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CAD/CAM - IMPROVED DESIGN QUALITY, INCREASED PRODUCTIVITY

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ABSTRACT

Maintaining productivity levels while assuring the quality of engineering products grows increasingly more difficult and costly for industries such as the energy industry which are heavily committed to product design. The man/machine interface made possible through the development of computer-aided design/computer-aided manufacturing (CAD/CAM) technology can be applied to the design process as a tool for increased control to assure the quality of the final engineering product. The quality control aspects of CAD/CAM technology will be addressed in this presentation.

INTRODUCTION

The design process has long required multiple input in the preparation of quality engineered products, increasing the potential for human error and demanding allowances for time that bog down production cycles. A new product, or one undergoing modification, typically involves input from engineering, design, analysis, drafting, manufacturing planning, part programming, and inspection. The product is shaped and modified by persons from several disciplines, operating from varied points of view with different levels of skill and expertise. The potential for human error and the time required in the design process increase as the design passes through the many hands required in its preparation, creating a need for stricter controls to assure quality engineering output. CAD/CAM technology brings the power of the computer to bear in maintaining controls during the design process by decreasing and in some cases eliminating chances for human error and speeding up the entire design process.

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CAD/CAM TECHNOLOGY

Man-Machine Interface

During the last decade, the power of the computer has been integrated into the design process through the introduciton and development of CAD/CAM technology. Complex operations performed manually by the design engineer using traditional methods have been incorporated into CAD system software providing him with a tool to aid not only in the construction of the design graphics but also in analysis and in the final manufacturing of a product.

The CAD/CAM market offers a variety of capabilities to meet specified needs. EG&G Idaho recently entered the CAD market, specifying a system that would meet the needs of a multi-discipline design/drafting/analysis environment. The system selected is capable of simultaneously performing multiple discipline design tasks and computations in the construction of two-dimensional or three-dimensional drawings. Information can be extracted from the resulting drawing files that may be used in analysis or for generating listings used by manufacturing in ordering materials, product assembly, and in the driving of numerically controlled machinery in the production shop.

CAD System Hardware

The CAD market offers a variety of CAD hardware configurations ranging from specialized graphics generating software packages that have been developed to operate as a subtask on mainframe computers already resident and operating within a company, to stand-alone mini-computer based systems that operate completely independent of any other computer operations. The CAD system recently purchased by EG&G Idaho is a stand-alone mini-computer based system. With this system configuration, work stations in response to operator commands, act as intelligent drafting boards, providing the engineer, designer, or draftsman with a electronic sketchpad, pencil, template, compass and eraser. The ease with which CAD operations may be learned and comfortably incorporated into a design/drafting environment will effect acceptance of the system as a design tool as well as the productivity that may be realized through the implementation of CAD/CAM technology.

CAD/CAM Applications

As referred to earlier, CAD/CAM technology provides a man/machine interface that combines the power of a computer and human expertise in the performance of engineering tasks with a high degree of accuracy in much less time than the manual preparation of engineering data requires. Engineering applications that have been developed and are currently in use in industry include electronics, mechanical engineering/manufacturing, architectural/engineering, mapping, analysis, simulation testing and model building.

COMPUTER-AIDED QUALITY CONTROL

Improved Product Quality

Quality control over the final engineering product, including; the drafting of the product design; informational listings extracted from the engineering drawing; and, where CAM technology is applied, the manufactured part itself, are built into CAD technology.

In the construction of the design, a drawing is put together with components, standard parts and symbols, that are stored in the disk memory of the computer and called up by the designer/draftsman for use on a drawing. Standard parts or symbols such as gears, bolts, pipe sections, walls, beams, resistors, capacitors and even entire sub-assemblies may be used repeatedly once they have been stored in disk memory. Standard parts and symbols can be stored in a common location on disk for general use. Repeated use of a part or symbol that has been created once and is repeatedly used in construction of a drawing assures that if the original part is drawn correctly and according to predefined standards, all such parts appearing on the drawing will reflect consistent quality since they are exact copies of the original part drawn and stored in the CAD system. Each drawing may have available for its construction several hundred predefined parts or symbols. A part or symbol stored in the system may be modified at any time. Such modifications are automatically reflected in the part or symbol appearing on the drawing so that the designer/draftsman does not need to individually change each instance of the modified part as it appeared on the drawing after he has modified its definition in disk memory. This automatic change feature assures the accuracy of changing a design concept, freeing the designer to concentrate more on the quality of the design itself rather than the detailed accuracy of the geometric portrayal of the design concept. Drawing standards and accuracy, especially with repetitive tasks, are a built-in feature of CAD technology.

Segments of a drawing may be assigned to any or all of a multiple number of levels in the drawing file. These levels act like transparent overlays and they can be selectively visible or invisible, changeable or unchangeable, on the drawing area as the designer/draftsman may choose. Parts or symbols appearing on more than one level can be manipulated simultaneously, ensuring consistent changes on all levels, which is of great value in ensuring the accuracy of changes to product design in application areas such as integrated circuit design.

High degrees of precision in detail are available in CAD assisted construction of engineering drawings. EG&G Idaho's three-dimensional system for example can graphically portray an object of about 130 feet in length to a ten-thousandth of an inch, and 3000 miles can be drawn to one-foot accuracy. CAD systems designed specifically for large scale integration applications used in the production of very dense integrated circuit design allow for approximately forty times more detail density than this. Magnifying a particular area on the drawing

with such degrees of density available allows for a high degree of accuracy in product design, enhancing the quality of the final drawing in terms of detailed accuracy.

The readability of CAD generated drawings, whether in the form of a full-scale plot or microfilm output, demonstratively assures quality through consistent and uniform computer generated lines and geometries. When the drawing file is used to create tape output defining numerical control tool paths used to drive production machinery in the manufacturing of the product designed on the CAD system, the quality of the design is also automatically assured and reflected in the final product.

Programming capabilities of the CAD system also can be employed by the designer/draftsman to solve computational problems based on the geometries being constructed; to check drawing relationships for clearance or interference; to extract listings that reflect exactly the information appearing on the drawing; and to create routines that allow the designer to custom design standard parts interactively. Since all such functions employed in design construction are performed at the same point of control, the CAD work-station, quality levels are enhanced as the chance for human error through physical handling of the drawing are decreased.

The Design Process (Fig. 1)

Accuracy and timeliness are key ingredients in assuring quality results from the design process. Minimizing the chance for human error by involving less people in the design process and limiting the accessability of the drawing file and related documents as stored in the CAD system are key attributes in implementing computer aided design into the design environment.

In manual design, the interfaces necessary to perform all of the steps in a quality design process necessitate the passing of engineering documents through a number of hands, each requiring time to perform assigned tasks, exposing the documents to a degree of vulnerability to change at any point in the process, thus increasing the complexity of document control.

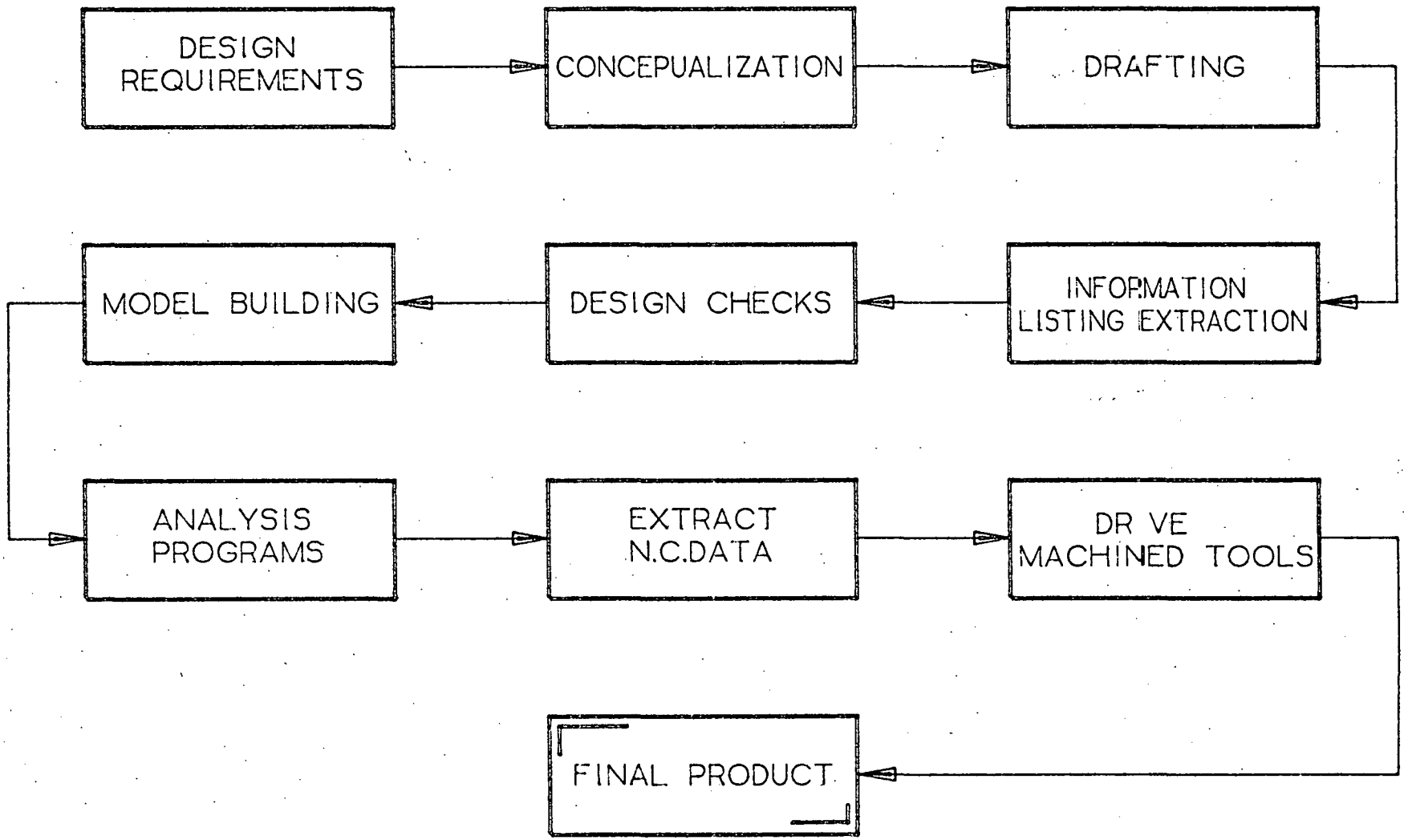
Steps included in the CAD/CAM process that lead to a finished product may include conceptualization, analysis, drawing construction (drafting), manufacturing planning (including model building and simulation testing), part programming, inspection and documentation.

These steps are all accomplished at the CAD workstation, minimizing the chance for human error by actually eliminating some of the need for human interfaces to the design and by maintaining one physical location where changes to the design can be made. Changes to the design can quickly and accurately be incorporated at any point in the design process as a result of input generated during any phase of the design process. Time spent coordinating the design process, such as the need for design reviews and awaiting the incorporation of the

FIG 1

CAD/CAM DESIGN PROCESS

PRODUCT NEED:



resulting recommended changes, can be reduced and in some cases eliminated, by conducting design reviews at the work station, manipulating the design until satisfactory results are achieved. Analysis models can be extracted from drawing files created by the designer, eliminating the need for reconstruction of the part for analysis purposes. Informational listings extracted from the drawing file are automatically updated to reflect current drawing information as changes are incorporated, assuring the accuracy the timeliness of information listings used in ordering materials or in assembly or production of the final product.

Cost efficiencies resulting from decreases in time requirements and the need for human interface are apparent. Increasing work load, and thus productivity, while maintaining present manpower levels is made possible through the implementation of CAD/CAM technology. Assuring that standard parts and procedures are employed in the design process is enhanced by CAD system operating procedures and one point of control is possible since access to the original drawing can only be obtained through a CAD system work station.

Drawing File Controls

Engineering drawings stored on magnetic media (magnetic disks and tapes) are resident and active in the CAD system once they have been input. Among CAD systems available in the CAD market there exists a wide range of security controls. The CAD system selected for use at EG&G Idaho has a high degree of security control built into the system software. Some systems are very lacking in their ability to maintain control over file accessibility.

The EG&G CAD system offers drawing management provisons at three levels: system, group and user. The CAD system manager retains provileged access to the entire "system". He can then allocate limited drawing access to a "group" of users operating the system according to and confined to a specific application which they share in common (i.e., electrical, mechanical, facility groups), allowing users access only to the drawings in their assigned group area on the disk. Each "user" in a group is then also granted access to drawing files resident on his own assigned area of the disk, with a specific, unpublished password for logging into the system.

Drawing file information may be shared by all users of the system through accessing files stored in a common location on the disk and available to the entire user base. Access to files may also be controlled through establishing accounting privileges which allow or disallow the duplication, alteration or deletion of the drawings resident in the file. Special accounting privileges as assigned by the CAD system manager allow the user of the CAD system to:

* Gain access to a drawing file
  - via an assigned account number
  - via an assigned password

* View only the drawing resident in the file

* Change the drawing resident in the file

* Save (store) the file

* Delete the file

The transmition of drawings or informational listings from magnetic storage to hard copy media may also be a point at which drawing accessibility may be controlled. Since the drawing original resides in the CAD system, any to-scale plots generated are only copies and changes made to them manually will not effect the original stored in the CAD system and available only to those with special accounting privileges. Also, manual changes to a CAD generated plot are very easy to identify. Full implementation of CAD technology and accompanying control procedures essentially eliminates manual change problems to engineering drawing originals. An additional hard copy option is available through directly outputting drawing information to microfilm, eliminating the need for a full-scale, reproducible plot.

Drawing originals resident on CAD system storage media may also be copied and stored for file backup on duplicate magnetic storage mediums and distributed to multiple sites for storage and protection to ensure the availability of drawing files in case of an emergency.

Increased control over drawing accessibility impacts the designers ability to assure accuracy and thus the quality of the final design product.

CONCLUSION

Increases in productivity levels and improvements in design quality and quality control are natural outgrowths of implementing CAD/CAM technology into an engineering/production environment. The resulting cost efficiencies more than justify entry into this new computer aided approach to the design process.