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THE ASSEMBLY OPERATION SEQUENCE MODEL

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Abtract

The research within the development of digital factory concept concerns also the assembly process as an important part of the production. This paper presents an assembly operations sequence model as a part of design and planning method for the assembly process. This model enables to obtain a precise graph presentation as a tool for computer support.

Key words

assembly, assembly operation sequence, oriented graph

Introduction

Digital factory is a new concept based on the application of digital models, modelling and simulation. This concept has a great potential to rapid and effective solving of the products and production systems. The assembly as a part of the production processes requests a systematic consideration owing to the processes' complexity and lower level of development.

Assembly operation sequence planning

One of the important approaches is the development of the theoretical and methodical procedures of assembly process formalization and its exact description. The increased possibility of computer support in the assembly design process requires the new CA-oriented models for various design and planning tasks.

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The main goal in the developed integrated methodical procedure for assembly process design was to create a scope in which the designer can move in a large knowledge base and to use relatively independent methodical tools. The assembly operation sequence planning is a part of a complex system of assembly process and system design. All approaches in this filed use some types of graph presentation [1], [9].

Model of assembly operation sequence planning

The general scope of the proposed model of assembly operation sequence planning is a hierarchical division of the assembly operation planning into three levels minimum. These levels come out from the assembly operation definition. In this model, there is the assembly operation defined as a process of joining of minimum 2 parts or product components that must be carried out at one place and must be finished, since the division of this joint process into “smaller entities” can cause a failure of position, orientation or other requested parameters. After finishing the assembly operation, the assembled product can be stored, positioned, clamped, tested etc. without any impact to the quality.

This definition defines three main levels of planning the assembly operation sequence. The basic level is planning the assembly operation according to the above-mentioned definition. The lower level is planning and analysing the assembly actions contained in the operation. The higher level is oriented to analysing and planning the operation aggregations. This level is very useful for more complex products (with number of parts about 30 and more) and by generating the assembly operation sequence variants. All this three levels are in correlation. The analysis can be carried out on any level. The transfer between the levels is simple.

The methodical procedure of assembly operation sequence planning – basic level (Fig.1) supposes the integration of product structure and assembly operation sequences into one unit that represent the process nature, i.e. gives into the relation the objects (assembled product parts and assembly results) with the performed activity (assembly operations).

Identification of the assembly operation inputs

The first step is the decomposition of the product into “the parts” e.g. inseparable items from the point of view of assembly, and the definition of the set of product parts.

The second step is the identification of the set of assembly operation.

The set of assembly operations $M_o = \{O_1, O_2, O_3...\}$ and the set of a product parts $M_S = \{S_1, S_2, S_3...\}$ are in correlation than can be expressly formalized. The elements of both sets are in graphical representation graph tops and the relations between them are the graph edges. The elements of the set M_S “put into” the set $M_{o.}$ The main parameters of this relation are input part number and the order of their input.

Identification of the assembly operation outputs

After performing every assembly operation, an assembly point is defined. The set of the assembly operation results can be written as $M_v = \{V_1, V_2, V_3 ... V_n\}$, where V_n is the final product and $_n$ is the number of assembly operations.

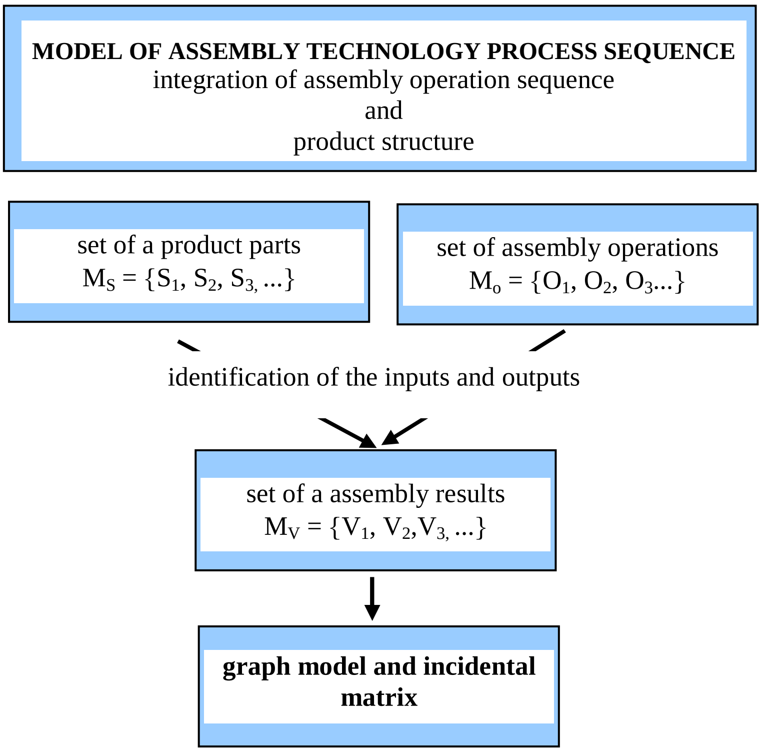


Fig. 1 *Analysis steps of assembly technology process model*

Graph of assembly operation sequence

Graph model of assembly operation sequence (Fig.2) with inputs and outputs and with several parameters is implemented under the following conditions. The graph tops are the elements of part set M_S and elements of the assembly operation result set M_v, e.g. inputs and outputs of assembly operations. In the graph is also listed the number of the parts. This data gives an answer to the question, whether all parts were used. The elements of assembly operation set M_o are represented by a rectangle. The relations are represented by an oriented graph edge, which is described as **(i, j),** where **i** is the number of elements put into assembly operation and **j** is the order of their input.

It is possible to describe the graph model in the form of incidental matrix. The incidental matrix contains the same information as that contained in the graph.

The model application

The presented model was applied for a large number of different product types in the Slovak companies as well as in the university training and research. The analysis enables for instance to create a technologically correct assembly sequence from a 3D model of the product (Fig.3). Fig. 4 shows a 3D model of a personal car - ventilating grid. By the analysis of the assembly technology process sequence for this product, the above described approach was used. Fig. 5 shows the result, a model of assembly technology process sequence for one sub-assembly of the ventilating grid. Incidental matrix for this graph is presented in Fig. 6.

On this basis, type technological assembly sequences of various assemblies and products as gear pump, water pump, ventilating grid, buffer cylinder, wiper mechanism, door hanger etc was designed. The model of the assembly sequence was successfully applied for all these products or assemblies with the result that the description of the assembly sequence by this model is correct and it can express all possible variants of the assembly process.

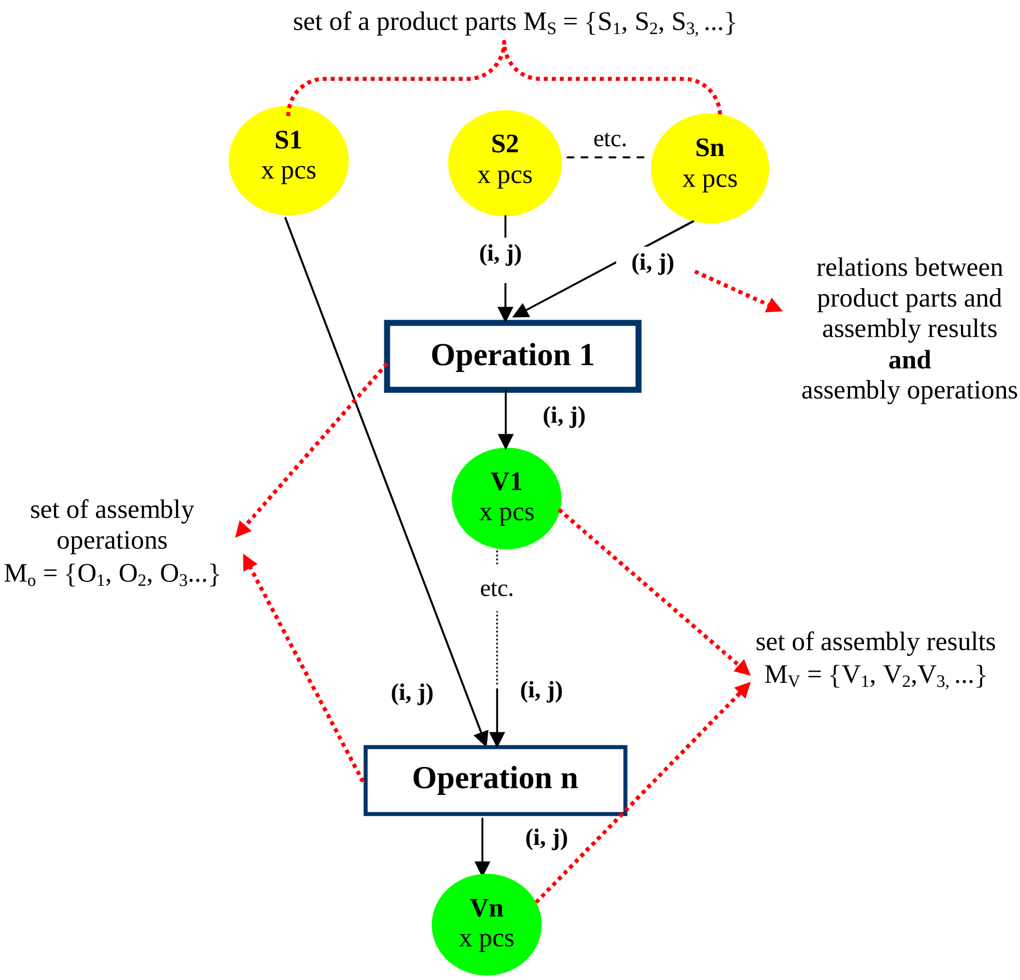


Fig. 2 *Principle of assembly operation sequence model*

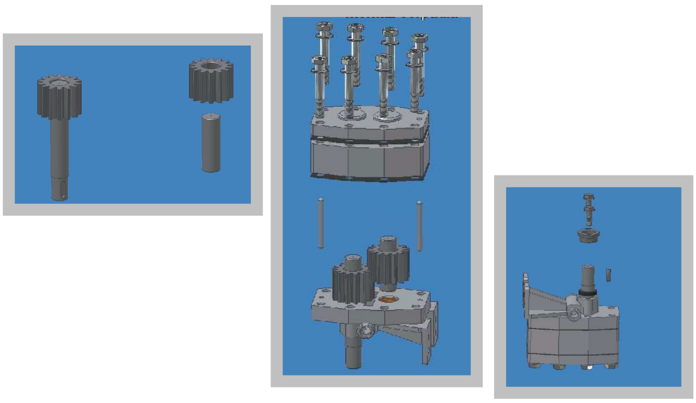


Fig. 3 *Printscreens of the assembly sequence created from a 3D model of the product*

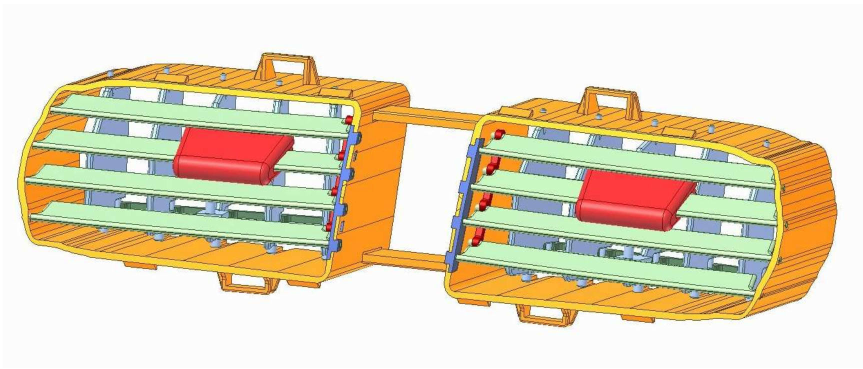


Fig. 4 Analyzed product - ventilating grid of personal car

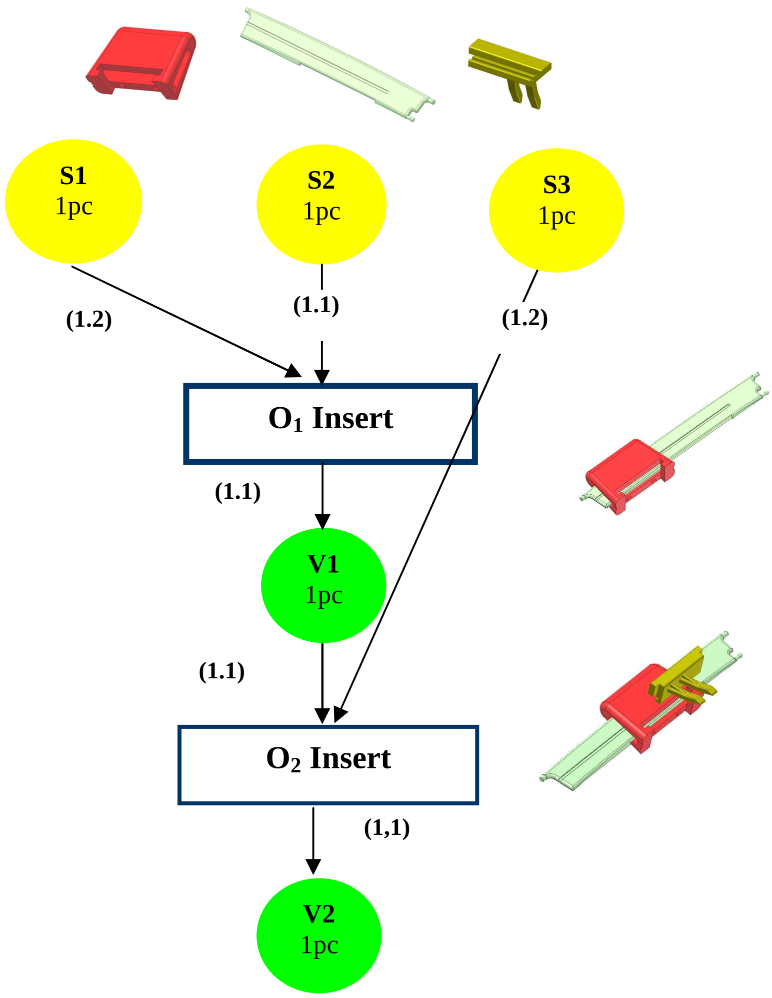
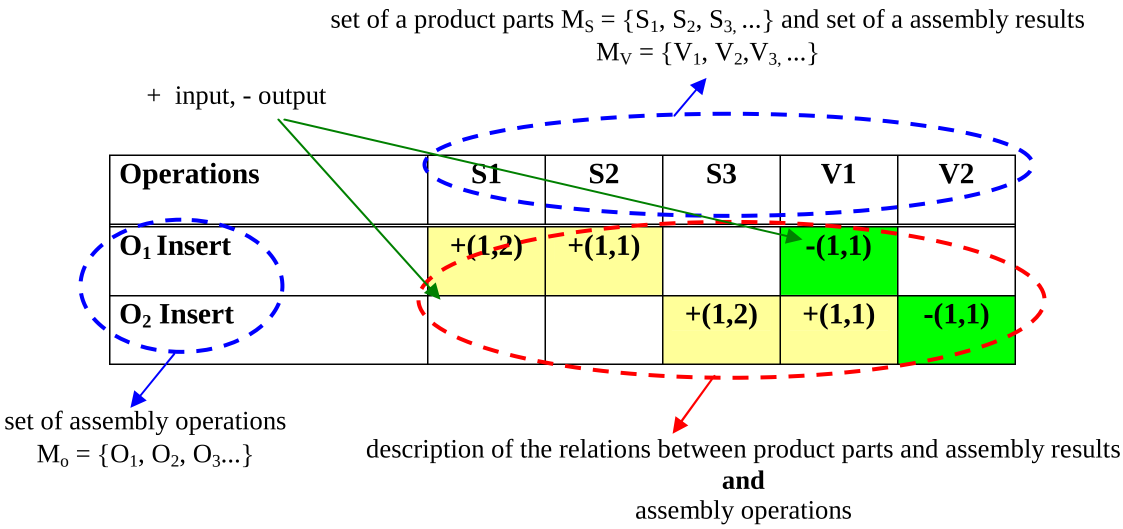


Fig. 5 Model of assembly technology process sequence for one sub-assembly of the ventilating grid



Operations	S1	S2	S3	V1	V2
O_1 Insert	+(1,2)	+(1,1)		-(1,1)	
O_2 Insert			+(1,2)	+(1,1)	-(1,1)

Fig. 6 *Incidental matrix for assembly technology process sequence graph*

Conclusion

On the basis of the obtained results, we can say that the great advantage of this approach is the possibility to obtain a logical linear formal description. Defined model can use the computer support. This concept enables also to analyze more complex products and to express parallel operations. The possibility of viewing angle selection enables individual application, modular implementation and interconnection. The model is precise, can be simply stored and repetitively used for standard components. This makes possible to develop a standard or unified model of the assembly operations sequence for the standard or unified components.

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