TRAINING ON THREE-DIMENSIONAL COMPUTER-AIDED DESIGN FOR NEW EMPLOYEES OF MACHINE DESIGN DEPARTMENT AND ITS EVALUATION

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ABSTRACT: 3D CAD has been established as a standard; however, a significant change is experienced at the actual design sites. The change is a result of the insufficient recognition of the fact that the ability required for designing is different from that required for drawing. Conventionally, drawing carried out by hand using the JIS drawing method has been mainly performed, and the drawing ability required to convey the design intent is significant for designers. Even in two-dimensional CAD, only the drawing that has been carried out by hand is replaced by the computer; therefore, the work related to drawing while imaging the orthographic projection (projection method) is essentially similar to that required for hand drawing. Improvement of design efficiency by the practical application of 3D designing has been promoted. This holds true for designers with extensive work experience. For designers with insufficient experience, it is considered that the purpose and concept of 3D CAD have not yet been established. In this paper, to address the following problems, namely, (1) insufficient understanding of the design method by young designers, (2) unclear design concepts regardless of the ability to create a shape model, and (3) insufficient understanding of two-dimensional drawing, the contents of 3D CAD training for new employees of a machine design department are examined. In addition, basic and general knowledge on machines required to carry out machine designing are examined and actual examples of training for the purpose of improving design ability and its achievement are discussed.

Keywords: three-dimensional design, 3D CAD, machine design

1. INTRODUCTION

It is necessary for companies to continuously create innovative and original products that cannot be copied by third parties in order to survive in the 21st century, in which high-quality and rapidly producible products are desired. The most important task in realizing this is strategic training to produce truly experienced design engineers.

Until a few years ago, there were questions on whether three-dimensional (3D) computer -aided design (CAD) is really useful for machine designing, and thus, 3D CAD was rarely adopted by companies. One of the reasons behind the slow spread of 3D CAD is the temporary decrease in the pace of designing, because many parts are reused during machine designing and this requires a huge amount of paper drawings.

However, with the strengthening of the competitiveness of Japanese manufacturing businesses in the international market, competition has increased; therefore, the strengthening of overseas production sites, the shortening of product life cycles, and the production of various products in small lots

have been carried out. Because Japan came to play the main role in planning and designing, Japanese companies inevitably started to use 3D CAD.

Furthermore, although we begin using 3D CAD, two-dimensional drawings are still necessary. The drawing tasks such as inputting attribute information still remain. The work of producing orthographic projection can be carried out using 3D CAD; however, the work that is dependent on the designer's qualifications, such as functional and effective designing, should be carried out and structured by designers according to their judgment.

2. DESIGN OCCUPANIES AT ARTNER Co., LTD

Figure 1 shows the outline of design roles at Artner Co., Ltd. In addition, the structure of personnel involved in design is shown in Fig. 2.

3. OUTLINE OF TRAINING SYSTEM

Designers who are highly motivated, can work independently, and can produce original and creative designs are required. Three -dimensional (3D) computer-aided design (CAD) is a mere method for verifying designs, and we must consider how design specifications should be quantified to realize the design target and what is essential for the realization of the design target. Moreover, it is also important to feel the joys and pains of designing by working continuously on designs.

Figure 3 shows the results of the questionnaire on training completed by employees of the company and its customers. Figure 4 shows the contents of the training related to machine design.

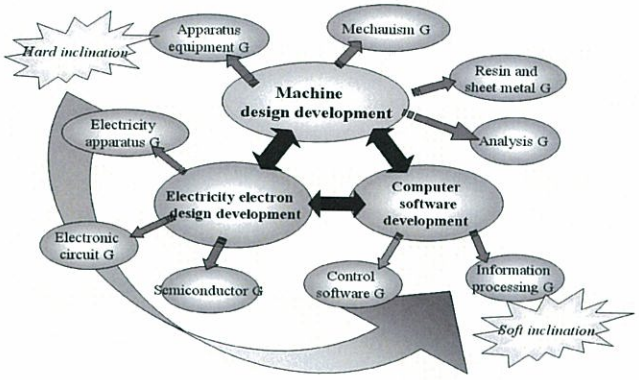


Fig.1 Outline of design roles at Artner Co., Ltd.

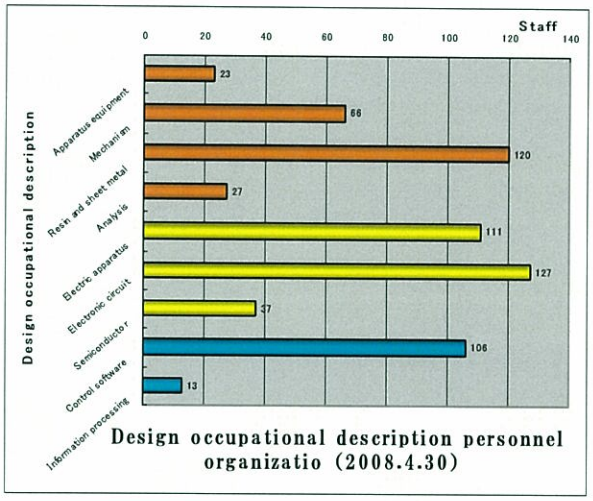


Fig.2 Structure of personnel involved in design

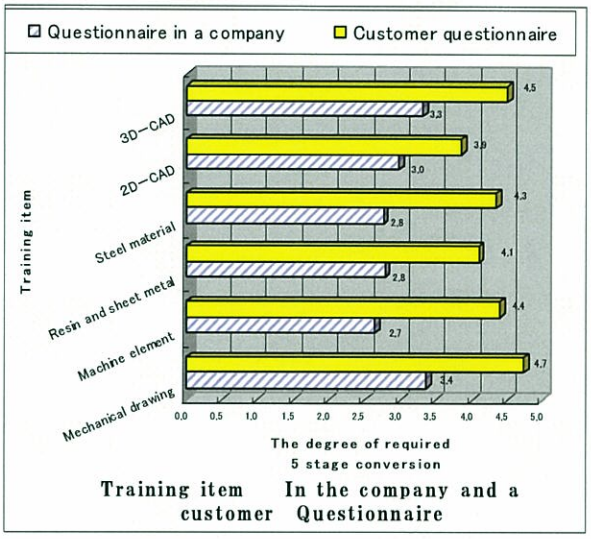


Fig.3 Company and its customers

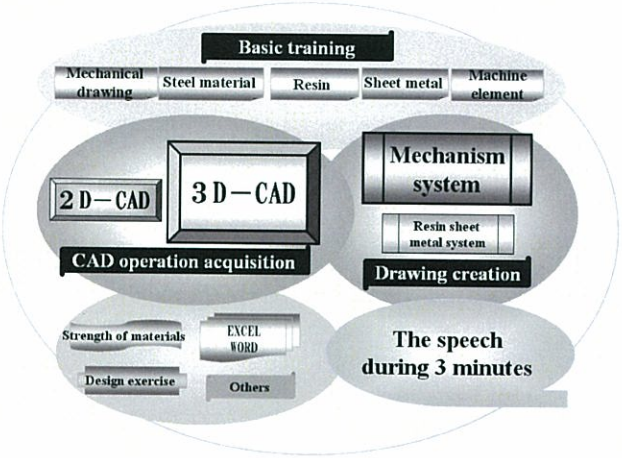


Fig.4 Contents of the training related to machine design.

The main software used in the training includes Micro Cadam and AutoCAD for two-dimensional (2D) CAD, and Ideas, Catia, Pro-E, and Solid Works for 3D CAD.

4. EXAMPLE OF TRAINING TO ENHANCE SKILL

4.1 Training in design process

Trainees should understand that the design process is more important than the operation of 3D CAD. Trainees learn the following processes.

① Clarify the specifications of products.
② Design the shape and mechanism of products on the basis of the specifications, namely, the target numerical values.
③ Verify the results of designs with respect to the specifications.
④ Use 3D CAD as a tool for verification.

4.2 Training in modeling techniques

Trainees acquire practical modeling techniques for reducing the time necessary to accommodate a design change by approximately 90% and to generate data that can be used to produce products without defects (separation and lacking of surfaces) and other techniques as follows.

① Methods of developing models with which the design can be easily changed (addition and omission of dimensions and shapes).
② Modeling methods for shapes with a free curved surface, including exteriors of home electrical appliances and mobile phones.
③ Methods of maintaining revision history.
④ Preparation of parts list.

4.3 Training in basic operations

The following techniques correspond to general operation training.

① Creation and saving of new files.
② Modeling of rectangular parallelepiped and round columns.
③ Preparation of drawings.
④ Representation methods of movable parts such as cams and links using 3D CAD.

Figure 5 shows the assignment of basic operation modeling that Artner Co. developed. Figure 6 shows a manual of basic operation modeling for 3D CAD.

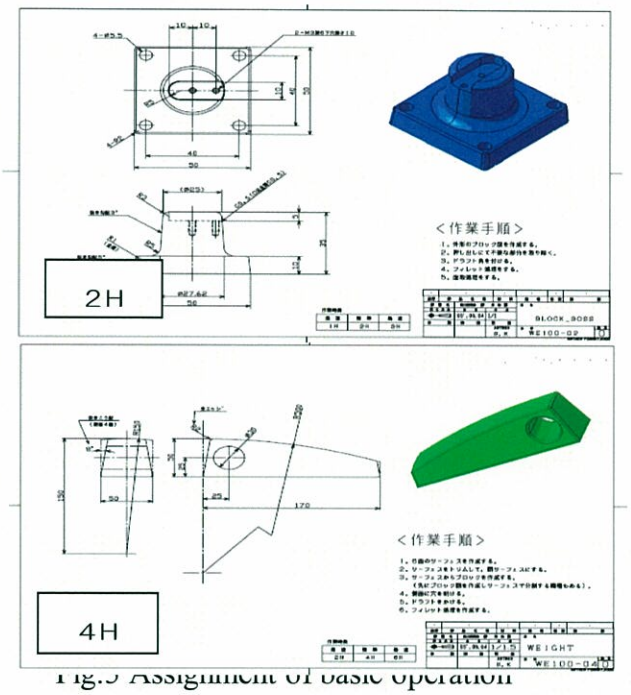


Fig.5 Assignment of basic operation (1of2)

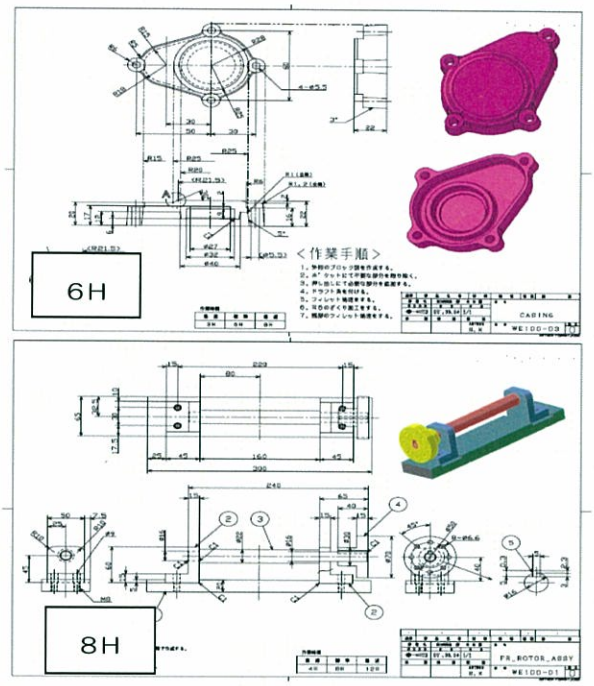


Fig.5 Assignment of basic operation (2of2)

modeling (1)

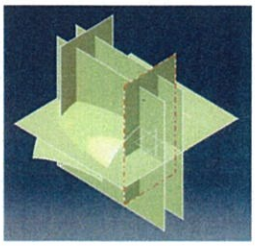
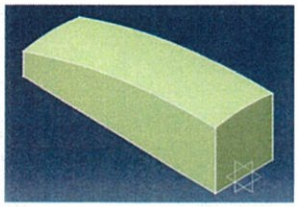
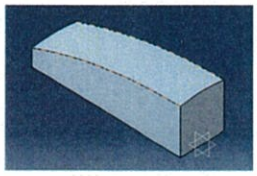
Work	Screen	An used command	Bench
12. The Surface of the 6th page is displayed.			
13. The trim of the Surface of the 6th page is carried out, and an inner side creates the Sur face of a cave.			
14. A Surface is closed and an inner side is made solid.			

Fig.6 Manual of basic operation (1of2)

modeling (2)

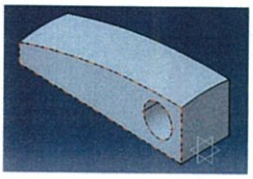
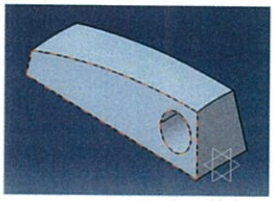
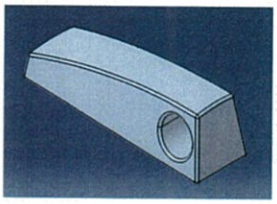
Work	Screen	An used command	Bench
15. A hole is made in the side.			
16. A draft is applied to the 4 sides.			
17. The angle of an edge part is rounded.			

Fig.6 Manual of basic operation (2of2)

5. EXAMINATION OF BASIC KNOWLEDGE OF MACHINES IN GENERAL FOR DESIGN OF MACHINES

The basic knowledge of machines required for carrying out machine design are summarized, with consideration to the improvement in the skills of young machine design engineers. Upon training, they are expected to become excellent engineers with high ability in the near future.

Chapter 1, 3D CAD:

Modeling, assembly, and preparation of drawings of parts

Chapter 2, JIS drawing method:

Standards associated with drawing, types of lines, projection, cross-sectional drawing, notation of

dimension

Chapter 3, Accuracy design:
Quality and accuracy variation, reasons for the variation, tolerance and statistical treatment

Chapter 4, Material selection:
Type and usage of metal materials and plastic materials

Chapter 5, Strength design:
Type and unit of forces, stress and strain, problems regarding tension, bending, and torsion

Chapter 6, Reliability design:
Lifetime of machine, type and cause of machine failure, design method to avoid failure

Chapter 7, Element design:
Design method for screws, gears, and bearings

6. ACTUAL EXAMPLES OF TRAINING FOR IMPROVING DESIGN ABILITY AND ITS RESULTS

New employees must endeavor to develop the abilities required for design processes, including the preparation of specification documents and design concept, before operating CAD.

6.1 From planning / design concept

When we receive an order from a customer, the requested specifications are presented by the customer. We then aim to manufacture and realize products with functions that meet these specifications within budget, which is the goal of design. First, engineering techniques and mechanisms for realizing the motion of machines, which are produced to conduct operations, are developed. Existing techniques and proven mechanisms are used in some cases; but we sometimes need novel ideas and inspirations derived from natural phenomena.

Recently, familiar designs that adopt existing techniques rather than a technique that requires new element tests have frequently been observed because high efficiency and cost performance are pursued in design. As a result, less trial and error has been performed in the progress of design, and priority has been given to design efficiency.

6.2 Examination using rough drawings

The examination stage, in which creativity and ideas are required, is the most important and enjoyable among design operations. In concrete terms, a rough picture is drawn on a paper using a pencil to make note of an idea. While drawing a picture during deep cogitation, a novel image is sometimes unintentionally created.

The imaging of an idea, namely, the representation of an idea using pictures and characters, is the most suitable method for maximizing the possibilities of designing at operation branches and for briefly explaining information.

When designing, the designer focuses on a white paper, lets the mind wander, and draws a component. Creating a design idea probably means incorporating new ideas into a shape while considering the shape of new products by imaging the shape of products that are already known, that is, the products the designer has previously seen and touched. We think that 3D CAD is unnecessary up to and including this stage of design.

6.3 Results of computer-aided engineering (CAE) depend on experience and sense.

Because there are many varied design targets, it is difficult to ensure the quality of analysis

results unless a modeling technique is standardized to some extent. Moreover, at present, there is an evident difference between designers in their design quality depending on their skill, even when the same tool is used. This can be regarded as a problem of training. In other words, designers are required not only to learn how to use CAE but also to have the ability to make decisions in order to accurately examine the behavior of objects, which is supported by experience and a feeling for design (which can be gained by experiments and theoretical consideration).

7. DISCUSSION

Organizational rearrangement is required for innovation in design. Five points should be considered to realize this.

1) Ideal planning.
2)Examination of tasks related to all processes at the upstream stage of design and reflection of the results of examining designs.
3) Reduction in the number of prototypes and minimization of amount of manufacturing.
4) Mechanization of manufacturing and inspection processes.
5) Information sharing and integrated management.

Today is an era of specialization and designers must acquire their own special skills. However, to be a skilled designer, design should be understood not from the limited academic viewpoint but from the viewpoint of industrial problems.

In addition, designers must always understand problems from a broad viewpoint and carefully analyze individual problems derived from their research.

Furthermore, designers are required to make quick timely decisions. Also, cogitation that can shift from realistic thinking to abstract thinking is always necessary. This is because many inspirations occur as a result of abstract thinking.

Designers become creative through such rigorous training and behavior guided by a trained mind.

8. CONCLUSIONSC

Design, which is the origin of all industries, is a world of devising and creating, in which new styles and the innovation of techniques are constantly demanded. Constant effort and diligent study are needed for designers to create designs that can appropriately meet the demands of the present age. It is also necessary to have flexible and unique ideas as well as a challenging spirit to realize such ideas. Young designers are expected to contribute to our society through their skills and ideas and to play an active role in various fields as machine design engineers who form the core of specialists in a technology-based country such as Japan.

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