A Proposal of the Topology CAD and CAE Integrated System for the Next Generation∗

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3D-CAD system is needed for the Designing of plastic processing products that are required art-design. But the current use Boolean 3D-CAD system takes too much man-power of the operation, and design engineers can not use it directly. And this situation have made the degeneration of the design technology. We have developed the new topology-CAD system as next generation-CAD. Also the current CAE system has the same problems as CAD. And so, the design engineers depend on the out-source-technology. We have also developed the new genera-use-CAE system integrated in the Topology-CAD using particle analysis.

Key Words: CAD, CAM, CAE, FEM, Modeler Topology, Boolean Trimming, Fillet Transform

1. Introduction

3D-CAD system is required for the design of plastic processing products. And the modeling technology of CAM system for die engineering have preceded in system development. But it takes too much men-power to be used for design engineers. At first the draft of CAD development had made on the Topology-CAD (Manifold-CAD), but it was not succeeded. Then the Boolean CAD technology was introduced from the CG technology. The first system named CGS-Solid-system is used in short period and B-Rep-Solid-CAD have toke the part.

Solid-CAD define the basic feature by the Boolean operation of primitive elements and it requires the sequence of Boolean-operation to define the 3D-model and it takes very large data volume. B-Rep-Solid is defined by the surface boundary using trimmed surface and it has some error in connection. And the Boolean operation has something like machine processing but the object of 3D-CAD is the design of plastic processing products. I think the Topology-CAD we have developed is the honest solution for the requirement.

The first prototype of Topology CAD/CAE integrated system had been developed on the DOS-V PC reinforced by the back end Parallel-Transputer-System(1) in 1990. And, the present system have been developed on the Windows/PC.

2. Basic Function of the Topology CAD

Using Topology-CAD, we can define the model by transformation of the basic topology model or the preceding design model and reduce the rots of design power (Fig. 1). This function is also useful for the process design of the plastic processing products such as press and forge and we can use the same topology to the process design (Fig. 2).

One of advantage of Topology-CAD is that the continuity of the surface element is preserved and filet curve is automatically defined in the transform operation. These functions reduce the power of design operation to 1/10 of current CAD and CAM.

Next advantage exists in the principle of topology graphics. Generation of living body may depends on the rule of topology and they can be defined by vary small data size (Fig. 3). And this characteristic of topology-CAD is

Fig. 1 Example of connection rod design transforming the basic plane topology (Filet shape and extraction slope are defined automatically)
hold on the rationally designed plastic processing products, and sometime reduce the data size to 1/100 (Fig. 4).

3. The Capability of Topology-CAD (tpCAD) Original Surface

Figure 5 shows the same topology models and the capability basically depends on the functions of tpCAD original surface. Figure 6 shows the relational definition function of the surface and the child feature on mother patch is defined without error of C0 and C1 continuity. And the child feature can slide on mother patch. The mother patch can be transformed to circular patch keeping the relativity of child patch.

The surface is used in the current CAD systems that have high degrees of freedom. And sometimes, it takes many men power for the amendment of the waves form of surface (fairing operation). We can reduce this power for fairing by the use of relational definition function of tpCAD.

Figure 7 is an example that shows the pliability of tpCAD surface and a blade of axle fun is generated from a patch that is defined on axis corn that is divided to 2 × 3 patches.

4. tpCAD Original Graphic Render Function

We have developed original rendering function that we say real-render. Figure 8 shows an example of real-render with current polygon render. Real render depends on the point cloud that has vertical vectors to the surface and the processing load is in proportion to the rendering
area, but the road of polygon render depends on the number of polygon. And the each rendering load are nearly equal in the examples of tire model (On the note PC). We think the rendering technology of next generation will be the real-render accelerated by hardware logic.

The point cloud data of real-render is used for the NC cutter pass generation of CAM system in tpCAD.

5. CAE-Function-GOKU of tpCAD

CAE function should be integrated in CAD system. Because the main task of design engineer is not design drafting but design analysis. And Finite Element Analysis is one of the most important computer oriented technology but it takes many man powers for the operation. And so, design engineers inevitably depend on the out source. This trend of technology makes deteriorate the ability of design engineers. Still more, the CAE-analysis technology is limited within the current application programs, but we need to apply analysis technology on the new unknown application field before the current analysis tools have been developed.

CAE-GOKU we have developed, reduce the man powers of making the analysis model and automatically generates the analysis program from the definition language that define the target model. Language of GOKU consists of two Languages CSSL++ and DEML. We define the dynamics of element by CSSL++ and define the finite element model by DEML. GOKU-Purser decipher the meaning of definitions and GOKU-Generator generate the analysis cord. Figure 9 shows an example of Finite Element Model using particle method and Fig. 10 shows an example of plastic deformation analysis.

6. Reverse Engineering Function of tpCAD

Whole 3 degrees expression of tpCAD original square patch has 48 freedoms and it can be fitted to the measured surface point data that is minimizing the square sum of errors (Fig. 11). We can get the fair design surface from the measured data that has errors and this function is effective for the reverse engineering such as the revival of historic technology.

7. Conclusion

CAD system is not only the design tool but also the basic culture of human society. And, it should have all round capability including the possibility of evolution. We are convinced that Topology-CAD (Manifold-CAD) has
excellent nature for the CAD of next generation and is able to include all most all merits of current Boolean Solid CAD. Only one problem is that the idea of Topology-CAD is not familiar and the preconception of current Boolean-Solid-CAD refuse the new culture emotionally. We are planning to develop the systematic theory of Topology-Graphics for the base of Topology-CAD.

References