Utilization of 3D-Viewer in KOMATSU

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"3D project" has come to be widely promoted to shorten development term and improve quality by establishing a concurrent development system with 3-dimensional CAD technology. Particularly, to fully utilize 3D models, the employment of 3D-Viewer is rapidly spreading. It means that 3D models come to be utilized not only in design department but also in many other departments related to development. This report introduces how 3D-Viewer is utilized in KOMATSU and our future vision.

Key Words: *3D-Viewer, 3D-CAD, 3D Project, Design Review, Concurrent Development, Drawing-Less*

1. Introduction

According to recent rapid progress of 3-dimensional CAD technology in both software and hardware, 3-dimensional CAD, which has been applied only to specific duties in a whole design flow or to specific parts of an equipment to be designed, comes to be widely used in design work. KOMATSU began to introduce in earnest 3-dimensional CAD in around 1996 and has been actively promoting "3D Project" to design all equipment by 3-dimesional CAD, centering on the construction machinery that is to be developed newly. Under such circumstances, 3D-Viewer, which enables full utilization of shapes developed by 3-dimensional CAD, is spreading rapidly. This report describes how 3D-Viewer is utilized in KOMATSU and our future vision.

2. 3D-Viewer

As the name indicates, Viewer is a computer application that the chief object of which is viewing. 3D-Viewer is a dedicated application for viewing 3D models developed by 3D-CAD.

To view a 3D model with 3D-Viewer, it is necessary to convert the 3D-CAD model into the data format to which the viewer is adapted. In addition to Viewer specific formats, the general purpose formats that are used to exchange data between different CAD systems (※1IGES, ※2STEP, ※3VRML, ※4STL) are adapted.

Recently, however, new types of Viewer have a built-in direct converter for 3D-CAD and therefore can view 3D-CAD models without data conversion are marketed. (**Fig. 1**)

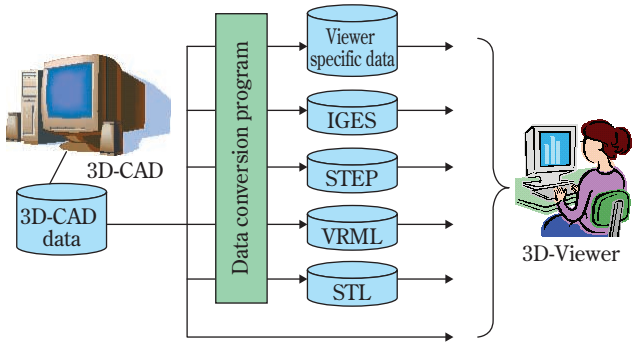

Fig. 1 Data available with 3D-Viewer

The object duties for introducing 3D-Viewer include:

1) Design review in design department
(Check by design managers and the supervisors in charge of drawing check)
2) Productivity examination by design department and production department
(Indispensable tool for concurrent development)
3) Investigation of safety and maintainability by test and research department
4) Cost estimation duties in production and purchasing department

5) Investigation of the workability of assembly and process planning by assembly department
6) Creation of illustrations by material creation department

In the early stage of introducing 3D-CAD, we intended to perform all these duties with 3D-CAD. However, due to difficulties including the high price of 3D-CAD system and the time required to master its operation, it was hard for 3D-CAD to spread beyond the members in charge of design. On the other hand, low-price 3D-Viewers that can be mastered in a short time have been appearing on the market for these several years, and it came to be recognized that these duties can be performed with them. Today, 3D-Viewer is regarded as indispensable for utilizing 3D data and is spreading rapidly.

3. Functions of 3D-Viewer

Main functions of 3D-Viewer are described below: In reality, Viewer functions differ with models. Described below are the basic functions that are possessed by most Viewer models.

3-1 High-speed display of large-scale model

With KOMATSU's standard 3D-CAD, or Pro/ENGINEER (hereinafter called "Pro/E"), the volume of data becomes very large because reference data and historic data are included in addition to profile data (a little under 10 GB for one machine of hydraulic excavator). As a result, it takes much time to display a large-scale model, and models larger than a given size cannot even be displayed. This is resulted from the limit that the OS (operating system) of currently used personal computers cannot deal with 2 GB or greater data because of incomplete adaptation to 64-bit CPU. For construction machinery, automobile and other heavy industry related products (aircraft, etc.), it is impossible to model a whole product while viewing the overall model on 3D-CAD. However, by converting into Viewer data of only profile data, the volume of data can be reduced, and high-speed display of large-scale model becomes possible. (**Fig. 2**)

Taking hydraulic excavator for example, it may take 10 minutes or longer time to display the assembly of several units with Pro/E, while with Viewer, even a whole machine can be displayed within several minutes.

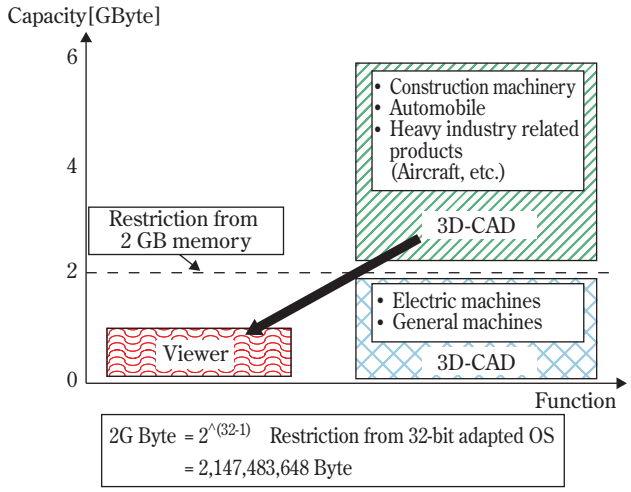

Fig. 2 Restriction on data volume with which OS can deal (Model of one whole product)

3-2 Zoom-in, zoom-out, move, rotate

After display, in order to find parts that need to be checked, zoom-in, zoom-out, pan and other functions are necessary. In addition, the rotate function is useful for 3D models. These functions are most frequently used during operation of 3D-Viewer. They are operated mostly by dragging the mouse. Unfortunately, however, which buttons to use for operation differs with Viewer models, requiring much time for us to master.

3-3 No-showing of specific models

A disadvantage of viewing a 3D model is that we cannot see hidden portions. Therefore, the function of no-showing of specific models (machine cab, etc.) is indispensable. Here, "no-showing" means to make the object temporarily invisible, and it must be possible to immediately restore "no-showing" parts whenever necessary. Today, there are models that have not only the no-showing function but also the transparent display function. (Transparency can be adjusted.)

3-4 Measurement

One of the main purposes to use Viewer is the measurement of dimensions. In addition to the basic function of measuring length, the capability to measure the distance or angle between parts is necessary. Some kind of Viewers displays measured values temporarily, and other models displays measured values using dimension lines, like on drawing. There are also some Viewers that can calculate area, volume, the center of gravity, and the moment of inertia or models that can check interference.

With these measurement functions, we must be careful that they are less accurate than 3D-CAD because of data conversion. Especially, above mentioned STL, etc. requires attention because trigonometric approximation is used for display. For other types, no great error occurs that affects actual duties except on quite rare extraordinary occasions.

3-5 Creating a cross-section

Like the deleting of specific models, the function is necessary that creates a cross-section at arbitrary position in order to view a hidden portions. This function is frequently used to measure a gap by creating a cross-section. Some types allow us to dynamically move the position of cross-section with a slide bar.

3-6 Saving the viewed condition

This function is also called "snap shot" or "thumbnail". This function stores arbitrary state that is set in above 3-2 or 3-3 and call it as needed. When accustomed, we can efficiently perform duties with this function. This function is indispensable especially for creating sketches.

3-7 Markup

When we want to keep the content that is checked with Viewer, we can add a note or a symbol (○, △ or other symbol drawn freehand) with the function called "markup". Markup on 2D (image) and 3D markup that is interlocked with model are provided. Though it resembles 3-dimensional note, which is described later, it is essentially temporary memo writing.

4. Types of 3D-Viewer

4-1 Simplified 3D-Viewer

Of Viewers, those with only the functions described in 3-1 to 3-3 are referred to as Simplified 3D-Viewer. As they have only view functions, they are hardly used in practical business. They, however, are mostly provided free of charge and evaluated as a tool for beginners.

Recently, a high-precision and high-compression format called ※5XVL is drawing attention, but it requires longer time to extract because of higher compression ratio, and problems, such as data volume becoming larger, are reported, so that its application is limited to specific fields.

4-2 Middle-range 3D-Viewer

The viewers that have all the functions described in 3-1 to 3-7 are referred to as Middle-range 3D-Viewer. 3D-Viewer generally means middle-range 3D-Viewer. The price ranges from approx. 100,000 to 400,000 yen.

4-3 High-performance 3D-Viewer

The 3D-Viewers that have not only all the functions described in 3-1 to 3-7 but also the capabilities of simulation, including VR (virtual reality) and DM (digital mock-up), are referred to as High-performance 3D-Viewer. It is used to evaluate the design, riding comfort and operability of automobile, etc. For construction machinery, CAT and JOHN-DEERE have applied it to VR for stereoscopically viewing the visibility from operator's seat or the movement of work equipment. The price ranges from one hundred thousand to as high as several hundreds million yen. (**Fig. 3**, **Fig. 4**)

5. Utilization of 3D-Viewer in KOMATSU

Examples of utilizing 3D-Viewer in KOMATSU are introduced below:

5-1 ProductView

This is a middle-range Viewer provided from PTC, the manufacturer and dealer of Pro/E. As this viewer is low-price and fully equipped with useful functions, it is widely used in KOMATSU. Sample applications include: design review by design department, the investigation of safety and maintainability by test and research departments, and productivity examination by design and production departments. The system to automatically convert Pro/E models into ProductView data at night is established, contributing to concurrent development. (**Fig. 5**)

5-2 ProductViewLite

Like ProductView, this is a product from PTC. It is used on Web and therefore not suited to large-scale models, but can sufficiently work for parts on ordinary OA personal computer. Because dimensions on drawing come to be omitted due to the introduction of simplified drawing, this system is used to measure dimensions by production, purchasing and quality assurance departments.

The system to automatically convert Pro/E data into ProductViewLite data (data format is the same as ProductView) by the following day of the release of drawing is already established. As multiple licenses need to be purchased as a batch, this system costs approximately 20,000 yen per license. Namely, it is a very cheap Viewer. It is almost equal to middle-

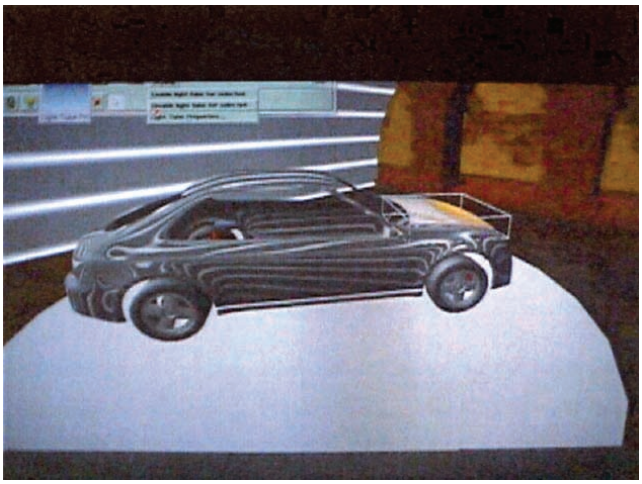

Fig. 3 Automobile design evaluation (zebra curve)

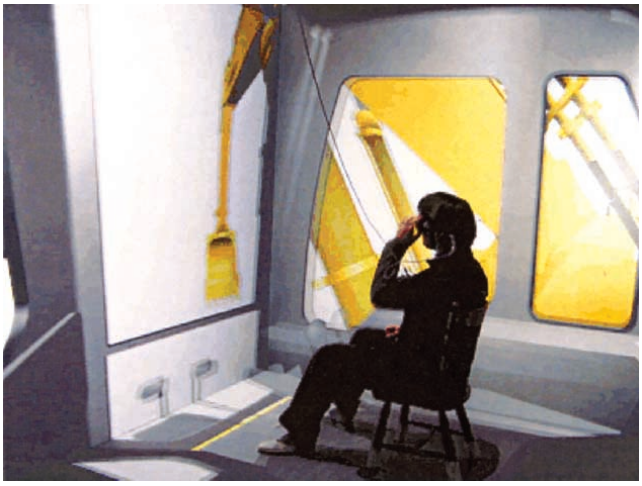

Fig. 4 Stereoscopic view

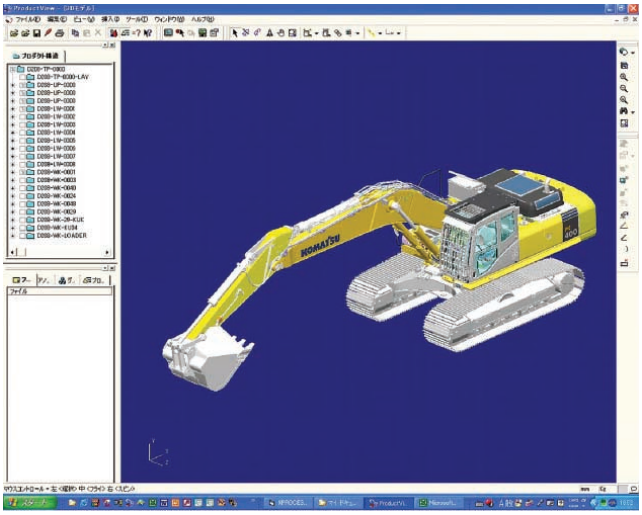

Fig. 5 ProductView

range Viewer functionally, but we cannot but feel insufficiency. (**Fig. 6**)

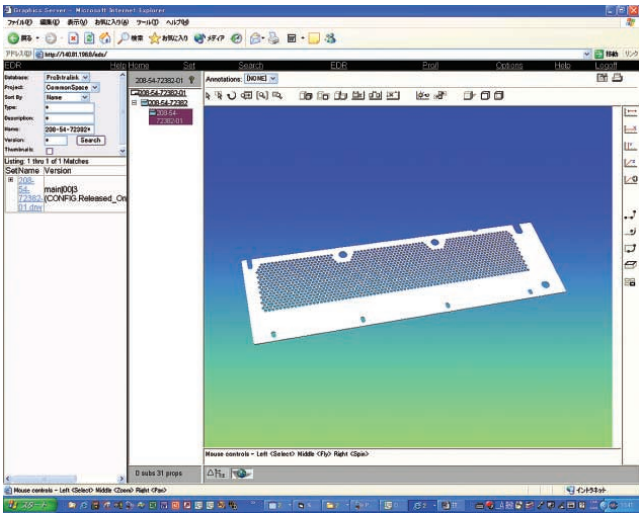

Fig. 6 ProductViewLite

5-3 VridgeR

This is a middle-range Viewer provided from DIPRO. It is so devised as to enable customization by user as well as easy change of the structure of model. These advantages are fully utilized mainly by assembly department to investigate assembly procedure, process planning, etc. It also facilitates the preparation of assembly/disassembly manual, and used by the department in charge of documentation. In both cases, main objects are to investigate assembly/disassembly works and keep the result as image data.

Also for VridgeR, the system to automatically convert Pro/E models into VRML data at night is established, contributing to concurrent development. (**Fig. 7**)

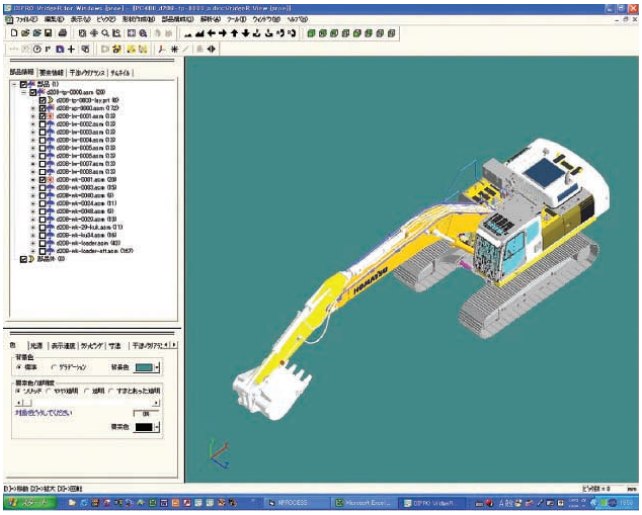

Fig. 7 VridgeR

5-4 VisView/Pro

Concerning 3D-CAD, Komatsu Forklift Co., Ltd. uses Unigraphics (hereinafter called UG) in addition to Pro/E, where VisView/Pro (Central Visualization Professional) for UG corresponds to ProductView for Pro/E. VisView/Pro is almost the same as ProductView in functions, price and usage. (**Fig. 8**)

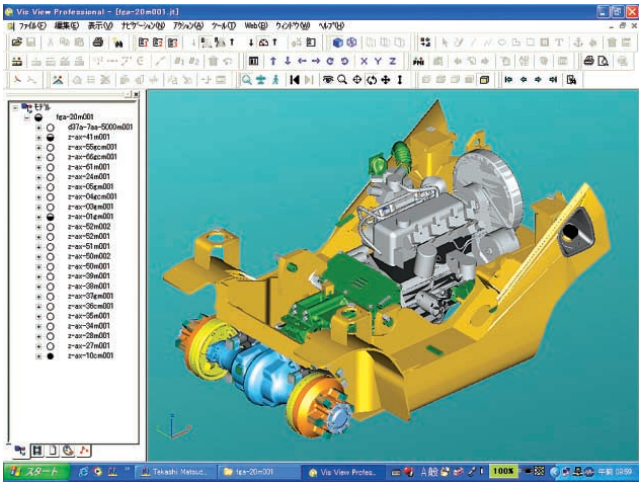

Fig. 8 VisView

6. Future 3D-Viewer

Today, 3D-Viewers are almost complete functionally. In the future, their price will be lowered to expand application fields. On the other hand, Viewer will be used from the needs completely different from that of today. Namely, “drawing-less” application.

The subject “drawing-less” has been discussed for a long time, but even when the linkage with CAD/CAM progresses, information other than profile data must be described on drawing. True “drawing-less” manufacture has been limited to mold parts that can be manufactured if we have only the profile data.

Recently 3D-CAD systems with the function of 3-dimensional note are increasingly brought to the market. They are defined as an effective tool toward “drawing-less” manufacture. It is said that notes indicated on drawing can be eliminated by adding them directly to 3D models. With this system, it may be possible to manufacture products without drawing, using the 3D models to which 3-dimensional notes are added. 3-dimensional note, however, is the function that works only within the CAD system and does not work when the data is transferred to 3D-Viewer or other CAD system.

Recently, the field of “3D drawing” was established in various standard organizations, such as ※6ANSI and ※7ASME, and various activities were started to improve the quality of data exchange among different CAD systems. Especially, Pro/E conforms to ASME Y14.41 and is said to become able to display 3D models in the future, to which 3-dimensional notes created with ProductView are added. (**Fig. 9**, **Fig. 10**)

Then, “drawing-less” manufacture will be promoted further, 3D-Viewer will become indispensable to view 3-dimensional drawing, and Viewer will spread more widely in the future.

Future image of drawing-less manufacture

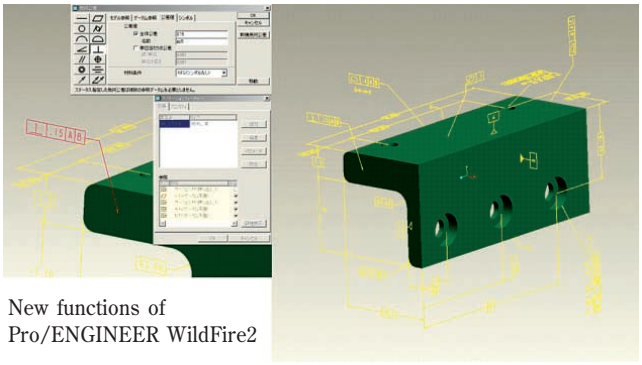

Fig. 9 3-dimensional drawing

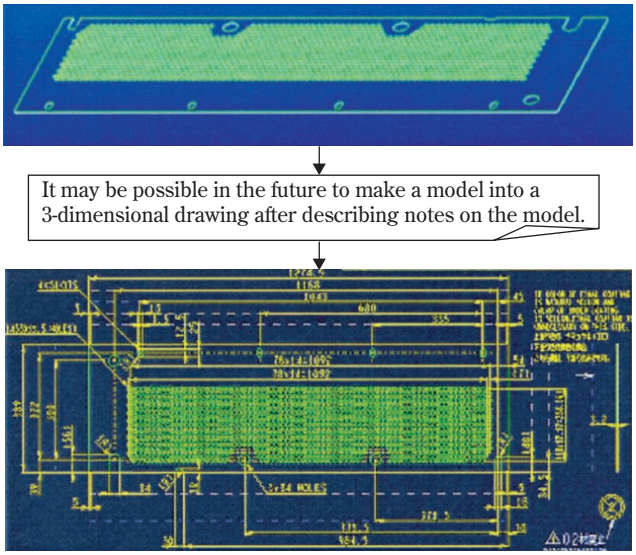

Fig. 10 Displaying drawing on Viewer may be possible in the future.

References

1) "Engineer's Handbook", Nikkei Business Publications, Inc.

※1 IGES: Abbreviation for Initial Graphics Exchange Standard
One of the intermediate file formats used to exchange data between different type CAD systems, established by ANSI. Because supported by many CAD software, it is in reality world standard.

※2 STEP: Abbreviation for Standard for the Exchange of Product Model Data
International standard for product data exchange, now being progressed by ISO. Its objects include not only CAD shape data but also all types of data, such as NC data, B.O.M. (Bill of Material) and material.

※3 VRML: Abbreviation for Virtual Reality Modeling Language
Description language for 3-dimensional graphic data. The specifications were determined on condition that it is used on Internet browser. VRML2.0 became ISO

※4 STL: Abbreviation for Stereo Lithography
Standard format for input to optical shaping system. It expresses the surface of solid model as a group of small triangle.

※5 XVL: Abbreviation for extensible Virtual reality description Language
Developed by Lattice Technology, Inc. A file format for expressing 3-dimensional shape such as CAD and polygon on Web.

※6 ANSI: Abbreviation for American National Standards Institute
Nonprofit organization for establishing industrial standards in USA. It is also a member of ISO.

※7 ASME: Abbreviation for American Society of Mechanical Engineers
Private association for promoting activities for standardization and qualification based on established standards, centering on the field of mechanical engineering

Introduction of the writers

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[A few words from the writers]

KOMATSU began to introduce 3D-CAD in around 1994 when there was no concept of 3D-Viewer. For these several years high-function low-price 3D-Viewer systems have been marketed one after another, promoting the employment of 3D system in development stage. So, our concept of future 3D-Viewer may be realized in a near future.