Research and Application of Autodesk Fusion360 in Industrial Design

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Abstract. In 2016, Fusion 360, a product introduced by Autodesk and integrating industrial design, structural design, mechanical simulation, and CAM, turns out a design platform supporting collaboration and sharing both cross-platform and via the cloud. In previous products, design and manufacturing used to be isolated. In the course of design, research and development, the communication between designers and engineers used to go on through different software products, tool commands, and even industry terms. Moreover, difficulty also lies with the communication between design thoughts and machining strategies. Naturally, a difficult product design and R & D process would trigger a noticeable gap between the design model and the actual product. A complete product development process tends to cover several major areas, such as industrial design, mechanical design, rendering and animation, computer aided emulation (CAE), and computer aided manufacturing (CAM). Fusion 360, a perfect design solving the technical problems of cross-platform data exchange, realizes the effective control of cross-regional collaboration and presents an overview of collaboration and breaks the barriers between art and manufacturing, and blocks between design and processing. The “Eco-development of Fusion360 Industrial Chain” is both a significant means to and an inevitable trend for the manufacturers and industrial designers to carry out innovation in China.

1. Background and Significance of Research

(1) Development Trend of Multi-disciplinary Integration. Fusion, literally referring to combination, does integrate a lot of correlated techniques. For example, it fuses Windows and Mac, mixes direct modeling with parametric modeling, integrates T-Splines modeling and B-Rep modeling, and absorbs desktop software into cloud computing, a term commonly pointing to 360. Fusion 360, a perfect model integrating parametric modeling and direct modeling, both preserves the flexibility of direct modeling in industrial design, and caters to the consideration of modeling history and parametric control which the structural design requires. Designers can complete the entire product development process on Mac and PC and carry out data exchange between the two systems. As a result, the cooperative work among team workers could be realized at any time, in any place, and via any device.
2 Feature of 3.0-era Design. With the transformation of China's economy from “manufacturing” into “creation”, the effect of design innovation is more and more prominent. It is changing our lives in a unique yet firm way. As is stated by Academician Lu Yongxiang, the former dean of CAS and vice president of the Standing Committee of the National People's Congress, in the third wave of industrial revolution, “innovative design” will lead the sustainable development of civilization, green, intelligent, sharable and featured by informatization and network. China needs to set as a significant strategy the promotion of its innovative design capability so as to enhance innovation-driving, accelerate transformative development and build an innovative country. Design by China should lead the global developmental trend and step into the design 3.0 era. “1.0 era refers to the traditional design in the agricultural society, 2.0 indicates the modern design in the current industrialized society”, Academician Lu Yongxiang explained, “while by 3.0 is meant the innovation destined to emerge with boom of design and material innovation in the global knowledge network”.

2. Functional Modules in and Analysis of Autodesk Fusion360

Fusion 360, a product introduced by Autodesk and integrating industrial design, structural design, mechanical simulation, and CAM, turns out a design platform supporting collaboration and sharing both cross-platform and via the cloud. As is shown in Fig. 1, Fusion360 comprises several working environments and modules: modeling, molding, surface patching, rendering, animation, simulation, CAM, drawings and so on.

![Figure 1 - Function Module of Fusion360](image-url)

(1) Modeling. A salient feature of the direct modeling in Fusion360 is the visibility of outcomes. The direct modeling technology enables users to perform follow-up modeling upon models both featured and non-featured (such as the nonparametric models acquired by other CAD systems). In the whole process, any modification or addition makes no difference to the establishment of models.

(2) Rendering. Fusion 360 could visualize your product model basing on cloud computing. That is to
say, your models could acquire a photo-level effect via the real-time ray tracing, rendering engines or powerful cloud rendering.

(3) **Connecting Assembly.** Fusion 360 supports the connection-based assembly technology, a method easy to apply. Traditional practice tend to include too many meta-constraints that would affect the using effect, while the method mentioned in this paper deals with assembly from the opposite direction, or the freedom of parts. The higher the degree of freedom is, the less constraint emerges, and vice versa. The introduction of this assembly into a large model can greatly reduce the number of meta-constraints and promotes the efficiency of design.

(4) **Animation.** The animation module in Fusion 360 is a key-frame one. Its working environment includes commands concerning a series of subjects, such as storyboards, changes of commands, labels, views, and release. Drag the slider on the animation timeline to manipulate the model, and users could record the key-frame animation.

(5) **2D Drawings.** When generating 2D drawings associated with 3D models, 2D drawings will be automatically updated when there are any updates occurring in the 3D model.

(6) **Simulation.** When detecting with Fusion simulation and animation, users can find the weakest place in the model. Notable time and resources would be spared once users could fully understand or clearly learn the designed work before its delivery. Fusion 360 is equipped with a kinematic pair, used to simulate the operation of the equipment under a certain power or drive so as to verify the reasonability of the design.

(7) **CAM.** Fusion 360, perfectly combining parametric design, variable design, feature modeling technology with traditional physical and surface modeling capabilities, realizes computer-aided manufacturing (CAM) and makes processing more integrated and computation more accurate. It could perform an automatic control and optimization upon a CNC machining, while providing tools for users to carry out a secondary development.

(8) **3D Printing.** Users could directly configure 3D printing strategy in Fusion 360, output models and print them with a 3D printer. Fusion 360 supports 3D printing utility tools of Spark platform, Autodesk Print Studio, and will also integrate Ember3D printers directly.

3. **Comparison and Example of Modeling**

(1) **Parametric Modeling.** Top-down design: break the model into main components, and decompose main parts into sub-components and parts. In the process, the link between various sub-components and the assembly methods should be clarified and agrees with the overall design conception of the model. This method adapts to the frequent modification of the product and agrees with the design concept of products.

Bottom-up design: initially determine the detailed information of the parts, gradually complete the sub-components, then assemble the main components, and eventually finish the design of the entire product. This method cannot fully reflect the design conception and increase the chance of design conflict or even errors, thus lacking in flexibility. This method applies to those designs not requiring frequent modification, such as the middle- and late-stage. It is a widely-employed design method.

Fusion 360, incorporating both top-down and bottom-up parametric designs, supports skeleton models, components borrowing, and a distinctive segmented modeling methods.
(2) **T-Splines Modeling.** T-Splines modeling is a new modeling technique with the characteristics of NURBS and subdivided surface modeling techniques. As is shown in Fig. 2.

![Fig. 2 Comparison of Parametric Modeling and T-Splines Modeling](image)

(3) **Comparison of T-Splines and NURBS Modeling.** Fusion360 kernel is ACIS (a branch of Autodesk), but Autodesk integrates the T-Splines kernel in this kernel. If there is a better modeling technique than NURBS modeling, that must be T-Splines. Compared with NURBS, T-Splines, greatly reducing the number of surface control points in the model, fitting location subdivision and raising the speed of modeling, is the very technology that can replace NURBS modeling.

Fig. 3 respectively illustrates the chairs generated by T-Splines, NURBS, and Mesh from left to right. After a comparison, it could be readily found that the T-Splines parting line is sparse and even distributed, and the quality of the model surface is much better.

![Fig. 3 A Comparison of T-Splines modeling, NURBS, and Mesh](image)

4. **Cloud Rendering and Local Rendering**

Each 3D modeling software is equipped with its own rendering tools, simple or complex, realistic or suitable for 3D and 2D rendering. Different ones cater for different needs and have their own merits. Fusion 360 is no exception. In addition to a huge rendering material database, the current version has two rendering methods, local Ray Tracing rendering, and cloud ShowCase 360 rendering.

Fusion360 also supports the inner rendering of canvas, a process referring to the real-time rendering of scenes. Fusion360 would perform continuous rendering and iteration, which gradually renders the rough scene delicate. As is shown in Fig. 4, what lies in the lower right corner of the view is the action bar for rendering time, progress, iteration, and quality.

![Fig. 4 Rendering Progress](image)

Rotate the view angle, and the software shall recalculate the rendering. Some rendering settings are software-defaulted, while others can be manually selected by commands. Figure 5 provides a comparison of the quality of the canvas, iterations, and the actual rendering effect in different stages.
|    | Begin | 2 S | 1% | 0 | Ordinary |
|----|-------|-----|----|---|-----------|
| Middle | 43 | 10% | 4 | Good |
| Later  | 510 | 70% | 41 | Great |
| End    | 1200 | 100% | 152 | Perfect |

Fig. 5 RenderingComparison

5. Design and Animation of Component Assembly Based on Connection

In the process of assembly design, a project manager, once being imported necessary information in, can automatically generate the list of assembly parts, and realize the driven assembly of mechanical components under constraints. When assembling parts in the same design environment, we can assemble parts based on the same coordinate point, and set various types of joints, such as swivel, sliders, cylinders, pin troughs, and spheres. The user can also set the movement limit of the joint and make precise configuration of the numerical settings for moving, so as to realize a real-time preview of the movement. Fusion 360 assembly commands render a very clear picture of the relationship between parts, and help produce assembly animation when consulting the animation modules.

The assembly system in Fusion 360 provides seven kinds of contact movement: rigid, rotating, sliding, cylinder, pin slot, plane, and ball. The production of assembly animation runs as follows:

Fig. 6, illustrating the assembly design of Flash Disk, renders a clear picture of the assembly relationship of components.

Fig. 6 Flash Disk Assembly Design

6. Simulation Analysis

In Fusion 360, a typical CAE process includes pre-processing, solving and post-processing steps. In the pre-processing phase, the designer would model the physical properties of the geometry (or expressions represented by the system), the design process and the environment by imposing loading constraints upon. Then, solve the model with appropriate mathematical formulas concerning basic physical field. In the post-processing phase, the results are to be presented to the designer for viewing.

The merit of Fusion 360 simulation lies with the reduced costs for product development, shortened development time and improved product quality and durability. Moreover,
users could tailor their design decisions based on the impact of design on performance. The use of computer simulation in prototype testing can not only save time, efforts and funds, but also guarantees a correct assessment and optimization of the design.

Fig. 7 shows a static stress analysis with a buckle model made by the author. The results can be viewed through the cloud and grid.

| Static Stress Analysis Results of Buckle Model |
|-----------------------------------------------|
| Displacementcloud | Stress Cloud | Grid |
| ![Displacementcloud](image1) | ![Stress Cloud](image2) | ![Grid](image3) |

Fig. 7 Static Stress Analysis of Buckle Model

Fusion 360 simulations can show the performance in the early stage of the development process when the cost of alteration and modification minimizes.

7. CAM and 3D Print

(1) **CAM.** A host of processing techniques is set in the Fusion 360 CAM work environment, such as 2D processing, 3D machining, drilling, multi-axis, and turning. As Fusion 360 is still in the development phase and updates are launched every three weeks, multi-axis machining is just been placed in the toolbar and the two orders for the side-edge processing and multi-axis contours are not perfect.

1) 2 axis / 2.5 axis Processing. CAM in Fusion 360 includes machining simulation, and CNC programming.

The CAM in Fusion 360 can share the same recognized CAM kernel HSMWorks and Inventor HSM™, quickly complete, shorten the development cycle, calculate the optimized tool path, reduce the abrasion of machines and tools, and produce the best finished parts. 2D processing can perform drilling, external and interior contour processing, and surface processing.

2) 3-axis Machining. Exploiting the 3-axis machining technique, it can generate 3-axis machining paths and strategies, including rough, semi-finishing and finishing processing.

3) Processing Simulation. Possessing a good processing simulation system, it can generate a processing animation, used to observe processing.

The following figure made a 2D milling and 3D milling comparison.

Fig. 8 2D and 3D Millings

At present, there are more than 1,000 kinds of numerical control system, among which the ones commonly used in China are Fanuc CNC system of Japan, Siemens CNC system of Germany, DMG CNC system, Haas, CNC system, the Chinese CNC system, and so on. Fusion360 can support hundreds of current CNC systems including Farrah, Siemens, DMG, Haas, and so on.

As post-processing files are targeted, different software and CNC machine tools require their own
file format and suffix. Therefore, users of Fusion360 can select and generate the type of post-processing files according to the specific type of CNC system and view G-codes.

(2) **3D Printing.** Fusion 360 can be easily employed in 3D printing software utilities, such as Autodesk® Print Studio, which is supported by Spark. This software prepares users to communicate directly with Autodesk Ember™ 3D printers.

As is shown in Figure 9, if the print model does not match, the entire model in the scene will show a red color, a signal indicating “error” in Print Studio. On the contrary, a blue model indicates that the model works well. Print Studio also provides the function of model analysis and repair.

| Correct Model | Wrong Model |
|---------------|-------------|
| ![Correct Model](image1) | ![Wrong Model](image2) |

**Fig. 9 Correct Model VS Wrong Model**

8. **Conclusion and Outlook**

In summary, Fusion360, realizing the integration of design and manufacturing, rendering and analysis, cloud computing and collaborative management, and supports more than 50 document formats, making it ideal for the design and development of small products. Currently, with widely encouragement of innovation in the whole society and each field, the “Eco-development of Fusion360 Industrial Chain” is both a significant means and an inevitable trend for the manufacturing and industrial designing to carry out innovation in China.

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