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PROBACOM
Computer Aided Project Based on Features

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Abstract

In this work the wide concept of feature will be analyzed in the area of CAD/CAM (Computer Aided Design/ Computer Aided Manufacturing). An application program on a group of interdependent features was developed, with the support of a commercially CAD program available. One of the objectives is the expansion of the capacity of the CAD package and the satisfaction of the needs of the users, which simultaneously are the designers and schemers and should be able to have a new group of options, in the sense of increase the power of the chosen graphic system and to improve the timing of the design of a product called mould.

Keywords

Feature, geometric feature, integration, modeling, CAD

1 INTRODUCTION

These called computer aided design/project based on features, introduced at the beginning of the 80s, is the development of the computer aided design for the conception of the product drawing through the relationship among entities, which is also supported by a model of geometric representation. Our practice shows that it is more intuitive to manufacture a model in terms of certain particularities or features, such as holes or cavities, applying stored information associated to each one of those particularities, than to think out parts of the geometric model and to find the identification, Anderson & Chang (1990).

Throughout a number of years the notion of feature in drawing was restricted to processes planning or parts to be manufactured in spite of some forms classifications.

Nowadays some different classifications have been emerging in a higher multiplicity of applications areas such as in numerical programming and in drawing by geometric modeling.

The work of Pratt & Wilson (1988) pioneer in the cataloguing of features, applying them to the geometric models conception.

L. M. Camarinha-Matos (ed.), *Re-engineering for Sustainable Industrial Production*

The conception of feature

By **feature** we mean the relationship between components or parts of a geometry which may be used as the origin of other forms initially dependent on this.

The features occur as a possible solution for the **connection and integration between CAD/CAM** emerging a multiplicity of definitions. To mention the definition of a standard feature becomes a difficult task, depending mostly on the perspective we visualize the geometry of a certain object, as well as the perception and knowledge of the person that manipulates it. For this reason, a certain speculation arises among the authors of the field on which best definition to adopt.

In a wide context of features definition, we soon conclude that conception and modeling features are also of product and technology, along the assert for that a feature is a set of geometric or technologic information.

Others definitions may also occur, as being any form or entity whose presence or dimensions are relevant for one or more manufacture functions integrated by computer and whose use for the designers is a primitive in the drawing process. In such definition the feature is described as a set of properties able to be codified, deriving also from a classification of forms to schematize particular classifications or specific geometric configurations in a surface or edge, this allow the modification of the extend shape, so that an intended function would be performed as a part of a drawing description such as, for example, a hole, a cavity, a slot, a channel or any other detail.

The design by features has begun in geometric models and the emergence of algorithms for the recognition of the drawing or manufacture details, having a purpose for representation parts of separate pieces or models, appeared to the designers as an accessible and of easy to use tool.

A geometric feature of forms has various types of manufacturing processes: it is common to specify the nature of the geometry or technology used, which has to do with the dichotomy CAD/CAM. To sum up, the design by features allows a high level of abstractions in the draw of graphic entities geometry.

Examples will be given mainly in the areas of **design, process planning, computer numerical control programming and testing/control.**

As results from those experiments we give evidence of the fact that different areas relevant to a sequence of operation, which provoke the emergence of **specific particularities** or, in a general way, **features, which may become data to use in a latter phase of the CIM** (Computer Integrated Manufacturing) **chain, when the objectives is to achieve better quality of any product**.

On conclusion the perception of a certain object is influenced by the knowledge that the user has of this object, this way **different types of features** will provoke a greater **connection of the areas of CAD/CAM** and expand the concept of CIM.

Objectives of the work

The author's professional experience achieved for two years and a half in the moulds industry, allows him to assert that a product's drawing component is of crucial importance from the moment that it is conceived throughout all the phase of manufacturing. That experience was crucial in the increase of interest in the potentialities of the design aided by computer based on features.

In specifying the practical objective, it was taken into account the especifity of the mould plastics industry *, situated mainly in the coast area of the country (Leiria, Marinha Grande, Oliveira de Azeméis), being mainly constituted by companies or groups of small companies whose activity is based on the design and manufacture of moulds for external market.

At the beginning of the 90's, the design systems aided by computer were present in most of the productive process, because the potentialities of the PC's personal computers and their low price which were the main factors in its acceptance in this type of companies

The main objective of the current work was the mixing of various created functions, as a solution for different problems met by the users in the area of design of moulds for plastic, this is done within a fast repetitive tasks hypotheses in the act of conception of the mould, creating dependence relations or features among graphic entities, for a better efficiency in the conception of the article (design/drawing) and its transference for the machining process.

The creation of those relations between graphic objects directed for the areas of design, process planning, testing and control, were achieved by mean of programming the development module of the chosen system, using the instruction of the ADS-AutoCAD Development System AutoDESK(1994), which is similar to C++.

In order to attain the given objective, programming analyses from CAD to PC were put into practice. The PC programs more common in Portugal for the industry of moulds for plastic are: AutoCAD, Cadkey, Microstation PC, these systems having possibilities of transferring files into graphic stations, like SUN, DIGITAL or HP. Yet they have different geometric modelers and some of them using mixed modeling systems like B-Rep and CSG, Rembolt (1993).

The AutoCAD was chosen in a PC environment with processor 486, 100 MHz, on which features functions were implemented about the two-dimensional entities.

Adding to AutoCAD existing menus, new options were created to provide the expansion and to create others solutions that apply to the dependence relations or geometric features among graphic entities.

A moved production cycle that needs the drawing details of the specified article consist on: **Design/Design consulting room**, **Planning/Work preparation** (studies and methods), **Milling** (remove the exceed steel material by CNC-computer numerical control), **Lathe** (conventional and CNC), **Erosion** by CNC, **Grinding** (plain and cylindrical), **Workbench** (assembly and improvement), **Control and Testing.**

We emphasize that the information about the parts currently being manufacture in that area of production is conveyed, in this industry, in a two-dimensional way.

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* We emphasize that the meaning of some words in the productive sector have a very specific meaning: **mould** - tool in steel to produce a product by the means of an injection of plastic stuff; **article** - product to be produced.

2 ARCHITECTURE AND FUNCTIONS

For an easy usage of the commands of the present applications and to provide a agreeable man/machine interface, we had to create a menu with new options or geometric features. The menu is stored in the file "acad_1.mnu", which is a transcription of the main menu of the AutoCAD named "acad.mnu", with some changes, namely making use of the menu POP10, Omura (1991), that until then was not used and is shown in the top right corner of the main screen in Figure 2.

In order to make clear the potentialities and objectives of these applications, which we intend to be an extension of the capacities claimed by the AutoCAD main program, some explanatory pictures are present as a way of involving the capacities of the option, in the effective resolution of some needs presented by the base program.

We apply these new geometric features as a tool in the achievement of fast solutions to the designer work with this type of graphic computing environment.

The explanatory sequence of the new options is about a mould design conceived for industry, following various stages of conception, respectively the **preliminary design** and the **final design,** in order to create a design/design of easy comprehension and reading and respecting the manufacture rules.

The first option of the menu that comes up to the user after the installed of the PROBACOM is the option of loading the various constituting files using the option [LOAD]. Some brief information related with the name of the application also exist, that is the option [Sobre] (About). Only then the areas of the general options follow, grouped within a main menu with various possibilities **[PESQUISA, ALTERAÇÃO, CÓPIA, GERAÇÃO]** (SEARCH, CHANGE, COPY, GENERATION) as seen in Figure 1, these options allow the user to access a number of related operations at the level of the two-dimension drawing being automated, namely having access to some properties information like area entity co-ordinates and radius. Then in a fast and interactive way, the graphic entities positioned in the screen which have the dependence relations among them, can be edited by using search, change, copy, identification and calculus of the number of objects, with the same properties present in the drawing.

The set of options [PESQUISA] (SEARCH) as seen in Figure 2, apply to entity (circle or arc) and the options [Proc. Circ. Raio], [Proc. Arco Raio] are used for fast search of entities with the same radius being the options [Proc. Circ. Dam.] and [Proc. Arco Dam.], similar to the previous ones, but the search of the entity is liked to the diameter. At the level of the code of language ADS the function *ads_rtos ()* is used to convert real values in sets of strings, that may be used as textual information. We use this function to convert the radius or diameter value (numerical values) into string of values in a way that it can be handled as text. The option [INFORMAÇÃO] gives to the programmer details of the graphic entity to be used in the language code ADS, at the level of implementation.

All the functions, in a direct or indirect way, manipulate elements of a list of the project entities being that list created by *ads_buildlist ()* and is built for the text typed entity, in which various fields are defined and allow the text identification control, to be introduced in the drawing through the manipulation of the existing variables in the list.

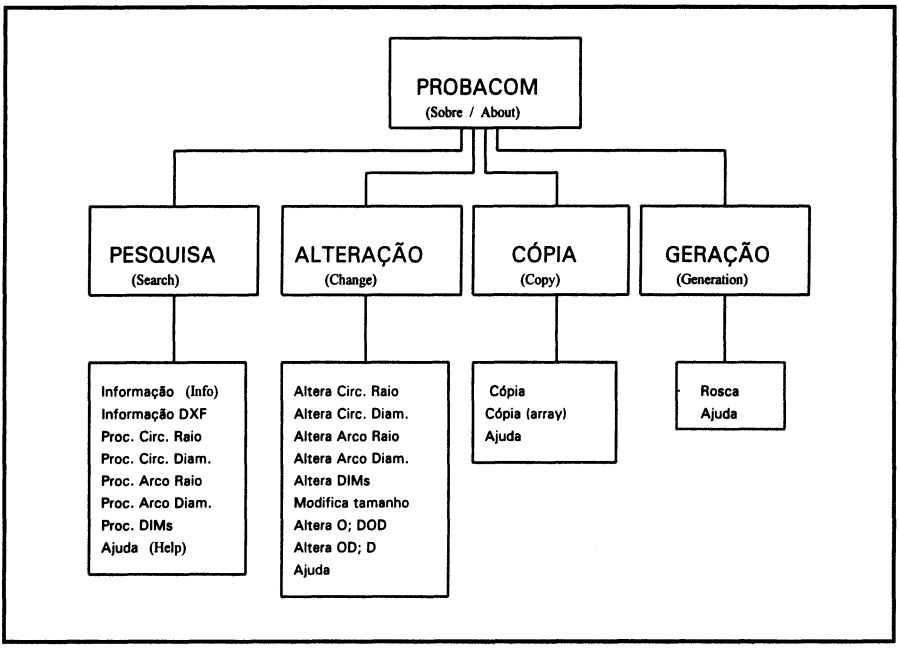

Figure 1 Diagram of the areas and options developed.

The option [Procura DIMs] allows the user to know how many entities of type DIMs coordinates exist and which are their particularities and their value.

The area of function [ALTERAÇÃO] (CHANGE) has various options with different characteristics, but the option [Altera OD; D] as shown in Figure 3, (O original entity; D descendent entity) being this strictly related with the option [CÓPIA] (COPY), because it is a command that allows to modify, simultaneously, the original picture and all copies (created by the option [CÓPIA]), due to the **relations of mutual dependence** generated when the copies were created. If the options [Altera OD; D] is used in an entity that is a copy and not the original picture, the changed pictures will be only those that are copies of this same entity.

When the selected entity is a circle or an arc the user is asked to introduce a new value of the entity radius. After the introduction, this value is positioned in the corresponding field and then an entity is changed using the function code *ads_entmod()*. After the original picture is changed, the program searches among all the entities of the drawing those which are copies of the original entity and changes them in the same way. For polygons, and after the introduction of the new co-ordinates, the function updates the vertex position through the code function *ads_entmod()*, being the copies of the original picture also changed.

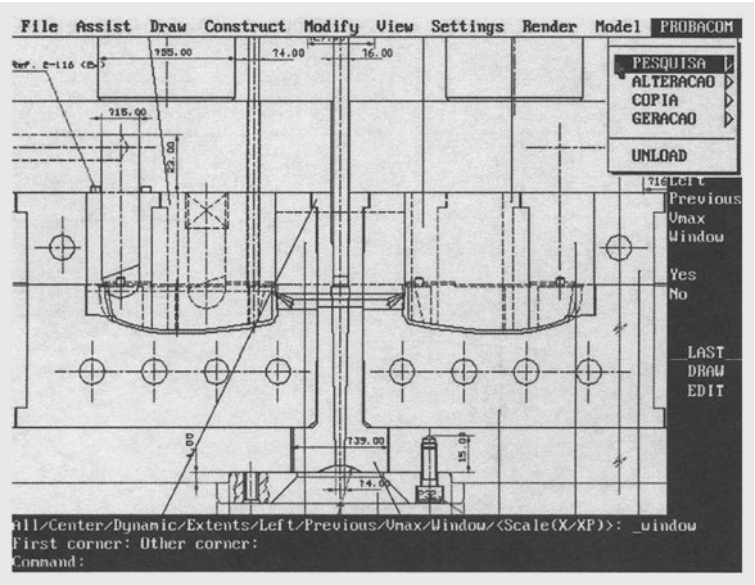

Figure 2 The access to information about the entities is one option [PESQUISA]

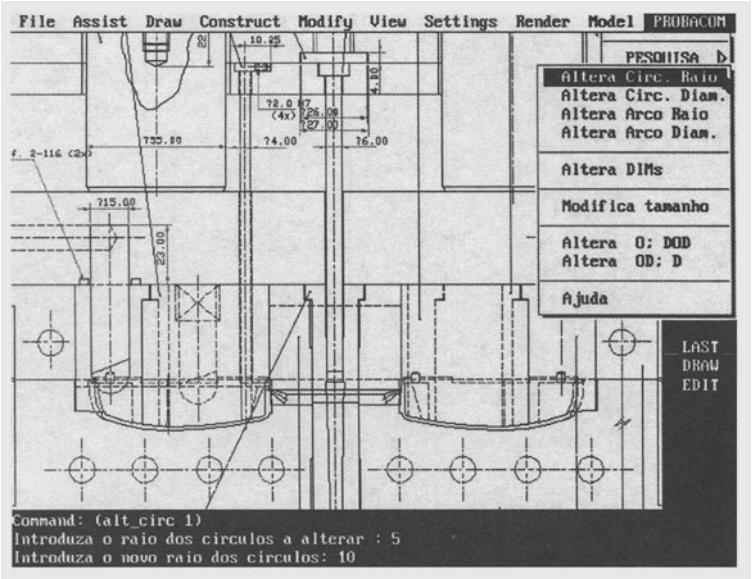

Figure 3 Change the value radius 5 to 10 in circles

The options [Altera Circ. Raio] and [Altera Arco Raio] as shown in Figure 4, are used to change the circle and arc entities with the same radius, being the options [Altera Circ. Diam.] and [Altera Arco Diam.] to do a similar change, but by the entity diameter.

We give evidence to the option [Altera DIMs] (Figure 5), that changes the co-ordinate entities of a given project drawing by a given scale factor that the user introduces through a dialogue box among inches, millimeters and meters.

In the option [Modifica tamanho], the user may modify the point by stages or percentages.

After the drawing entity selection by the code functions *ads_entsel()* and *ads_entget()* this latter is put in the respective buffer and its type is verified. When there is a change of the entity's buffer there is the drawing updating through *ads_entmod()*

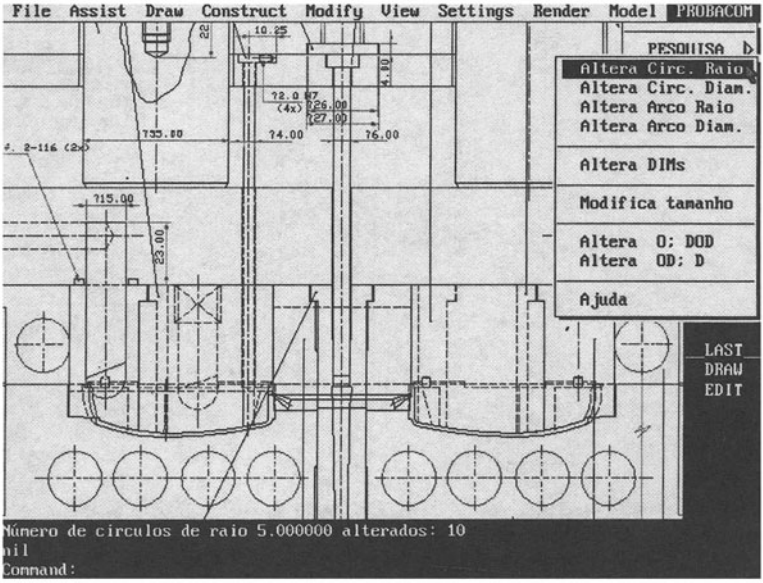

Figure 4 After the simultaneous change of the circles they have now radius 10

The option [Altera O; DOD] distinguishes itself from the others, because each of the entity copy, suffers a change including the original picture, every time a descending image is changed.

Within the area [CÓPIA] reference to an internal function *registar()* must be done that is only found in this option and that is addressed to perform in an ordered way the usage of the function *ads_tbsearch()* that records the name of the option [CÓPIA] in the table APPID, AutoDESK(1994), which is necessary for the correct functioning of the function.

The option [CÓPIA] allows to copy every entity, circles, arcs and polygons, generating **dependence relations** among copies and their original pictures, in a way that, when any change is made in the original drawing, using the option [Altera OD, D] every copy of this drawing will be simultaneously changed.

After the selection of the type of entity to create, circle or arc the program asks the user to input the center of the new entity and puts this value in the field 10 codes DXF, Omura(1991), creating then a new entity using the code function *ads_entmake()*.

In case the entity is a polygon, the copy is more complex because we are facing a group of entities, that are vertexes of that polygon. The option [CÓPIA(array)] is a copy of entities version, but it has the particularity of performing it in a certain direction (horizontal, vertical or leaned) and specify the request number of copies of the entity as well as the distance

between them. The functions used are basically the option ones [CÓPIA], maintaining the features of the geometric dependence among entities.

The area [GERAÇÃO] mediates the option [ROSCA] that is an application particularization and allows drawing various entities (screws) producing a dependence relation between the circle and the arc constituting the screw thread. Thus when the option [Altera OD; D] is performed over the circle of the screw thread, the arc will suffer a change in order to maintain the correct proportions between its radius, using the functions *ads_entmake()*.

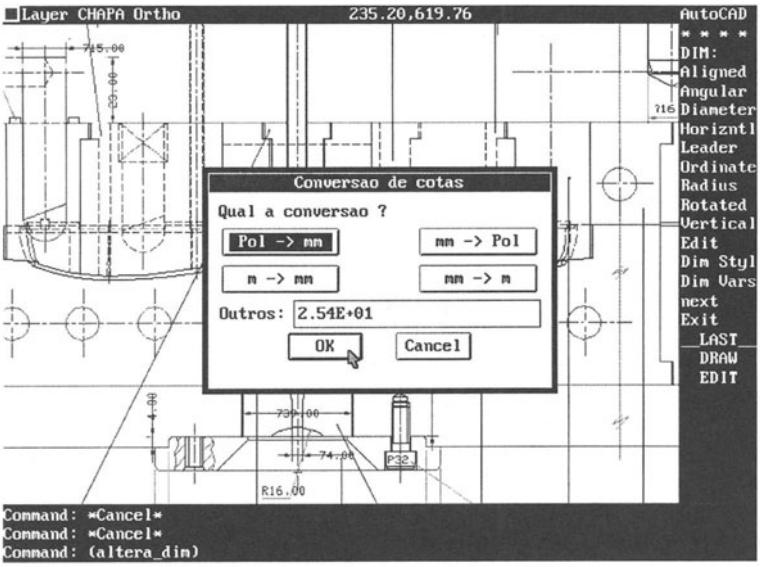

Figure 5 Dialogue box to access to options to convert the co-ordinates

In the option [GERAÇÃO] we intend to present a **pre-defined technological feature** [ROSCA], having geometric relations. We may compare with the type of features, where the designer will access a components library which has different sizes, but in this case of the screw thread the designer will define the size that better suits him.

The designer still has different information tables, that inform him when he intends to evoke any unknown or complex entity, as an auxiliary and fast help of the design accomplishment. This way, **the preliminary design** of a mould gathers the study of the object, the implementation of the object in the moulding position, the dimensions definition of the different components of the object namely, the cavity definition, the core, the study of the moulds mechanics and the special elements, such as movements and unscrew.

In the phase of **the mould final design** an implementation of the different components is put into practice, such as the guides, coupling-box, screws and extractor.

A definition of the final dimensions about the previous constituting parts is given and this is followed by the study of the plastic stuff injection, as the definitions of the moulding areas, cooling circuits (bores, tampons, o-rings) and injection circuit (nozzle of injection, runner system, manifolds), being necessary to improve every process stage.

To conclude this preliminary explanations about the mould building we must speak about object extraction stage, which involves the moulding areas definition and the maximization of the extractors position, cooling circuits and mould supports.

In the representation and design of all these components through a graphic computer program we must use a layer technique of the building stages, associating to them some properties such as type, line thickness and color for an easy reading and interpretation of the drawing phases, creating different layers, such as **moulding core, cooling core, support, screws, core dimensions, cavity dimensions and material lists.**

The application areas of these features function and grouped in [PESQUISA] (SEARCH) (Figure 1) are mainly for the design and processes planning, the ones grouped in [ALTERAÇÃO] (CHANGE) are for design, being necessary to emphasize the geometric features implementation in a one direction and two direction interdependence relations. Within this group a sub-option [ALTERA DIMs] appears as a feature belonging to the testing and controlling area. The option [CÓPIA] (COPY) entails two ways of performing the entities reproduction having relationships between them and it is used in the areas of design.

The option [GERAÇÃO] is a technological feature that applies a mathematical formula that represent the entities type and its consequent reproduction in different sizes and it is inserted in an area of design and processes planning.

3 CONCLUSION

These new options on features in application PROBACOM, maximize the conception of the design stages, but these are dependent on the user skills in the manipulations of the base system menus for a fast design building. The current application becomes useful in the designs and design rooms environment that have computer aided drawing systems for the drawing of two-dimension entities.

In this PROBACOM application the dependencies are mainly built upon single pictures such as circles, arcs and two-dimensional, polygons, taking the real advantages in the manipulation of those entities by saving edition timing by mainly when handling dozens of those entities, which is common in the case of the moulds drawings.

To obtain the AutoCAD base commands associated to these new functions commands is a development of the program itself, because the user may avoid in different circumstances the repetition of actions to achieve a picture change on a group of descending pictures of their copies.

The feature concept is going to evolve within each area according to the geometric entities to being develop. Motivated by one or another detail in the geometry of solids being models other feature type will emerge, with different ends and specific particularities to obtain the geometric pictures of the wished entities.

The approached concepts were focused starting with a bibliographical research and followed experiments in the industry area in order to create homogeneity of the studied topic and connecting it with the theoretical framework that is available as support of these system. This is illustrated with real cases in a mould manufacturing, where the application of new features options are used.

It was our intention to create an application that could be used in the daily life of the productive area, in a sense of improving the interaction between the application and the users, including their work performance.

Comparing this program to other graphic PC programs and by means of common language in engineering as the "C language" and the ADS's functions, we obtained a better performance of the basic options of the AutoCAD, being difficult to obtain the same results with other programs, such as Cadkey or Intergraph PC, due to their peculiar developed languages, which are less well known and requires more learning time and consequently increasing costs..

In the current program the restrictions or interdependencies are only generated among simple pictures, being one aspect to reformulate by the creation of more complex with those properties.

Another aspect to be improved is the building of three-dimension pictures, where the API module, AutoDESK(1994), should be used so that its dependence relations do not create insatiability between faces or vertexes in order to avoid distortions.

The association between pictures would be a way to complete the performed work as well as the mechanisms of interaction between the user through a set of feature windows to be applied to the pictures. The difficulties found throughout the development of the PROBACOM application are mainly concerned with the complex nature of the data structure of the AutoCAD graphics program.

The PROBACOM application was developed mainly using the version 12 of the AutoCAD but are also compatible with the version 13.

4 REFERENCES

Anderson, D.C. & Chang, T.C. (1990), *Geometric reasoning in future based design and process planing.* Computers Graphics vol. 14, Nov. 2, pp. 225-235.

AutoDESK Incorporated (1994), *Reference manual AutoCAD v. 12 and v.13, Manual ADS's* AutoCAD - U.S.A.

Omura, G. (1991), *Mastering AutoCAD,* Sybex, 4ª edition.

Pratt, M.J. & Wilson, P.R. (1988), *A taxonomy of features for solid modeling.* Geometric modeling for CAD applications, Elsevier Publishers-IFIP, Holland.

Rembold, U. & Nnaji, B. & Storr, A. (1993), *Computer Integrated Manufacturing and Engineering.* Addison Wesley Publisher's Company.

5 BIOGRAPHY

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