Development of Concept Design CAD System

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1. Purpose

In order to shorten the product development time and improve the product quality, 3 dimensions at CAD/CAE system is essential. It is necessary to develop a system which utilizes the concept design data at the early stage for the whole process of the product development.

The purpose of this project is to improve the product quality by the sufficient design study iteration at the early stage of design. A CAD system which can be used for the concept design and an appropriate CAD environment should be developed. And another purpose is to shorten the product development time at the late stage of design.
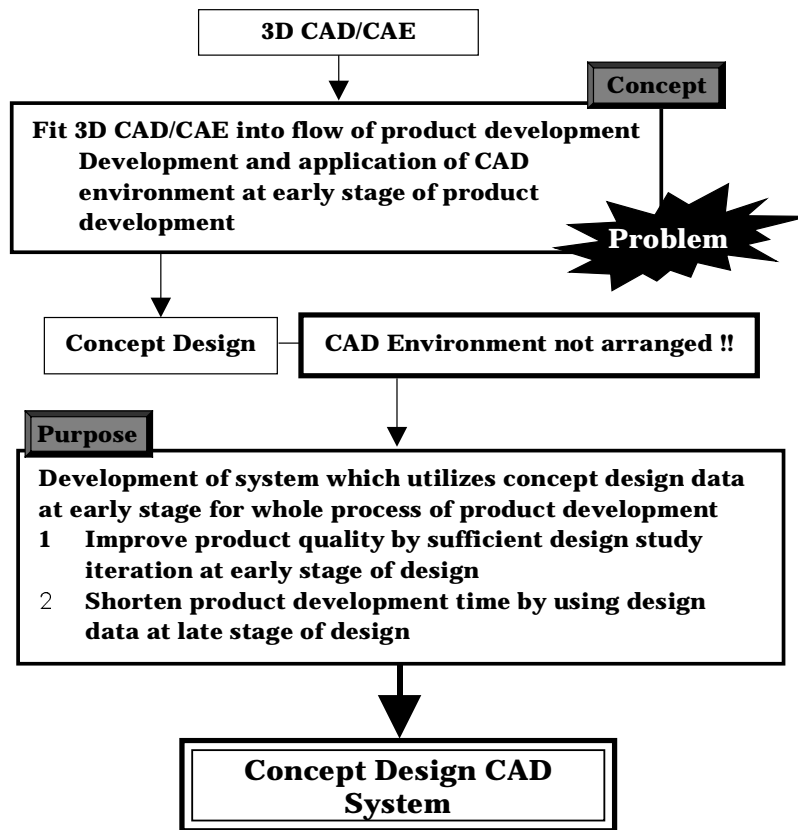
Figure 1
Purpose of Concept Design CAD System

2. Background

(1)   Current Product Development Procedure (Office, Industrial Machines)

The current product development procedure of the office and industrial machines shows on Figure 2.

After determining the product specification, a concept design is done. Several layouts at the concept design stage are made and the interior structure is examined and divided into units. The unit design is done by referencing the concept design drawings. A layout for each unit is decided, each unit is divided into assemblies by function. The detailed designs for assemblies are done by the assembly engineers. After the detailed design is finished, the whole design is reviewed to check every function and coordinate one unit to others. If there is no problem with this review, component drawings and a component table are made. A component prototyping and a structure prototyping are done. Then a prototype is accomplished to be examined and confirmed. This product is produced in a large commercial quantity.

(2)   3 Dimensions at CAD/CAE system

In order to shorten the product development time and improve the product quality, 3 dimensions at CAD/CAE system should be introduced to the current development procedure. However only by using 3 dimensions at CAD/CAE system, we could not achieve this goal. We should fit 3 dimensions at CAD/CAE system into the flow of the whole product development process.

3 dimensions at CAD system is often introduced to the detailed design. The information of the detailed design can be used for the later stage of the process. For example the CAD data of the detailed design is transferred to a processing machine.
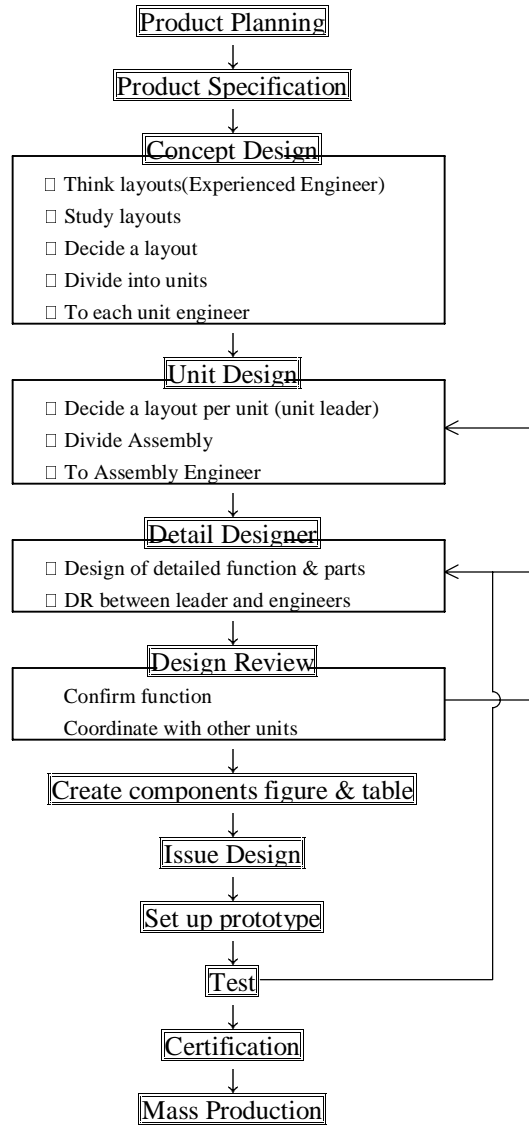
Yet with this procedure, the information before the detailed design cannot be used for the next stage. It is important to develop and apply the CAD environment in order to use this information at the early stage of the development.

We have focused on the concept design and found that the environment for CAD system is not organized yet at this stage.

(3)   Design Tool for Concept Design

At the early concept design stage, an experienced engineer makes several layouts using his past experience and knowledge. He uses 2 dimensions at CAD system as design tool, of which the operation is easy. As at this stage it is not necessary to draw detailed shapes, the engineer has chosen as design tool the one which can be used like hand drawing to fix basic shapes. On the other hand, 3 dimensions at CAD system has all functions and the design information is expected to be used at the later design stages if it is introduced. There is a conceived idea that the operation of 3D CAD is hard to learn and 3D CAD is not accepted by engineers. In conclusion for the concept design the 3D CAD which has the same ease of use as the 2D CAD in terms of placement, movement, change of shape is desired as design tool.

One layout among several layouts which have been made by the experienced engineer is chosen by watching the hard copy drawings. As the information which can be taken from the drawing is limited, the method to confirm the mechanical movement visually is expected but no additional operation at the concept design stage is wanted. At this stage it is enough to see the relative positions of the mechanical components when moving and static. The ease of use to draw the basic shapes and fix the mechanical movement is the necessary condition for a design tool of the concept design.

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                    ┌─────────────────────┐
                    │  Product Planning   │
                    └─────────────────────┘
                              ↓
                    ┌─────────────────────┐
                    │ Product Specification│
                    └─────────────────────┘
                              ↓
         ┌────────────────────────────────────────────┐
         │ Concept Design                              │
         │   ☐ Think layouts(Experienced Engineer)     │
         │   ☐ Study layouts                           │
         │   ☐ Decide a layout                         │
         │   ☐ Divide into units                       │
         │   ☐ To each unit engineer                   │
         └────────────────────────────────────────────┘
                              ↓
         ┌────────────────────────────────────────────┐
         │ Unit Design                                 │
         │   ☐ Decide a layout per unit (unit leader)  │
         │   ☐ Divide Assembly                         │
         │   ☐ To Assembly Engineer                    │
         └────────────────────────────────────────────┘
                              ↓
         ┌────────────────────────────────────────────┐
         │ Detail Designer                             │
         │   ☐ Design of detailed function & parts     │
         │   ☐ DR between leader and engineers         │
         └────────────────────────────────────────────┘
                              ↓
         ┌────────────────────────────────────────────┐
         │ Design Review                               │
         │     Confirm function                        │
         │     Coordinate with other units             │
         └────────────────────────────────────────────┘
                              ↓
         ┌────────────────────────────────────────────┐
         │ Create components figure & table            │
         └────────────────────────────────────────────┘
                              ↓
                    ┌─────────────────────┐
                    │    Issue Design     │
                    └─────────────────────┘
                              ↓
                    ┌─────────────────────┐
                    │   Set up prototype  │
                    └─────────────────────┘
                              ↓
                    ┌─────────────────────┐
                    │        Test         │
                    └─────────────────────┘
                              ↓
                    ┌─────────────────────┐
                    │    Certification    │
                    └─────────────────────┘
                              ↓
                    ┌─────────────────────┐
                    │   Mass Production   │
                    └─────────────────────┘
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Figure 2
Development procedure of office, industrial mechanical products

3. Procedure

(1)   Procedure to resolve the problems of the concept design
For the product development of the paper conveyor machines, in order to develop the CAD environment at the concept design stage,

- ☐   Develop a mechanical simulation to understand the concept design
- ☐   Make a concept design by CAD
- ☐   Transfer CAD data at the concept design stage to a mechanical engineer

(2)   Effects of institutionalizing the concept design CAD system
By using the system mentioned in 3.(1), the following effects are expected for the product development of the paper conveyor machines

a)   Concept Design
At present when one layout is chosen among several layouts, it is done by using hard copy drawings and examining functions. Using this system, from the concept design stage the mechanical simulation model is made and can be checked on the display.

b)   Unit Design, Detail Design
At present the concept design information is given by 2D CAD Data but not used enough for the late stage of design. Using this system, the concept design information (example: shape of components, values on coordinates for components) can be transferred to 3D CAD.

c)   Design Review (DR)
With the current method, DR is done by the hard copy drawings. Using this system it is possible to check movement and functions on a display without hard copy drawings. Compared to the static drawings, DR is easier with this system as the mechanical movement can be visualized.
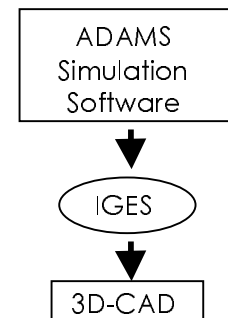
4. Concept Design CAD System

(1)   Prototype System
Using the method in 3. (1), a concept design CAD system was developed for the prototype of paper conveyor product development.

Normally products are developed by the successive designs and prototypes. To shorten the product development time and improve the product quality, a simulation is needed between the design and the prototype. A method is thought. CAD is used for design, a model is made for a mechanical movement simulation and a simulation is done. But with this method, there is more operations for simulation and the development time is not shorten.

We used a mechanical simulation software ADAMS for the concept design and thought of the method to transfer the data to CAD. The concrete procedures are as follows:

- ☐   Do a concept design using ADAMS
- ☐   Output the data as IGES file from ADAMS
- ☐   Transform IGES file into 3D CAD model data
- ☐   Input the data in 3D CAD

Figure 3
Concept Design CAD Prototype System

(2)   Application examples

a)   Application Model
A prototype system was applied to the simplified conveyor model. (Details are shown in Table 1)

b)   Create models
Developing models by using ADAMS corresponds to the concept design in the practical design.
The necessary input data for this model development is in Table 2.

c)   Change of data
After the concept design, the design information is introduced to 3D CAD by the procedure 4.(1).
The data change procedure to introduce a model made by ADAMS into CAD is as follows
1   A model made by ADAMS is output as IGES file by each component
2   Transform IGES file into CAD model data
           This data is (a) IGES file name, (b) 3 D CAD model name
3   Introduce the transformed model data in 3D CAD
           This data is (c) 3D CAD model name, (d) 0 coordinates

Table 1 Application Model (Conveyor Mechanism Model)

Parts of Conveyor Mechanism Model		Parts used in ADAMS
Roller	11	Cylinder
Belt	3	Extrude
Conveyor Pass	1	Spline
Conveyor Paper	1	Link

Table 2 Input Data

Name of Parts		Input Data
Roller	Create	Position values on coordinates, Size (radius, width)
	Fix movement function of driving roller	Fix driving roller, Movement function
	Fix relation of rollers	2 rollers and their radius, Rotation direction
Belt	Create	Shape
Conveyor Pass	Create	Shape
Conveyor Paper	Create & Set up	Size (length, slope), Conveyor speed, Conveyor starting position, Conveyor pass

5. Status of Prototype System

- The most of the components created by ADAMS can be introduced to 3D CAD through IGES file
- The central coordinates of the roller can be picked on 3D CAD
- As the mechanical simulation software ADAMS is used to create models and do a concept design, a mechanical simulation model is created.
- When design fields (unit division fields, limited size to put the body) are decided, if fields are fixed by using box parts in ADAMS, its shape data can be introduced to 3D CAD.

6. Future Development of Project

By creating the above concept design CAD system, the detail design can be done, based on the concept design data introduced in 3D CAD.

For the following 2 points, the concept design CAD system will be developed and the CAD environment in the concept design will be established.
1) Development of the system which can be used in the actual design
The demonstration using the concept design CAD prototype system will be done. The comment from engineers will be picked regarding the functions needed to use this system in the actual design. Specifications for the system will be created. The system which satisfies the specifications will be developed.
2) Integration to the product development flow
3) As mentioned in 2.(2) 3D CAD/CAE, even if there is a system with excellent functions, if it is not integrated in the flow of the whole product development, there is no meaning. The actual product development operation will be analyzed, summarized as flow chart. It will be clarified that where this system should be used in the actual product development system in order for this system to become the most appropriate procedure.

Further in future, the attributes of the mechanical information (for example, the information that the cylinder in the conveyor model is a rotating object) are given to the components and the models created by CAD will become semi-automatically simulation models. The test before physical prototyping will be possible.

By building the concept design CAD system, the environment will be arranged, in which the design data of the early stage can be used for all stages of the product development. Then the product development time will be shorten and the quality will be improved.

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