Cours/Lecture Series

1986 – 1987 ACADEMIC TRAINING PROGRAMME

LECTURER : R. DASSLER / CONTRAVES, Zurich

TITLE : Computer-aided engineering in mechanics

DATES : 24 & 25 November, 1986

TIME : 11.00 to 12.00 hrs

PLACE : Auditorium

ABSTRACT

The various terms (CAD, CAM, CAE, CIM, etc.) are defined and put into a context. The historic development of CAD is touched and the general architecture and a classification of CAD-Systems is given. Functions and data structures of drafting oriented (2D-)systems are presented and explained. They allow, for example, the variation of existing drawings and the simplified definition of standard parts. Modelling systems create three-dimensional models of the real objects. These serve as geometric databases for further planning operations, e.g. the generation of arbitrary views and the calculation of mass properties is possible. Different types of models are described and their advantages/disadvantages touched. Modelling systems for practical use should contain a 2D-System for input and drafting purposes. Practical applications of CAD-Systems are given, the future integration into CIM-Systems is shown, and the interfacing of different CAD-Systems is discussed. The problems of data storage and data management are addressed.

- COPIES OF TRANSPARENCIES
Flow of information: dispositive: 
  technical:

Flow of material:

Model of industrial production
<table>
<thead>
<tr>
<th>Function</th>
<th>Computer application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development/Design</td>
<td>CAD</td>
</tr>
<tr>
<td></td>
<td>CAE</td>
</tr>
<tr>
<td>Process Planning</td>
<td>CAP</td>
</tr>
<tr>
<td>Manufacturing Control</td>
<td>PPS</td>
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<tr>
<td>Manufacturing</td>
<td>FFS</td>
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</tbody>
</table>

CAD  Computer Aided Design  
CAP  Computer Aided Planning  
CAE  Computer Aided Engineering  
CAM  Computer Aided Manufacturing  
CIM  Computer Integrated Manufacturing  
PPS  Planning and control of manufacturing  
FFS  Flexible manufacturing system

CAD in the industrial production process  
Definition of terms
CAD in the industrial production process
HISTORY OF CAD

**Phase I:** Research and development of basic algorithms and subsystems

- **1955** First applications for FEM and Circuit layout
- **1959** APT - Term CAD (Ross at M.I.T.)
- **1962** Concepts for DBMS (CODASYL)
- **1963** Application and programming of refresh displays (Sutherland)
- **1966** GINO (Univ. of Cambridge), programsystem with device independent graphic output
- **1967** Sculptured surface systems in GB, JPN, USA, D
- **1968** ASP - General storing structure for object data
- **1970** First description of relational DBMS
- **1971** First microprocessors for workstations
PHASE 2: DEVELOPMENT AND APPLICATION OF COMPLEX SYSTEMS

1965 START OF EXAPT-DEVELOPMENT

1969... UNIVERSITY DEVELOPMENTS OF 2D- AND 3D-SYSTEMS IN D, GB, USA, JPN
(e.g. COMPAC, PROREN, BUILD, ROMULUS, TIPS-1, GEOMAP, PADL)

INDUSTRY DEVELOPMENTS
(e.g. COMPUTERVISION, CADAM, CADD, SYNTAVISION IN USA, DBSURF, GEOLAN IN D)

1975... STANDARDISATION EFFORTS FOR GRAPHICS SOFTWARE (➔ GKS)

ORGANISATIONS WITH MEMBERS FROM INDUSTRY, UNIVERSITIES AND SOFTWAREHOUSES
(e.g. CEFE, IFIP, CAM-I)
HISTORY OF CAD

PHASE 3: COMPLEX SYSTEMS COMMERCIALY AVAILABLE

1980... IGES - FIRST ATTEMPT TO DEFINE A STANDARD FOR INTER-FACING DIFFERENT CAD-SYSTEMS ➔ PDES, STEP...

1981 GKS - STANDARD FOR GRAPHICS SOFTWARE

TODAY >100 CAD-SYSTEMS AVAILABLE

VDAFS - PROPOSED STANDARD FOR EXCHANGE OF SCULPTURED SURFACES

ATTEMPTS TO DEFINE MEANS TO GENERATE STANDARD PARTS (DIN) IN CAD-SYSTEMS
Different views of CAD-Systems

Functional Model
(User's view)

System architecture
(Programmer's view)

Product structure
(Salesman's view)
CONCAD - System architecture
Creation of geometric elements

Modification of the geometry

Dimensioning, hatching, and annotating

Main functions of a 2D-System for the automated generation of drawings (part 1)
Main functions of a 2D-System for the automated generation of drawings (part 2)
Example for the data structure in a 2D-Model
Graphische Darstellung einer ASP-Struktur
DRAFT MASTER Fertigteilzeichnung
Principles of the three-dimensional object representation
Processing of sculptured surfaces in surface-oriented 3D-Systems
Examples of surfaces in exact 3D-Models
Example of the data structure of a 3D-Model
W=Werkstück, KF=Kreisfläche, ZF=Zylinderfläche, K=Kreis

Beispiel für die Datenstruktur eines rotations-symmetrischen Werkstückes (3D-Modell)
Solid Models
Exact representation vs facetted representation

- Exact representation of the surfaces
- Heterogeneous algorithms
  - Difficult to achieve stability
- Decreasing performance
- Good suitability for CIM-processes

- Approximation of the object's shape
- Homogeneous algorithms
  - Good stability
- Performance depending on the degree of approximation
- Good suitability for graphics
Verwendbare Körper zur volumenorientierten Objektbeschreibung
Beispiele für die Anwendung von Modellierfunktionen in einem volumenorientierten 3D-System
Volumenorientierte Objektbeschreibung
Beispiele für die Anwendung von Modellierfunktionen in einem volumenorientierten 3D-System
Step 1: Beschreibung der Hauptflächen
Step 2: Beschreibung der Übergangsflächen
Step 3: Verknüpfung von Haupt- und Übergangsflächen

Quelle: DUCT

Anwendungsbeispiel eines flächenorientierten 3D-Systems
Ergebnisse eines volumenorientierten 3D-Systems
Explosionszeichnung einer Scheibenbremse

Anwendungsbeispiel eines volumenorientierten 3D-Systems
Perspektivische Darstellung mit SOLID MASTER "Innenansicht"
Files

for interfacing CAD and NC-Programming

Files

for interfacing CAD and NC-Programming
DBMS for interfacing CAD and NC-Programming
**CAD-Data**

<table>
<thead>
<tr>
<th>Workspace</th>
<th>DBMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D-Models</td>
<td>Product models</td>
</tr>
<tr>
<td>2D-Models</td>
<td></td>
</tr>
</tbody>
</table>

Data management in CAD-Systems
(mech. eng.)
CONCAD-CATALOG
Basic data structure (simplified)
STAGE 3
Add. access using tools of the DBMS

Tools of the DBMS, e.g.:
- Query Language
- Screen Handler
- Report Generator
- Program Generator

STAGE 2
Access via Dialog of the CAD-System

STAGE 1
Archiving of the CAD/CAM data in files

Relational DBMS
Forming of object-oriented structures and archiving of the CAD/CAM-data under the control of the DBMS

CONCAD
Steps of permanent data storage
Design phases and design types

- Conceptual design phase
- Rough design phase
- Detail design phase

New design

Adaptive design

Variant design
Design phases and design types
Application of DRAFT MASTER
Design phases and design types
Application of DRAFT MASTER and SOLID MASTER
Vereinfachungen vom 3D-Modell zum FEM-Modell, 
1. Schritt: unwichtige Details eliminieren
Step 2: Consideration of symmetries
Principles to interface CAD and NC
CADCPL Drehteilbearbeitungssimulation

Längsdrehen

Längsdrehen noch nicht abgearbeiteter Partien nach erfolgtem Werkzeugwechsel
## Principles of Interfacing CAD and NC

<table>
<thead>
<tr>
<th>Input</th>
<th>general and geometry oriented</th>
<th>special and technology oriented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drafting definition</td>
<td>with basic commands</td>
<td>Workpiece description with special commands</td>
</tr>
<tr>
<td>Data Structure</td>
<td>K1 K2 B1 S1 B2 S2 P1 P2 P3 P4</td>
<td>FE1 K1 K2 B1 S1 B2 S2 P1 P2 P3 P4</td>
</tr>
<tr>
<td>Interfacing</td>
<td>CAD/NC general</td>
<td>Part Program</td>
</tr>
</tbody>
</table>
Technology specific CAE
• Improvement of input methods
e.g. Sketching/Dimensioning

Subject to research

• Processing of complex shapes
Var. of dimensions
Var. of the shape

High importance in practical use

• Automation (Programming) of standard sequences

Choice of stand. parts
Arrangement of stand. parts
Detailing

High importance in practical use

Possibilities to improve the efficiency of CAD-Systems
<table>
<thead>
<tr>
<th></th>
<th>Arbeitsschritte zur Verarbeitung von Handskizzen</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>sketching</td>
</tr>
<tr>
<td>2</td>
<td>digitizing</td>
</tr>
<tr>
<td>3</td>
<td>preprocessing</td>
</tr>
<tr>
<td>4</td>
<td>segmentation</td>
</tr>
<tr>
<td>5</td>
<td>identification, classification</td>
</tr>
<tr>
<td>6</td>
<td>orientation</td>
</tr>
<tr>
<td>7</td>
<td>composition</td>
</tr>
<tr>
<td>8</td>
<td>representation</td>
</tr>
</tbody>
</table>

Quelle: Spur, Jansen

Arbeitsschritte zur Verarbeitung von Handskizzen
Treatment of standard shapes

Symbols

Processing of schematic diagrams
Processing of graphic and non-graphic information

Macros

Procedure-Macro
Application of a parametrised sequence of commands

Program-Macro
Enhancement of the CAD-System on the program level

Data oriented Macro
Definition of a variable standard-shape in a graphic Dialog
Representation of the variation-rules in the object data structure
Beispiel für die Erzeugung eines dimensions- und gestaltvariablen 3D-Macros
Konstruktion von Ansichten mit Handskizzen und Konstruktionslinien

Quelle: Spur, Jansen
Spritzgussform

Anwendungsbeispiel eines volumenorientierten 3D-Systems
Layout einer Montageanlage
Automatically generated view of an industrial robot using solid modelling
Modellaustausch mit IGES

(IGES: Initial Graphics Exchange Specification)
CONCAD as an open system