

Research on Intelligent Layout of Door Hinge Based on CATIA CAA

Jingru Bao, Yi Ding, and Sibbo Hu
BAIC Motor Co., Ltd., BATC

Ping Hu
Dalian University of Technology

ABSTRACT

As one of the most important auto-body moving parts, door hinge is the key point of door design and its accessories arrangement, also the premise of the door kinematic analysis. We proposed an effective layout procedure for door hinge and developed an intelligent system on CATIA CAA platform to execute it. One toolbar and five function modules are constructed - Axis Arrangement, Section, Parting Line, Kinematic, Hinge Database. This system integrated geometrical algorithms, automatically calculate the minimum clearances between doors, fender and hinges on sections to judge if the layout is feasible. As the sizes of the clearances are set to 0s, the feasible layout regions and extreme start/end points are shown in parts window, which help the engineer to check the parting line and design a new one. Our system successfully implemented the functions of five modules for the layout of door hinge axis and parting line based on a door hinge database. An instance is carried out and the result shows that our system has great feasibility and validity to arrange the door hinge and shorten the design periods.

CITATION: Bao, J., Ding, Y., Hu, S., and Hu, P., "Research on Intelligent Layout of Door Hinge Based on CATIA CAA," *SAE Int. J. Commer. Veh.* 7(1):2014, doi:10.4271/2014-01-0753.

INTRODUCTION

The arrangement design of door hinge is a multi-factors, exploratory and trial and error progress, which needs lots of expertise and experiences to be implemented. The increasing individuation of customer demands and fierce market competition has driven automotive companies to speed up the development of new products. Intelligent CAD design tools and systems are powerful means to shorten the design cycle, which can transform some burdensome efforts into automatic operation, and helps to raise working efficiency by reducing the workload of manual design. On the other hand, the existing data and models are commonly wanted to be reused to reduce the costs of design and manufacture, that is, the development of generalization. Therefore, it's necessary to establish a database to help guide the design process for automotive industry. The secondary development based on CAD software customizes the specialized tools for user, which makes the software more effective and targeted. As one of the most popular common software, CATIA has been applied widespread to auto industry, while its secondary development technique getting more attention. Skarka presented a method of generative model creation in CATIA system [1]. König and Wintermantel presented an Evolutionary Algorithms that directly relies on the representation of mechanical structures and implemented this approach in CATIA V5 [2]. Zhang and Huang developed customized systems on CATIA for database

and parametric layout of door accessories [3, 4]; A TUW system of trimming line unfolding and flanging simulation based on CATIA for automotive panel was developed making full use of the function of property customizing of CATIA [5]. Hu studied the influence of master section parameters on the vehicle body performance, set up parameterized models and developed a measure tool for parametric master section based on CATIA CAA [6]. Zhang proposed a parametric design method of globoidal cam based and realized the 3D modeling of globular indexing cam by using CATIA CAA [7]. At present, construct system based on CATIA platform for parts design and analysis to implement intelligent design with the application of expertise and experience has become a new development direction of improving CAD technique with CATIA applications.

In this paper, an intelligent layout system for door hinge based on CATIA CAA is developed. We first introduce the component techniques of CATIA CAA in [Section 2](#), followed by a layout procedure of hinges after collecting and summarizing the experiences from engineers about how to arrange the hinge model in [Section 3](#). [Section 4](#) illustrates the five modules, "Axis Arrangement", "Section", "Parting Line", "Kinematic", "Hinge Database", which are created to constitute the system. Geometric algorithms about clearances calculation and parting

line are involved in Section 5. Finally, a door hinge instance is carried out and the intelligent layout system is verified to be effective.

SECOND DEVELOPMENT TECHNIQUE OF CATIA CAA

CATIA(Computer Aided Tri-dimensional Interface Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systemes. Commonly referred to as a 3D product lifecycle management software suite, CATIA supports multiple stages of product development, from conceptualization design, manufacturing, to engineering realization. CATIA has been widely employed to variety of industries, from aerospace and automotive, industrial equipment, to shipbuilding, architecture and construction. Many automotive companies, such as BMW, Daimler, Toyota, Ford, Hyundai, and Volkswagen, use CATIA varying degrees for car structures design, structure optimization, performance analysis, and development because of its excellent capabilities of modeling, analysis and customization.

CATIA offers a solution to model complex and intelligent products through the systems engineering approach. It covers the requirements definition, the systems architecture, the behavior modeling and the virtual product or embedded software generation. CAA (Component Application Architecture), a component object model (COM)-like interface, can adapt CATIA V5 using JAVA and C++ programming languages. As component-based software platform, COM has better module independence and extendibility, which makes the development framework clearer and reasonable, easy to maintain, develop and extend.

CAA implements the second development of CATIA by RADE (Rapid Application Development Environment) and API (Application Program Interface) interface programs. RADE is a visualizing development environment integrated in Microsoft Visual Studio VC++, which provides a set of integrated programming tools; CAA V5 C++ API is the application interface of CAA V5 C++. Dassault Systemes provides a set of CAA APIs, its methods, tools and interfaces are used for operating objects and be helpful to reduce the workload while improve the quality of products.

CATIA Geometric Modeler (CGM) is a complete software package for the development of applications with a need for 3D geometric modeling capabilities, and which want to take advantage of the power of the CATIA modeler and its solid, surfacing and wireframe capabilities [8]. CGM mainly offers objects that have a geometric or topological meaning such as curves, surfaces or topological bodies, which are grouped into the CATICGMObject interface, and also provides CATICGMContainer interface to manage the membership of the object instances to a given container while the CATGeoFactory interface creates the geometric instances inside a container. CATDialog is another common API for development. Dialog

framework includes two main class types: containers and components. The containers are used to contain several dialog components and to handle them as a whole, while the components are the dialog objects to let the user interact with application. All these classes derive from the abstract class CATDialog which includes methods to define their common behavior and attributes. In addition to the APIs above, the CATApplicationFrame is necessary in this paper. Workshop and workbench are created by using the API and gather a CAA V5 document associated with its own editing tools. Add-ins allows arranging commands in menus and toolbars that make up the workshop and workbench without rebuilding shared libraries and DLLs.

TRADITIONAL DESIGN METHOD FOR HINGE LAYOUT

Automotive companies accomplish the design and development of door hinge in cooperation with suppliers. For cost saving, a prior consideration is to select parts in an internal database contains developed models. Take the surrounding structure factors into account before arranging hinges, such as the ergonomic dimensions, vehicle body width, surface styling, and the relative positions between parts. Figure 1 shows wanted layout relations between front hinge and surroundings.

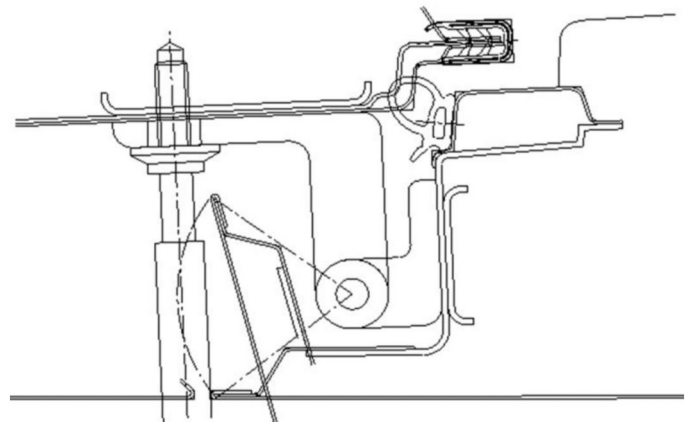


Figure 1. Relations between front hinge and surrounding parts

Door is suspended in pillar by a couple of upper and lower hinges. When the door is closed, the weight of the door and forces act on the two hinges, locks and latched system which fixed in the doorframe, while all forces are on hinges in the open state. As a consequence, force analysis of hinges and interference checking are indispensable.

Projects for development need to accumulate valuable practical experience to locate hinges. CAS (Computer Aided Surface) and door hinge models are prerequisite for locating in general, with an offered parting line to assist the design sometimes. The layout design of hinge focuses on axis arrangement, parting line and section analysis. Hinge axis arrangement influences the swing track of door, which can be checked at the preliminary design stage. Sufficient

clearances between structure parts are required to ensure the feasibility of the styling and avoid interference happening between door edges and surrounding parts (such as fender and front door, door and pillar), or between the front and rear door, and also helps to design the dimensions of pillar. During actual design procedure, the layout design should keep the following principles:

1. The hinge axis should be arranged away from the front part and close to the rear part. The more outward the axis moves, the less likely interference happens. However, the curving and slanted side surface will limit the movement of axis.
2. When it is permitted by structure, the distance between the upper and lower hinges should be set as long as possible to improve the stress condition and prevent doors from sagging. In practice, restricted by surrounding parts, such as external style, A pillar, B pillar, the space is not sufficient to make the distance longer. Experience shows that the ratio of the hinge spread to the door length should be not less than 1/3.
3. The hinge axis makes angle within 2 degrees both inward and backward to ensure that the door will automatically shut down when it is open. Meanwhile the lowest point in the door should be higher than the height of curb during the opening process.
4. The common range of maximum open angle of door is 65 degree to 70 degree. The comfort of getting on and off the vehicle, the convenience of closing the door when sitting in the vehicle, and interference between door and surroundings should be considered. As required, the maximum open angle of hinge has eight more degrees than the one of door. Interference can be checked between door and surrounding parts after the arrangement of axis.

The minimum clearance is checked by analyzing a series of swing diagrams, the procedure can be summarized as follow steps:

1. Arrange hinge axis;
2. Capture several sections perpendicular to hinge axis at key positions;
3. Mark the axis position at every section;
4. Draw panels and swing tracks;
5. Clearance analysis.

The relative position of door and door frame is up to door hinge assy, so the assembly location of hinge should be allowed to be adjusted in the directions of body coordinate axis. Besides, the manufacture deviation of the parts and painting dimension should be counted.

Figure 2 and 3 illustrate the analysis principle of kinematic clearance between the parts. Manufacture deviation of front door (a , b), and the depth of impacting on front door (c), are considered in the interference checking diagrams. When the

minimum clearance is positive and greater than a wanted value, engineers judge that there is no interference. As has taken all the factors of influence into account, the analysis result could be considered as feasible.

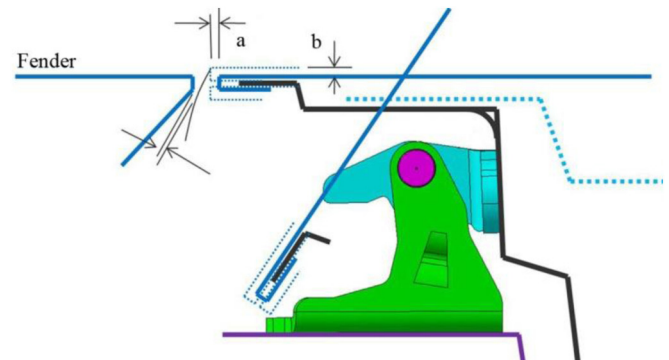


Figure 2. Swing solution diagram of front door

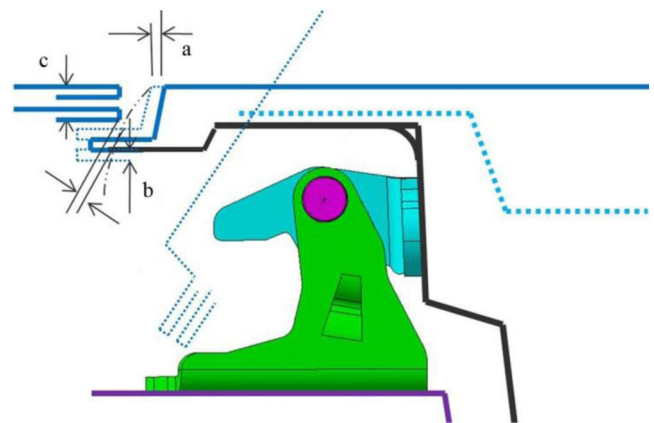


Figure 3. Swing solution diagram of rear door.

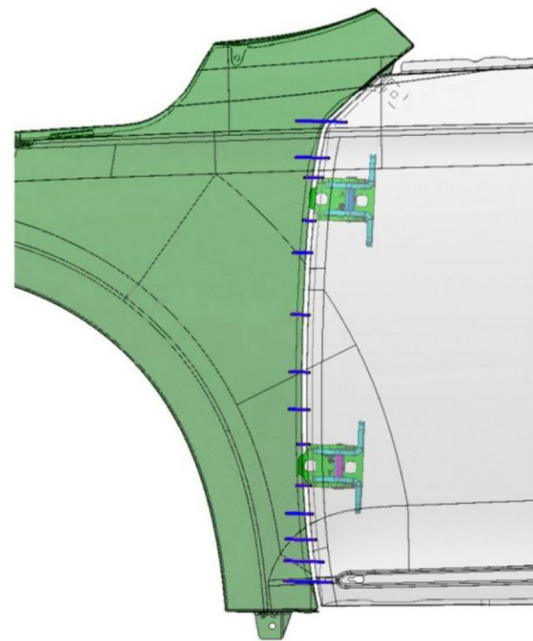


Figure 4. Parting line and extreme intervals