INTEGRATION POSSIBILITIES OF SOFTWARE TOOLS USED IN DESIGN OF MANUFACTURING SYSTEMS

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Abstract

Nowadays there is a great pressure on production systems design to be done in a short time and more effectively. Moreover, it must support the systems' flexibility, modularity and robustness. For these purposes several software tools have been used– mainly for project analysis, design and validation. Nevertheless, these tools have been used with a low integration level, including the absence of data coherence.

This paper deals with production systems' design, actually concerning the integration of particular software tools into a unified system. This work identifies different tools, describing their functions and principles of integration. It also addresses the way this integration enabled the automatic generation of simulation programs. Furthermore, it finally discusses ways of making this integration contributing to the automatic generation of different patterns of project layouts.

1. Introduction

The production system's design is a process of managing technical and organization variants in order to configure system elements with regard to the optimal usage of all sources (i.e. material, energy, areas), productive and nonproductive facilities (production machines, handling and checking facilities) and workers. These variants deal with spatial layout and also with dynamic time changes.
Generally it is possible to divide the used software tools into four groups:

- **Databases** – analysis of states, data storage, data mining
- **CAD systems** – graphic designs, verification of spatial layout variants
- **Discrete computer simulation systems** - verification of variants with time changes
- **Visual systems** – 2D, 3D animation or virtual reality for better understanding of suggested principles

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On the basis of experiences from several projects and analysis of the current state , the following disadvantages and limitations in using software tools have been found:

- Absence of data-flow between programs
- Existence of several independent data-sources
- Absence of feedbacks which are necessary for registering of changes suggested during the design process
- Managing of project variants

Manual project data-connection causes slowdowns in the process of designing, duplicating work or even being a source of mistakes.

We know about the existence of systems called "Digital factories" that involve thementioned tools in one common solution. The particular tools are connected by information flows. The big disadvantages are a huge price of these software packages, focused mainly on mass production (automotive industry) in large-sized factories, and also their excessive complication. The proof of complication could be the existence of only two systems of digital factories - Tecnomatix and Delmia. There is still not any similar solution for small and middle-sized factories with a very easy controlling and with functions focused on these kinds of factories and production problems.

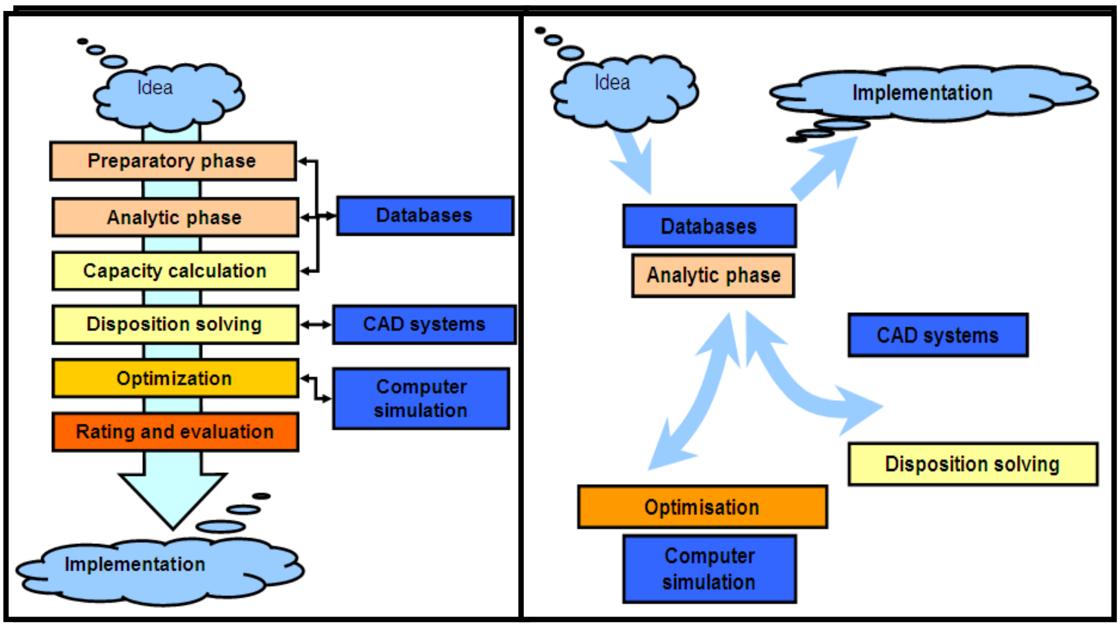

Fig. 1: Comparing of the current and new approaches of software interconnection

For these reasons a compact system has been elaborated on. It is to connect particular systems together, and to simplify and streamline designing of production systems. One of the main aims is to cover the wide range of problems and tasks solved during designing – such as:

- Dimensioning of storages and buffers, establishment of storage limitation
- Optimal usage of sources
- Bottleneck analysis

- Design of handling and supplying system (AGV, milk-run system, conveyor, manual handling etc.)
- Problematics of long-term designing (changes in product mix and volume), change of costs or other parameters
- Suggestion of detailed layout and real constraints (current facilities, walls, pillars, ergonomics, etc.)
- Re-layout problematic (more often than green-field designing)

In the figure 1 there is a comparison between the most frequently used principle of today (on the left side) and a new approach with the relative interconnection (on the right side).

2. Describing of the new approach

On the basis of possibilities and given requirements a system was suggested. There are three programs integrated, concretely **MS Access** (database), **Witness** Simulation tool (discrete simulation tool) and **AutoCAD** (CAD system for drawing of layouts). These programs were chosen for their usage expansion in this area of designing.

In the diagram 2 there is showed the overall integration with information flows and snapshots from particular programs.

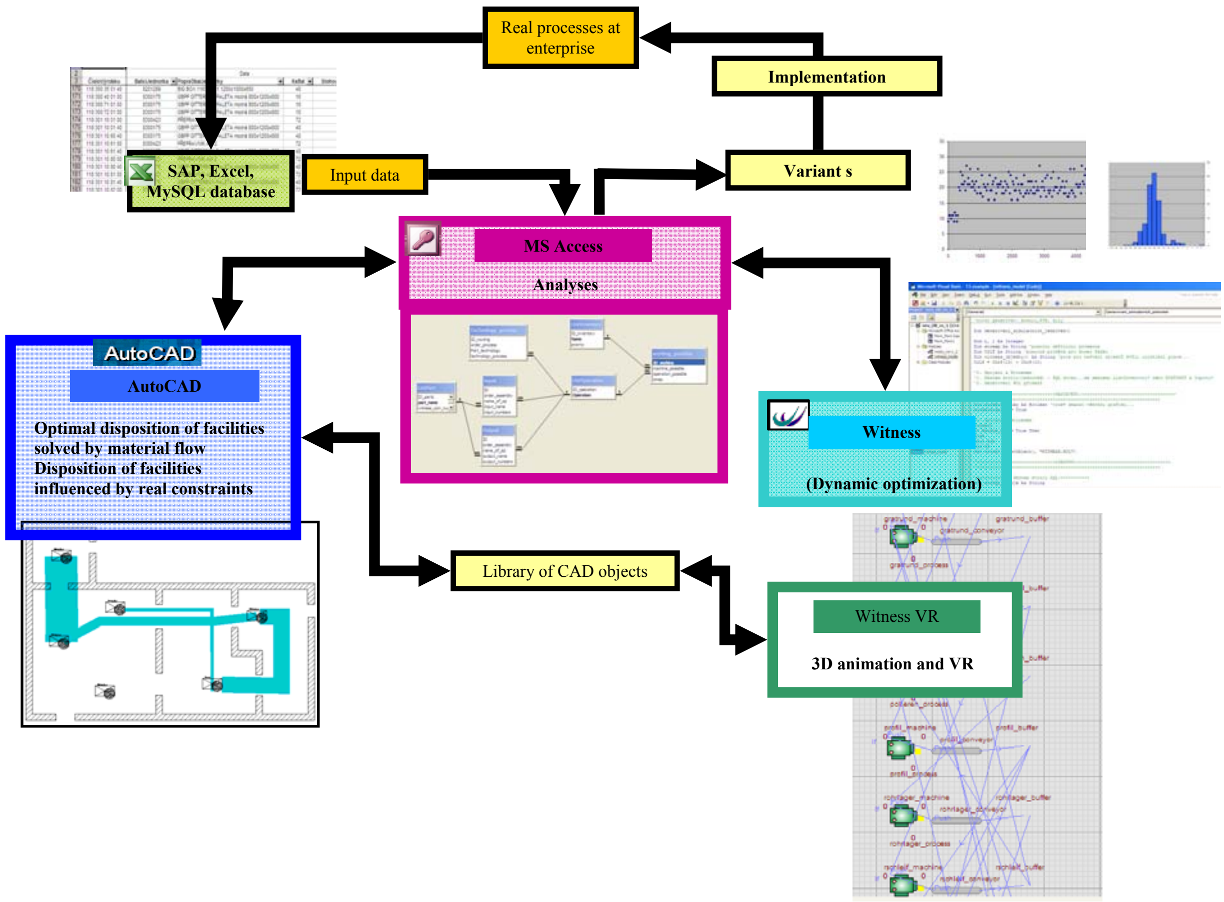

Fig 2: Overall integration

2.1. Interconnection

For integration and controlling of programs, Visual Basic for Application (VBA) was chosen like a programming language. The main reasons are:

- its involvement in almost all products of Microsoft, AutoCAD and many others (one common language simplifies the integration)
- easy language syntaxes and using (especially interactive development entertainment and visual tools)
- easy establishing connection to databases (e.g. with help of OLE DB Microsoft Jet)
- support of **OLE Automation** (Object Linking and Embedding) serves to controlling of other programs and using of their objects
- DDE (**Dynamic Data Exchange)** for data exchange between applications.

2.2. The detailed description of particular tools function

Database system

A common database (MS Access) serves as the source and deposit for project data (i.e. also for inputs and outputs data from simulation and CAD) and it builds a basic interconnection element. This database includes VBA macros for automatic generation simulation of elements and their properties with minimum user intervention. In the figure 3 the relational database with its structure and VBA macros is displayed.

The needed data for simulation model are:

- The definition of operation (inputs and outputs parts, size batches, assembly information, process times etc.,
- Production sequences of parts (i.e. their routing thought production facilities),
- Kinds of crates and transported quantity,
- Productive and nonproductive facilities (machines and handling equipment) and their properties (setup times, transport speeds),
- Scheduling of production,
- Workers and their properties.

The database contains also VBA macros for automatic loading of CAD objects into AutoCAD, also with a minimum intervention. There is also some fundamental analysis (mainly PQ analysis). An emphasis is placed on easy data entry and change – such as a production plan or volumes (in automotive industry it is concerned mainly with the product facelifts, expansion or new production launches). It is possible to make some experiments and test system with these data and search consequences into the designed system or to make a test of uncertainty influences and determinate the robustness and flexibility of the system.

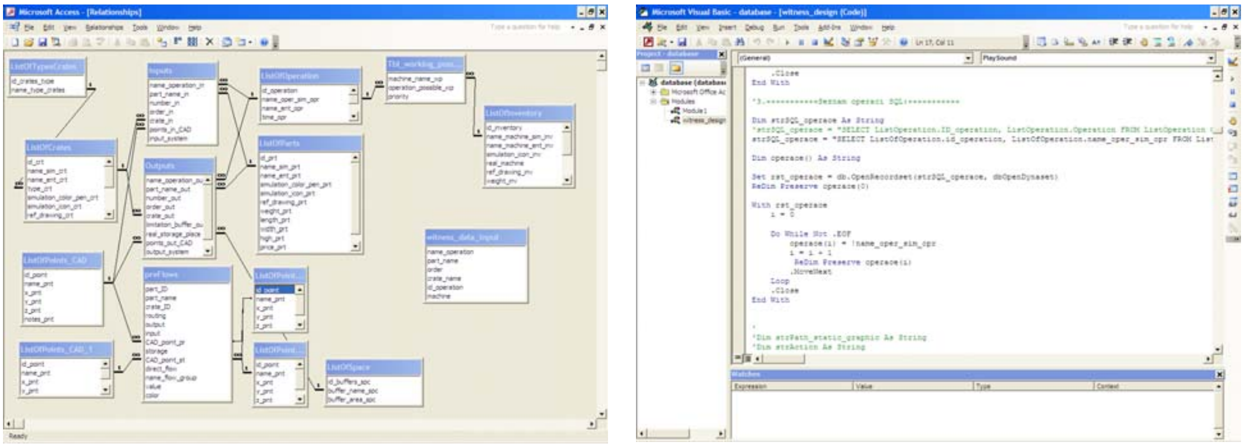

Fig. 3: Snapshots from the relational database and VBA macros

Simulation system

The generated simulation model consists of the elements mentioned before and some other elements such as lists (operation, facilities, parts etc.), module for project database establishment and other modules involving SQL queries for loading data. These modules feed simulation elements by data, and also automatically configure and update them. It is possible to configure model on basis of the actual data from the database (model's initialization at the beginning of the simulation run). So the users change only data in the database in user-friendly forms to manage the simulation model.
After generating and configuration of the model, a phase of simulation runs and experimentation follows. The obtained data are recorded back to the database. Output data are mainly stochastic material flows, average and maximal occupation of buffers (this information is used in the design of layout in CAD), usages of sources (machines, operators and handling system), bottleneck places, throughput of system etc.

In the figure 4 there is a show of generated simulation model in run. It shows the actual occupation of buffers (queues), usages of facilities (pie graphs), and some other information (list of facilities, parts, and operation). This model is just for a demonstrative show, it is a simulation of unpacking parts from transport crates and their assembly.

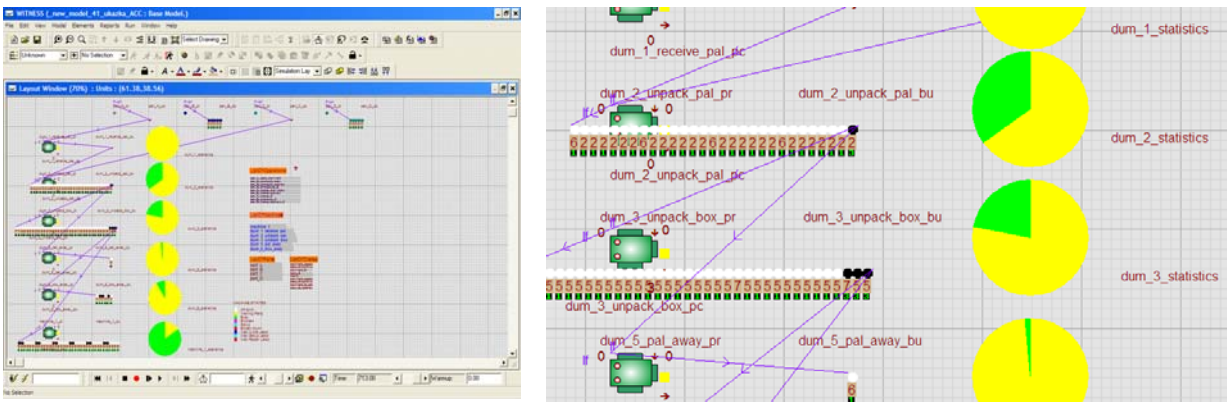

Fig. 4: Show of simulation model

CAD system

It is mainly used for displaying facilities in layout and their system settlement, i.e. finding the best location for each facility in layout. For that there are VBA macros enabling to find the best (ideal) positions according to a triangular algorithm based on the values of material flows. The detailed layout is influenced by several factors and limitations (current production facilities or building constraints). Graphic objects (drawing of facilities or simplifying compensation) are automatically put from libraries into the layout.

There are displayed material flows – deterministic or stochastic (obtained by simulation, and involving stochastic influences). The generated flows are defined like a direct two-point line, without respect to the real deformation caused by real constraints (e.g. building). For displaying real material flows, it is necessary to change these lines into poly-lines (a line defined by several points), and to modify their shapes with respect to the real constraints. The definition points of poly-lines are recorded into the database. In the figure 5 there is a simple show of layout with material flows (ideal and real) of particular parts. For comparing of project variants based on material flows, it is possible to count a sum of material flows (real length multiplied by its width), and to evaluate them by these numbers.

Flows could have various units (transported weight after some time or frequency of transport movement).

It is also possible to display flows according to various parameters – flows of specific parts, flows of one kind of transport or flows of one kind of crate (e.g. pallets).
There are used data, such as buffer sizes i.e. necessary areas for storages. It could help to design shelves and other logistic elements.

Output data recorded into the project database are coordinates of facilities, real material flows (coordinates of definition points) and also changes raised during the layout design – e.g. changes of pallets number obtained by simulation (original task) - it is necessary to reduce it because of lack of space (findings during layout design). In this case, there arises a question how this limitation influences the designed production system.

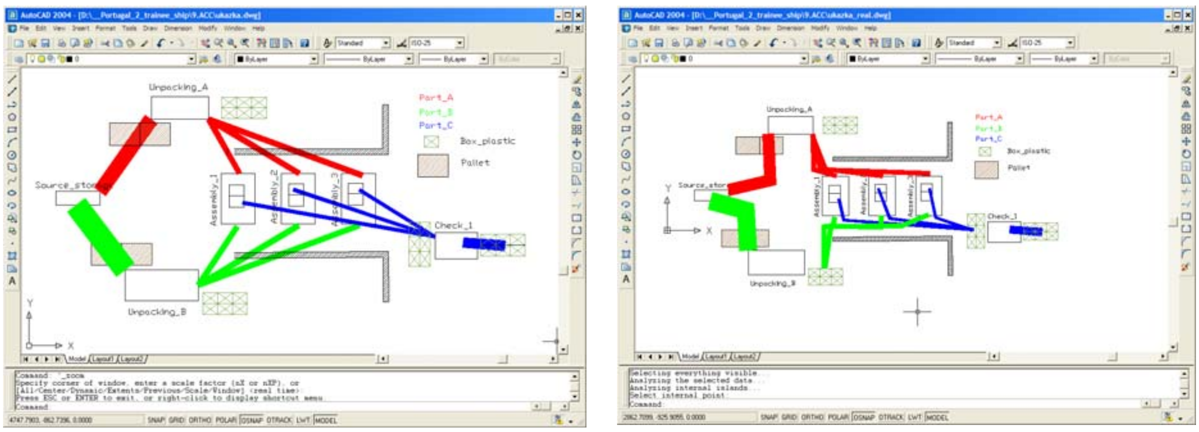

Fig. 5: Snapshots of layout in AutoCAD with material flows (ideal and real)

Other properties of integration:

One of the advantages resulting from this approach is a possibility of two ways of designing manufacturing systems, namely:

- Design of layout, then its verification by computer simulation
- Design a simulation model, then design a layout
- (Or possibility of combination work in both systems alternately)

Generally, for minimization of handling costs it is better to use the way starting in CAD, and then to continue by a computer simulation. In the case that the main aims are processes and their improving (throughput, bottleneck places, batch sizes, usage of handling system etc.), it is better to start by a computer simulation and to continue with the layout design in the CAD system.

3. Conclusion

The described solution integrates software tools used in production systems' design into a unique system where all tools are connected by a database.

The general aim of this work was to improve the process of production systems' design, removing redundant activities and replacing "manual" work by some automatic design phases.
It integrates static and dynamic layout optimization, increasing the factory competitiveness while helping the design of flexible and robust production systems.

Another benefit from this work is the intelligible illustration, e.g. rendering of material flows, 2D animation of processes within the simulation tool or the possibility to create virtual reality entertainment with Witness Virtual Reality Toolbox.

The most problematic issues of this approach are data-unification between companies and project databases, involving real constraints into layout definitions and some restriction as far as automatic generation of simulation models is concerned (models are generated just for solving specific and common tasks).

Future work will be focused on using this integration for solving real production problems, improving and adding some functions – such as solving routing problems, finding the best routes for transport vehicles (e.g. milk-run systems) or creating a tool for designing storage systems.

Literature

[1] ALEISA E., LIN L.: For effective facilities planning: layout optimization then simulation, or vice versa? , In Proceedings of the Winter Simulation Conference, 2005, s. 1381-1385
[2] BENJAAFAR, S., HERAGU, S. S., IRANI S.: Next generation Factory layouts: Research challenges and recent progress, Interface 2002.
[3] FRANCIS R.L., McGINNIS L.F., WHITE J.A.: Facility Layout and Location: An Analytical Approach, 2nd edition, Prentice-Hall, Englewood Clifs, NJ, USA, 1992.
[4] KULTUREL S.: Approaches to uncertainties in facility layout problems: Perspectives at the beginning of the 21th Century, In Springer Science and Business Media, Springer Netherlands 2007, ISSN 0956-5515
[5] MECKLENBURG K.,: Seamless integration of layout and simulation, In Proceedings of the 2001 Winter Simulation Conference, s. 1487- 1491.
[6] MELLER R.D., GAU Y.K.: The facility layout problem: recent and emerging trends and perspectives, Journal of Manufacturing Systems, v15, 351–366 (1996).
[7] MUTHER R.: Systematické projektování (SLP), SNTL, Praha, 1970.
[8] TAYLOR G.: Introduction to logistics engineering, New York, Taylor & Francis Group, 2008, ISBN 978-1-4200-8851-9
[9] VIK P.: Integration of CAD systems and computer simulation and its usage in designing of manufacturing systems, 3. mezinárodní konference Výrobní systémy dnes a zítra, 27.–28.11.2008, ISBN 978-80-7372-416-0
[10] VIK P.: Propojení nástrojů používaných pro navrhování výrobních systémů. Proceedings of 4th annual International conference for Ph.D studentesand young researches, Zlín 10. April 2008, ISBN 978–80-7318-663-0
[11] WU Y., APPLETON E.: The optimization of block layout and aisle structure by a genetic algorithm, Computers and Industrial Engineering, v41, no4, 371–387, 2002
[12] ZELINKA A., KRÁL M.: Projektování výrobních systémů, Praha: ČVUT, 1995, ISBN 80–01-013302-2
[13] Bureš M., Ulrych Z.,Leeder E.:Digirální fabrika – softwarové produkty pro oblast diitální fabriky, In Mopp – Modelování a optimalizace podnikový procesů, Plzeň 8.-9. 2. 2007 ISBN 978–80–7043–535-9
[14] Vilarinho P., Guimaraes R.: A Facility Layout Design Support System, Investigacao Operacional 23, 2003, p. 145–161, ISSN 0874–5161

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INTEGRATIONSMÖGLICHKEITEN VON SOFTWARE-WERKZEUGEN FÜR DEN ENTWURF VON FERTIGUNGSSYSTEMEN

Gegenwärtig besteht großer Druck bei der schnellen und überlegenen Erzeugung von Projekten von Produktionssystemen. Verschiedene Software-Werkzeuge werden für diese Zwecke hauptsächlich zur Analyse, Planung und Kontrolle von Projekten genutzt. Diese Hilfsmittel werden gewöhnlich gesondert oder mit minimalem relativem Datenzusammenhalt genutzt.

Dieser Aufsatz konzentriert sich allgemein auf die Thematik des Entwurfs von Produktionssystemen, konkret auf die Integration einzelner Software-Werkzeuge in ein gemeinsames System. Beschrieben werden mannigfaltige Hilfsmittel und ihre Funktionen, Integrationsprinzipien sowie andere Möglichkeiten, die von dieser Integration ausgehen, zum Beispiel automatisches Erzeugen lauffähiger Simulationsmodelle. Die Integration liefert auch die Erzeugung von Stellungen für Anlagen in der Projektskizze.

MOŻLIWOŚCI INTEGRACJI NARZĘDZI SOFTWAROWYCH STOSOWANYCH W PROJEKTOWANIU SYSTEMÓW PRODUKCYJNYCH

Obecnie duży nacisk kładziony jest na szybkie i wysokiej jakości projektowanie systemów produkcji. W tym celu stosowane są różne narzędzia softwarowe służące do ich analizy, projektowania i weryfikacji. Jednak w większości przypadków narzędzia te stosowane są samodzielnie i przy niskim poziomie integracji danych. Manualne łączenie danych projektowych wydłuża proces projektowania, powoduje powielanie czynności i stanowi źródło powstawania błędów.

Tematyka artykułu związana jest z projektowaniem systemów produkcyjnych, a w szczególności dotyczy połączenia poszczególnych narzędzi softwarowych w jeden system. W pracy opisano poszczególne narzędzia i ich funkcje, zasady ich łączenia oraz wynikające z niego możliwości. Należy do nich przykładowo generowanie modeli symulacyjnych z bazy danych, generowanie pozycji urządzenia w rozmieszczeniu (layout) produkcji oraz ich opty
malnego umiejscowienia wobec siebie w zależności od przepływów materiałowych.

MOŽNOSTI PROPOJENÍ SYSTÉMŮ POUŽÍVANÝCH V PROJEKTOVÁNÍ VÝROBNÍCH SYSTÉMŮ

V současné době je kladen velký tlak na rychlou a kvalitní tvorbu návrhů projektů výrobních systémů. Pro tyto účely se používá různých softwarových pomůcek pro analýzu, návrh a ověření těchto projektů. Tyto pomůcky se ale většinou používají samostatně nebo s minimální vzájemnou datovou provázaností. Ruční spojování projektových dat vede ke zpomalení v procesu navrhování, duplikační činnosti, případně je i zdrojem chyb.

Článek se obecně zabývá tématikou navrhování výrobních projektů, konkrétně integrací jednotlivých softwarových pomůcek do jednoho systému. Jsou zde popsány jednotlivé nástroje a jejich funkce, principy integrace a další možnosti plynoucí z tohoto propojení jako např. generování simulačních modelů z databáze, generování pozic zařízení do výrobního layoutu a jejich optimálního vzájemného uspořádání podle materiálových toků.