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CAD И CIM СИСТЕМИ: СЪСТОЯНИЕ И НАПРАВЛЕНИЯ ЗА РАЗВИТИЕ

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РЕЗЮМЕ
Докладът разглежда настоящето състояние на системите за компютърно обезпечено конструиране (CAD) и компютърно интегрирано производство (CIM). Пълен анализ на тези системи е представен като се използва голям брой информационни източници. Предложени са някои нови понятия, подходи и методи основани на теория на системите и изкуствен интелект.

ВЪВЕДЕНИЕ

На първо място във веригата от процеси в компютърно интегрираното производство (CIM) стои компютърно обезпеченото конструиране CAD (Computer Aided Design). Това е една определено млада технология, която започна през втората половина на двадесетия век като помощно средство в инженерните дейности. Серия от независими помежду си проекти (1956-59), които започнаха в MIK (Massachusetts Institute of Technology) под името APR - Projekt (автоматични програмирани инструменти), имаха за цел да способстват като инструмент в геометричното представяне на машинните детайли при производството им посредством машини с цифрово програмно управление (NC-Maschine). През 1962 г. се появиха първите интерактивни системи за компютърна графика ICG (Interaktive Computergraphik – System) за двудимeнсионни обекти и само една година по-късно R.E.Johnson [JOH-63] разшири възможностите на системата SKETCHPAD за тридименсионни обекти. С помощта на тази система стана възможно перспективното представяне (3D-представяне) на обектите върху равнината.

Първите CAD-системи бяха твърде скъпи и се прилагаха само в предприятията на автомобилостроенето и на самолетостроенето. Понастоящем тези системи се прилагат като основен инструмент във всички области на промишлеността. Те са в основата за повишаване на производителността, гъвкавостта и качеството [AUT-91], [HAA-92a], [HYK-90] и др.

Особености на съвременните CAD/CIM системи

А. Информационно осигуряване на проектирането и производството. Информационното осигуряване е стратегически фактор в проектирането и производството. Незадоволителното прогнозиране на желаните от потенциалните клиенти изисквания към основните технически параметри и качествени показатели на промишлените изделия, съотношение качество/цена и пр. са в основата на разпадането на множество фирми и индустриални обединения.

Информационните потоци в ориентираните към потребителите CAD/CIM системи обезпечават осъществяването на всички основни производствени процедури:
- развитие и конструиране (планиране, концепция, проектиране, технология);
- подготовка на производството (работни планове, NC-програмиране);
- производство и монтаж (технология, материали, инструменти, поточни линии, монтажни линии).

Б. Компютърноориентирано геометрично моделиране. Прилагат се:
- 2D–линейни и 3D–линейни модели, които се основават на следните основни елементи: точки, линии и кръгови форми;
- 3D–равнинни модели, които освен елементите в 2D и 3D–линейните модели включват и повърхнини;
- 3D–обемни модели, които освен елементите в горните два модела включват и обемни елементи.

В. Компютърноориентиран производствен модел. Най-често моделът има модулна структура със следните моменти: модул Конструиране, модул Планиране, модул Производство, модул Монтаж, модул Себестойност, модул Качествен контрол, модул Продажба. Тези модули се състоят от подмодули, в които детайлно се включват редица процедури относно технологията, качеството на материалите, данни за използваните инструменти, клас на точност, последователност от манипулации и пр. (параметрични подмодули).

Г. Програмен интерфейс. Данните за моделите и техните модули в рамките на една CAD/CIM система се съхраняват в кодирана форма посредством база от данни. Форматът на тези данни е в зависимост от използваната изчислителна архитектура и приложения софтуер. За ускоряване на обема на данните между множеството бази данни на CAD/CIM системите се прилагат двустранни канали (връзки).

Обща оценка на съвременното състояние на CAD/CIM системите

Прогресът в разглежданата област (компютърно обезпечено проектиране и производство) е внушителен и намира приложение във всички водещи фирми. Същото се отнася и до възможностите за гъвкавост на производствената номенклатура на изделията. Но в наличните литературни източници все пак липсват някои съществени елементи на съвременните концепции за проектиране:

1. Не се разглеждат въпроси отнасящи се до разработване на варианти в даден проект или конструкция.
2. Не е ясно доколко разглежданата конструкция съответства на теоретичните възможности за оптималност. Вероятно тези въпроси се решават предварително и извън наличната CAD/CIM система.

Направления за развитие на CAD/CIM системите

По наше мнение е желателно да се разширят интелектуалните възможности на новите поколения CAD/CIM системи.

1. Възможности за разумно генериране на варианти на проектните решения.
2. Възможности за многокритериален избор на оптималния вариант.
3. Възможности за по-точно отчитане на конкретния характер на средата, в която работи обекта на проектирането – условия на определеност условия на стохастична среда (риск), условия на неопределеност (размити условия на средата).

ЗАКЛЮЧЕНИЕ

Новите поколения CAD/CIM системи трябва по-широко да се основават на методите на теория на системите на методите на многокритериалната оптимизация и на изкуствения интелект.

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CAD AND CIM SYSTEMS: STATE OF THE ART AND DEVELOPMENT TRENDS

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ABSTRACT

The paper considers the present state of Computer Aided Design (CAD) and Computer Integrated Manufacturing (CIM) systems. A thorough analysis of these systems is presented utilizing a large number of information sources. Some new concepts, approaches and methods are proposed based on system theory and artificial intelligence.

Key words: information models anf flows (in CAD and CIM), system analyses

INTRODUCTION

At first place in the series of processes in the computer integrated manufacturing (CIM) stands the Computer Aided Design (CAD). This is a definitely new technology that started in the second half of the twentieth century as a subsidiary tool in engineering. Series of not linked to each other projects (1956-59), that started in MIT (Massachusetts Institute of Technology), with the name APR-Project (Automatic Programmed Tools) aimed at acting as a tool in geometric representation of machine details in their manufacturing by digital controlled machines (NC-Machines). In 1962 the first interactive computer graphic systems ICG (Interactive Computer Graphic – System) for 2D objects were invented and only one year later T.E.Johnson expanded the potentialities of the SKETCHPAD system for 3D objects. Using this system the perspective representation (3D representation of the objects on the plane became possible).

The first CAD-systems were too expensive and were applied only in automobile and aircraft engineering enterprises. Nowadays these systems are applied as a main tool in all fields of industry. They are the main factor for the increase of the productivity, flexibility and quality (Autodesk 91, Haasis 1992a; Held 1990).

Peculiarities of the present CAD/CIM systems

A. *Information providing of projecting and production.* The providing of information is an important factor in projecting and production. Inadequate prognoses of the potential customers' desired demands of the main technical parameters and quality indicators of the industrial products, quality/price proportion and so on are the main reason for the disintegration of many companies and industrial trusts.

The information flows in the user-based CAD/CIM systems provide the realization of all basic productions procedures.

– development and design (planing, conception, projecting, technology);
– preparation of the manufacture (workplans, NC-programming);
– manufacture and installation (technology, materials, tools, continuous lines, installation lines).

B. Computer-based geometrical modeling. Applied are:

- 2D-linear and 3D-linear models, based on the following main elements: points, lines, and circular forms;
- 3D-plane models that include not only the elements in the 2D and 3D-linear models but also surfaces;
- 3D-spatial models that include not only the elements from the two previous models but also spatial elements.

C. Computer-based manufacturing model. Most often the model has a modular structure from the following pieces: module Design, module Planning, module Manufacture, module Installation, module Prime cost, module quality control, module sale. These modules consist of submodules that include in details series of procedures referred to the technology, the quality of the materials, data for the utilized tools, grade of accuracy, order of manipulations etc. (parameter modules).

D. Program interface: Data about the models and their modules in a CAD/CIM system are stored as a code by a database. These data's format depends on the used architecture and the applied software. For speeding up the data exchange between a multitude of a CAD/CIM system's databases two-way channels (connections) are applied.

General rating of the present state of CAD/CIM systems

The progress in the considered field (computer-based projecting and manufacturing) is impressive and meets appliance in all leading companies. The same is the situation with the potentialities for flexibility of the products' production range. But in the available literary sources some important elements of the present projecting conceptions are still missing.

1. Questions referred to the development of variants of a certain project or construction are not regarded.
2. It is not clear how far a considered construction meets with the theoretic potentialities for optimum. Probably these questions are worked out beforehand and out of the available CAD/CIM system.

CAD/CIM Strategies

The design of CIM system may be started from the top. This can readily be done when a new plant is designed.

The advantages are as follows:

1 The information flow through the control modules from the top to the bottom will be defined in a concise and logical manner and the task of the modules can be outlined in a true hierarchical fashion.
2. All hardware and software modules can be provided with compatible data formulas, communication protocols, and interfaces.
3. Standardization of hardware and software modules is simplifies.
4. The modules can easily be interfaced in a hierarchical fashion and the interface to the lower tier is tested with a simulator.

The disadvantages of this approach are:

1. Often, modules are purchased from an outside vendor or developed in another plant and they are not compatible with the system being built.
2. When the system needs to be changed at a future date, a completely different control strategy may be followed, which, when implemented, requires a major revision of the existing architecture.

The bottom up approach has the following advantages:

1. Many control modules can be started in parallel and operated individually.
2. Modules from outside vendors are often easier to implement.
3. The implementation has less overhead than usually associated with most standards.

The disadvantages are:

1. The interfacing of applications on a control tier or between control tiers might be extremely difficult because no attempt was made to define interfaces, data formats, and communication protocols.
2. Computing and communication equipment used may not be compatible.
3. Programming of the computer system, in particular where hierarchical levels are tied together, may become very difficult because no considerations were given to the use of common languages and programming tools.

Usually, in a practical application, neither strategy is being followed. The systems grow together from the top and the bottom. The whole matter gets further complicated when a CIM system is approached with either a pure CAM, PP&C, CAD/CAM, or CIM strategy in mind (Nuber et al. 1989).

- CAM strategy: The computer is introduced by the manufacturing engineer. He tries to automate manufacturing process warehouse operations, material movement systems, and quality control standards. The installation of CNC and FMS systems without interface to design is another example.
- PP&C strategy: This approach is done from an organizational point of view. The main goals are to obtain improved schedules, to shorten set-up and lead times, to improve lot-sizing and timephasing, and to reduce the in-shop time of the workpieces.
- CAD/CAM strategy: With this approach, a so called vertical integration is taken to merge CAD, CAM, and CAQ. An attempt is made to reduce the duplication of processing and storing data. Usually, the integration process is done via design where all pertinent product data are used for all succeeding manufacturing planning and control operations.
- CIM strategy: This strategy usually builds on one of the before mentioned strategies. It is a consequent integration of existing computer controlled operation. There are two strategies possible. First, one starts with a centralized database and an existing application and integrates new applications in a well defined fashion. Second, one starts with a computer network and tries to coordinate the access to all pertinent data of all manufacturing modules, so that data can be used for common control purposes.

Development trends of CAD/CIM systems

One of the greatest challenges of CIM will be the integration of CAD, CAP, PP&C, and CAM. An open system architecture (OSA) for computer Integration will have to be provided to make common CIM modules, and computing equipment and peripherals available to the manufacturing community. There are several ongoing activities to define product, manufacturing and operational models which are the backbone of any standardization effort. These efforts try to tackle a broad spectrum of technique and components and adress a diversity of users. The results are often difficult to anderstand for an average manufacturing engineer because the models are usually very abstract and use an unfamiliar terminology. Efforts are underway whereby an attempt is made to design specification aids for CIM objects which combine the best features of the natural, formal, and grapfical representation methods.

One problem with the design of CIM modules is the software. There are many programming and system design languages being used and still under development. There is no direction to be seen where these developments will lead au to. The explicit languages are often too cumbersome to apply. Even simple applications are usually very complex when they are described completely. The implicit or task-oriended language may look to the user an answer to his problem.

Another tool to be mentioned in connection with software aids is the simulation. Simulation systems which we will allow the emulation of a factory from a global view down to the microscopic view should be available to lay-out new manufacturing systems, to plan manufacturing runs or to experiment with manufacturing alternatives. Certainly, there are many modular simulation products available. However, they are usually for special purposes or only represent a limited view of a manufacturing operation. A tool box for simulation aids must include models of all manufacturing processes and configurations means to set up the desired manufacturing environment.

Another promising development that appears on the horizon is the artificial intelligence (A.I.). The tools so far available for manufacturing really do not deserve to be named artificially intelligent. Expert systems are presently the most useful tools from A.I., which may be applied to planning and controlling of manufacturing systems. Until today, the possibilities of A.I. in manufacturing have been overestimated, and very few good applications do exist. However, the potential of A.I. is very great and it is necessary to develop methods which can be used for solving manufacturing problems particularly for operations planning. It is believed that with A.I. methods, it will be possible to take many routine jobs out of the responsibility of the manager so that he can devote his creative ability to solving complex problems. An hitherto not well understood problem is the merging of A.I. solutions with conventional ones. Very seldom, A.I. techniques will be used in their pure form. They have to be integrated into other technical systems and applications.

The management of an organization must have an integrated view of CIM in mind when a factory is automated. CIM is not something that can be bought of the shelf, it has to be engineered and configured to an application and the organization has to grow with this new technology.

In our opinion it is desirous for the intellectual potentialities of the new generation CAD/CIM systems to be expanded.

1. Possibilities for a rational generating of variants for the project.
2. Possibilities for a multicriterial choice of the optimal variant.
3. Possibilities for a more accurate analysis of the particular character of the environment where the projected object works – conditions of certainty, conditions of stochastic environment (risk).
4. Development of universal models of the product, the manufacturing system and the manufacturing operation.
5. Development of standards for the communication within a manufacturing system.
6. Development of modeling and animation systems for manufacturing processes.
7. Development of more powerful computers.
8. Investigation of new management strategies for CAD/CIM systems.
9. Development of new curricula for the manufacturing engineers.
10. Exploitation of the A.I. potential for manufacturing

CONCLUSION

The new generation CAD/CIM systems should be based widely on the system theory methods, the methods of the multicriterial optimization and the artificial intelligence.

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