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Procedia CIRP 56 (2016) 84 – 89

www.elsevier.com/locate/procedia

9th International Conference on Digital Enterprise Technology- DET2016 – "Intelligent Manufacturing in the Knowledge Economy Era

Rapid structure design and automated adjustment of missile body

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Abstract

In order to improve the quality and efficiency of missile design, it would be better to take structure design into account during the prophase of missile preliminary design instead of later phase or detail design phase. This paper presents an approach to implement rapid design, modeling, and automated adjustment for missile body structures by describing missile body structures' arrangement information and model information with parameters. A rapid missile body structure design module was developed based on NX environment and method above which can achieve rapid structure design, automated adjustment, as well as automated calculation and update of data such as mass, barycenter, and so on. Finally, an instance was presented to illustrate that this method is feasible and effective.

Peer-review under responsibility of the scientific committee of the 5th CIRP Global Web Conference Research and Innovation for Future Production

*Keywords:*preliminary design; missile body structure; parametric design; automated adjustment;

1. Introduction

Preliminary design of missile undergoes a complex process with the iterative and step-nice refined character which will absolutely affect the efficiency [1].So it is necessary to take missile body structural factors into account during the prophase of missile preliminary design to improve design efficiency and provide beneficial data for weight estimation, flight performance analysis, and other aspects. These factors and data are also needed by following optimization and detail design.

With the development of computer technology, computer aided technique have been applied in a great deal of engineering fields. In aviation area, computer-aided conceptual design system is firstly studied and applied in large aircraft design area and some design systems can even realize the complete parametric modeling of the whole aircraft [2-7], but rare systems contain the content of structure design for preliminary design, so these systems can't satisfy the demand of structure design in preliminary design stage both in plane design and missile design. And few researchers focus on structure design in preliminary design phase. Jiang developed a parametric geometry modeling toolkit for missile to generate the missile body's geometric shape [8].Some researchers studied the rapid design and optimization with the application of knowledge engineering [9-11]. Luo Mingqiang studied the rapid civil aircraft fuselage and wing structure design based on OpenCADS(Open Conceptual Aircraft Design System) which is developed for civil aircraft and not suit for missile design [12, 13].

Based on the demand of improving the efficiency in missile body structure design, we studied the parametric description, layout design and modeling method of missile body structures and developed a missile body structure rapid design module on NX, realising the rapid design and automated adjustment of missile body structures as well as the automated calculation of data related to weight.

2. The selection of parameterized tools

Simens NX is widely used in missile structure design, and most of design activities of missile structures are based on NX environment. There are four different effective parameterized levels in NX 8.0, and the most important parametric tools are KF(Knowledge Fusion), NXOpen, SNAP(Simple NX Application Programming) and NX's own parametric function [14].

As shown in Fig.1, the first three tools are application programming interfaces that allow users to customize or extend NX by programs. NXOpen, which can be regarded as

Peer-review under responsibility of the scientific committee of the 5th CIRP Global Web Conference Research and Innovation for Future Production
doi:10.1016/j.procir.2016.10.021

the updated version of UG Open API, is enormously broad and powerful. With interfaces designed by BlockUI we can customize our own module in the same style with NX. The main point of SNAP is that it's designed to be learned quickly by average NX users, so it's less powerful than NXOpen but easy to start. Knowledge Fusion is a superior technology that permits NX to take advantage of engineering knowledge bases in conjunction with rules to deliver powerful applications while permitting a knowledge based extension of NX by end users [15]. However, due to its complexity and inconvenient IDE, the KF is not used widely as NXOpen in complex product design. Overall, NXOpen and BlockUI are employed to achieve the rapid structure design and automated adjustment of missile body in this paper.

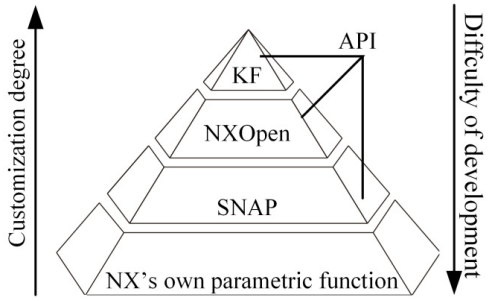

Fig.1 NX's parameterized tools

3. Parametric description and modeling of missile body structure

3.1. Coordinate system definition

In the process of missile design, we generally use the coordinate system shown in Fig.2. We set the missile nosecone point as the origin of coordinate system, the central axis of body as the x-axis.

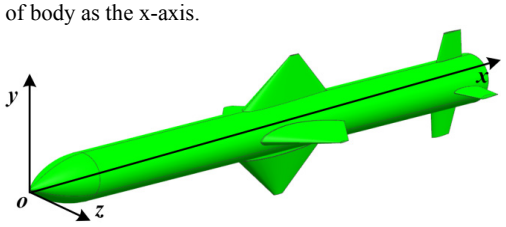

Fig.2 Coordinate system for missile

Meanwhile, to describe structures in wings more conveniently, designers will set a local coordinate system for each wing whose x-axis in the same direction with the x-axis in missile coordinate system and y-axis in the wing span direction. What's more, the origin is the intersection point of leading edge and bay section. The local coordinate system of missile wing is showed in Fig.3.

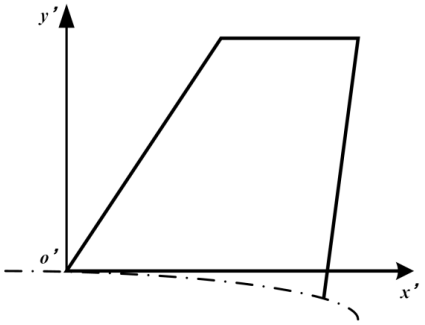

Fig.3 Local coordinate system of missile wing

3.2. Parametric description of missile body structure

Missile body is a shell with high-performance aerodynamic shape formed by missile skin, aerodynamic force surface and all sorts of mechanisms [16]. What we focus on are typical strength structures in bay sections and wings. As shown in Fig.4, according to the wing structures inside, we can classify wings into honeycomb sandwich structure wing, solid wing and skeleton structure wing. The strength structures in wings include main bulkhead, joint, skin, leading edge, honeycomb(in honeycomb sandwich structure wing), skeleton(referring to beam or rib) etc. [17]. The most important strength structures in bay sections are stringers, annular stiffeners and docking frames. Due to docking frames are similar to annular stiffeners in the process of arrangement and modeling, we regard the docking frame as a special annular stiffener with more complex cross section shapes. Fig.4 shows the typical strength structures in missile body. In this paper, we concentrate on the arrangement and modeling of stringers and annular stiffeners in bay sections as well as honeycombs and skeletons in wings.