, Tallinn, 2000, Pp.83-85.