The Use of CAX Systems as a Tool for Modeling Construction Element in the Aviation Industry

Korištenje sustavom CAX kao sredstvom za modeliranje konstrukcijskih elemenata u zrakoplovnoj industriji

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Summary

The article deals with the adjustment of the wing selected part of the plane Viper SD-4 from slovak producer with using environment of software Siemens NX9. The adjustment is carried out after consultation with the test pilots of this plane and tries to take into account the observations made during the test flights. The first part of the article is focused on the current construction of the wings and its parts. The second part describes how digitalize the real wing by using reverse engineering. The last section describes adjustment of the design and its 3D model in a virtual environment. The model is created in the environment Modeling and Aero Sheet Metal in software Siemens NX. When modelling was also used part of the drawing documentation from the manufacturer. This article deals with the wing treatment on the theoretical base.

Sažetak

Članak se bavi prilagodbom odabranog dijela krila zrakoplova Viper SD-4 slovačkog proizvođača koristeći se okruženjem softer Siemens NX9. Analiza se izvodi nakon konzultacija s pokusnim pilotima ovog aviona i nastoje se uzeti u obzir ona zapažanja koja su stečena za vrijeme pokusnih letova. Prvi dio članka se usredotočuje na tekuću konstrukciju krila i njegovih dijelova. Drugi dio opisuje kako se digitalizira stvarno krilo, korištenjem obratnog projektiranja. Zadnji dio opisuje analizu dizajna i njegov 3D model u virtualnom okruženju. Model se stvara u okruženju Modeling i Aero Sheet Metal softer Siemens NX. Pri modeliranju, upotrijebljen je također dio nacrtne dokumentacije proizvođača. Ovaj članak bavi se obradom krila na teoretskoj osnovi.

1. INTRODUCTION

Viper SD-4 is an all-metal two-seater ultralight aircraft designed primarily for recreational flying with the possibility of light acrobatics. The single-engine low-wing two-seat all-metal construction with seating arrangements side by side with its equipment and handling characteristics is designed for flight training and aero tow. More comfortable control of the aircraft contributes modern flight, navigation, communication and monitoring systems with a large LCD display. By adjusting its parts we want to achieve a better flight characteristic during flight training.

2. VIPER SD-4 WING CONSTRUCTION

Wing aircraft is generally rectangular-shaped with the main spar and the rear spar. Wing does not stringers. Twisting is prevented by using a stressed skin. The ribs maintain wing shape and they have the same shape and size along the length of the wings. Ribs includes slots for decrease weight. The wing is equipped with aileron to ensure cross-control, hinged flaps for increasing lift at lower speeds, electrically controlled in four positions. Wing of aircraft Viper SD-4 contains a fuel tank, which has a separate

construction built into the design of the wings. Wingtips are equipped with composite shape at the wing tip called winglets.

The wing of the aircraft Viper SD-4 is made of non-ferrous metal, more particularly aluminum and copper alloy (dural). Figure 1 shows the flap on the wing of Viper SD-4.

Figure 1 Flap on the wing of Viper SD-4

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3. CREATION OF THE WING 3D MODEL

Creation of the wing 3D model is primarily based on the knowledge of aviation engineering and work in the actual modeling environment Siemens NX9. The very structure of the Viper SD-4 wing consists of several elements: the main spar, rear spar, front and back ribs, skin, flaps, ailerons and winglet.

3.1. Main spar of the wing

Wing main spar consist of several sections of sheet metal riveted together. The principal part is the web of the spar and the flanges made in one piece over the whole length. Spar web has been created as the first part. The web of the main spar has been modeled in the Sheet Metal workplace. In this environment we have given the measured values by tool Rapid Definition. We have been used tool Tab to create a solid body. Then we have been used tool Break Corner to create a sharp curvature of the side edges of the web. As the next step we have followed by the creation of holes in the front of the spar by tool Hole. To create more of the same holes we used function Pattern Feature. During this action it is neccesary to ensure the correct selection of the extending direction of holes.

To obtain the wing main spar it has been necessary to create an assembly, where each individual part of the spar has been connected by joins. This act has been performed in the workplace Asembly. The main wing spar consists of several sheet metal parts. Foundation oj the spar is web, to which we have added additional parts: upper and lower flange with reinforcements, upper and lower struts of spar web and itself reinforcement of spar. In Figure 2 to see the parts of the main beam in a disassembled state.
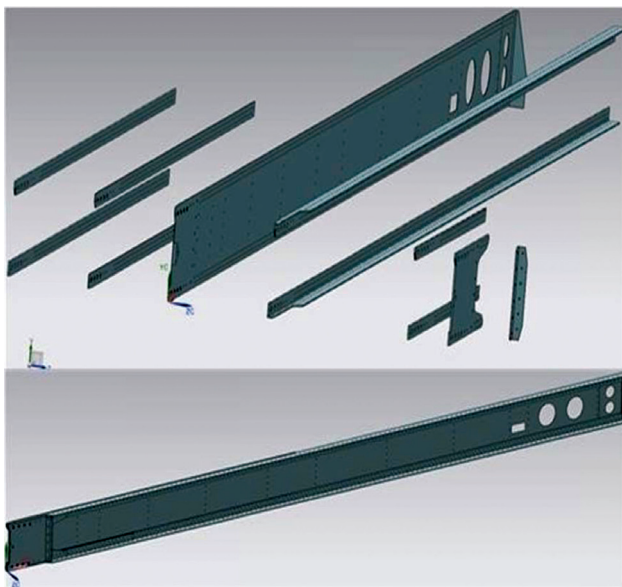

Figure 2 Main spar

3.2. Rear spar

The rear beam is one of the simplest construction and manufacture of the wing. The digitization of the rear beam has used a similar methodology as in the design of the main beam. The difference from the main beam is on the geometrical sketch, that we have created as one itself piece by using Extrude. Extrude tool is used to create a solid body by pulling. It is possible to create volume or extract volume.

3.3. Creating of ribs

Rib maintain the shape of the airfoil and at the same time reinforce the skin. Airfoil of the aircraft Viper SD-4 is created by front and rear part of rib. During modeling both parts of rib has been used same methodology of creating. The first step in creating a rear part of rib was the selection of a suitable working environment after running Siemens NX 9. In our case, the rear part of rib has been created in the workplace Aero Sheet Metal combination with the use of sheet metal working environment.

The basic shape of the rear part profile of rib we have drown in the scriber environment Skech. Accurate readings has been specified there by using the tool dimensions Rapid Dimension. To create a 3D model from 2D sketch of rib part we have used tool Tab in the working environment Aero Sheet Metal. With the Tab it is possible to create flat planar body with a choice of the desired thickness and direction.

After creating solid body of rib it has been followed by the creation of side edges by using the tool Aerospace Flange. After opening the dialog box of Flange Aerospace we have selected curve along the edge of the rib, where we want to create side edge by adding material. In the dialog box you can select the size of the angle and also can define length of side edge. All of the side edges has been created by same method.

In next step it was necessary to make holes for decrease weight of rib. To cut hole for decrease weight of rib we have used function Normal Cutout. During work with the function Normal Cutout is important to define the correct depth and direction of recess [4]. The advantage of this feature is cut materials of different sketches at once. After creating holes to decrease weight of rib it was necessary to make bends of each hole. As the tool for this action has been used Aerospace Flange.

Next step in modeling the rear part of rib it was necessary to make cuts and holes on each side edges. We have used same way as during making holes on rib, with the help of a tool Normal Cutout. At first we had to draw a sketch of cut shape and hole by using a newly created adjacent surface to the surface of the rib side edge.

For multipling of the incision we have used tool Pattern Feature. Pattern Feature is placed on Sheet Metal working environment. After opening Featture Pattern dialog box we had to select a curve on the side edge of rib to choose direction of multipling. In this dialog box is necessary to define the number and variance of the multiplication of parts [7]. For multiplication of the others side edges on the rear par of rib we have used same method.

In the last step during creating model of rear part of rib we have used tool Hole.

The digitization of the from part of rib was used a similar methodology as in modeling rear part of rib. The wing of the aircraft Viper SD-4 comprises the ribs with opposite direction flanges. For modeling opposite flanges on rib we hace used same method, but in Aerospace Flange dialog box we woted Reverse Direction.

3.4. Creating of flap

Flaps digitization methodology is quite a complicated process. Flaps is basically a scale model of the wing comprising spar, front and rear rib, hinges connecting the flap, L profiles and
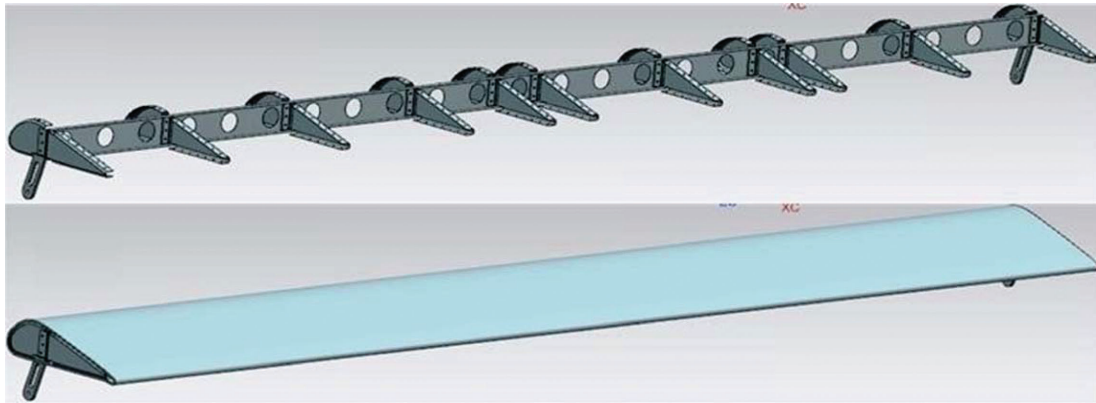
Figure 3 Virtual 3D model of flap

skin. All this parts connected together make flap. At first it was necessary to model the components of Flaps. The digitization of individual components of the flaps followed a similar methodology as in the modeling of the main part of the wing by using the same tools and features. The following figure shows flap without skin and with skin.

3.5. Creating of aileron
For modeling aileron we have chosen similar methodology as for digitalizing flaps. Ailerons as part of the wing consists of several components. At first we had to create all the structural parts of aileron: spar, piano hinge, front and back part of ribs, hinge for control aileron and skin [5]. After creating all parts it was neccesaty connected this component by joins. In next figure we can see aileron witout skin and with skin.
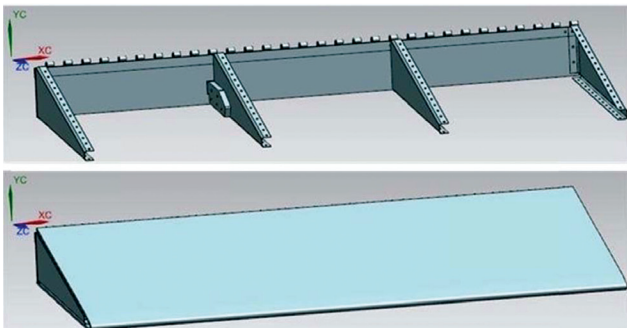

Figure 4 Aileron

3.6. Fuel tank
The fuel tank has been modeled as a single volume part of the wing leading edge. For creating fuel tank we have used sketch the rib, which we pullet to volume by using Extrude to the desired length.

3.7. Skin and winglet
Digitalization methodology of skin or winglet is similar. Both of such parts are made by sheet metal modeling with curves directly in the assembly. The procedure for modeling the wing skin is as follows.

At first it was necessary to create an shape of the skin in drawing environment Sketch. Then we have made the other surface by using Datum Plane [1].The distance from the first plane is setting the length of the skin. We have made the sketch of the same shape on the created plane. Drawing identical sketch has been done in environment Sketch by using tool Project Curve. On these curves we have created two points, as help for creating curve to close sketches of skin. On the basis of the selected curves we have created a surface of skin by using Swept. To determine the thickness of the coating is applied Thicken feature.

Digitalizing process of winglet was more complex. At first it was necessary to create a sketch, which will correspond to the shape of the end arc of winglet. As next step we have establish of the surface of the wings arc from sketch. Difference compared to the modeling of the wing skin was in tool used to creating surface of winglet. Here we have used tool Trough Curve Mesh [2]. Trough Curve Mesh tool allows to create surface with multiple curves.

The surface of winglet is divided into two parts, which are created individually. Lower part has been created as the first and then we have made upper part of the winglet by using instruments Trough Curve Mesh. To create a cutout on the winglets we have used tool Trimmed Sheet. For work of Trimmed Sheet it was necessary to create a sketch of the place viewport. From sketch we have made body of future hole by using Swept. In the last phase of winglet modeling we have determinated thickness by using the tool Thicken. In the picture below we can see the final form of a winglet.

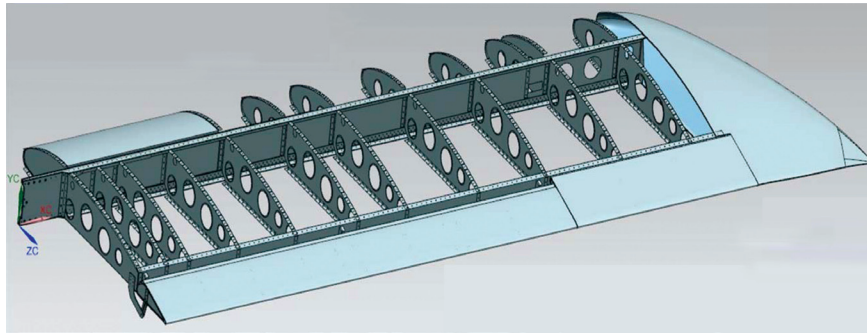Figure 5 Virtual model of Viper SD-4 winglet

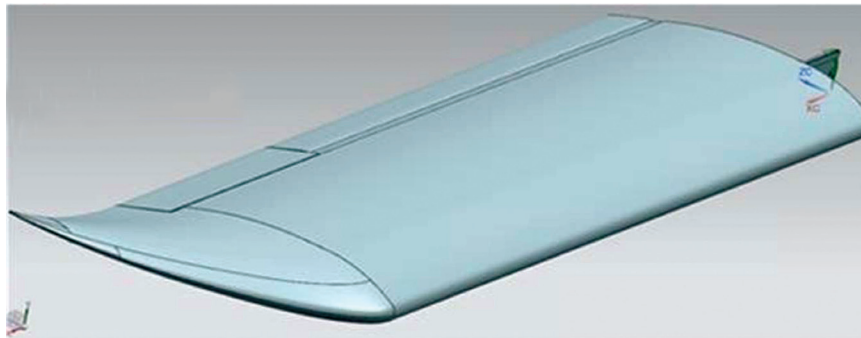Figure 6 Wing assembly with winglet

Figure 7 Completed wing of aircraft Viper SD-4

3.8. Wing assembly creating

The assembly is made up of individual 3D models and sub-assemblies that are loaded into the main assembly. Which are in the next step linked together in a final model by appropriate links. Each assembly carries information about location and position of the components in space [3]. Wing of aircraft Viper SD-4 consists of three parts (the main beam, flap, aileron), eleven rear ribs, seven the front ribs, fuel tank, skin and winglets.

Before creating assembly of wing, we must be sure that we are in workspace Assembly. In the menu bar of the working environment Assembly we choose tool Add, where we open a dialog window. In the dialog window of Add Component tool we choose and add individual parts into the assembly. As the first and also the main part of the assembly we insert sub-assembly of the wing main spar, which must be fixed in workspace by join Fix. Join can be determined by using the Assembly Constraints in his subsequent dialog box, where we can choose needed type of join . The main wing spar is the biggest part, which is designed as an assembly. This part carries the main function

of the entire assembly and other minor components and sub-assemblies are continuously connected with. The virtual model of the wing without skin is shown on figure below.

In the final step of wing assembling has been necessary to add the last component that has been skin of the wing. For creating a join between skin and construction of the wing we have used type of join named Touch Align with a focus on the surface. The following figure shows a complete assembly of aircraft wing of Viper SD-4

3.9. Methodology proposal of digitalization of selected structural components

The reason for size optimization is that testing pilots had found weaknesses on wing aerodynamic during flights. They found the disproportion of forces in rolling and pitching [6]. During deflection of control stick to the sides have been rudder deflection sensitivity considerably less than aileron had. Previous control conditions were sufficient only for well experienced pilots. For pilots beginners were previous
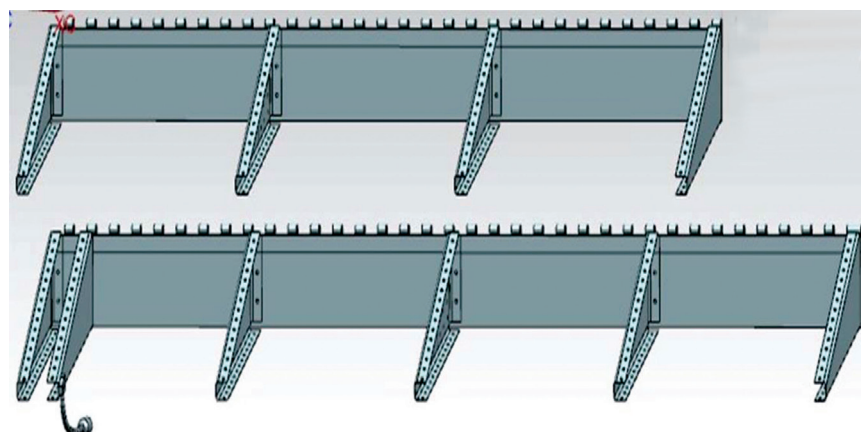

Figure 8 Optimalized aileron

controlling conditions inappropriate for training. So it was necessary to make changes in force imbalance.

Steering rudder deflection at the sides was rudder deflection sensitivity considerably less than the winglet. Previous management was sufficient only for experienced pilots. For novice pilots were previous inappropriate management which did not allow them to flight training. It was therefore necessary that imbalance forces managed to eliminate the appropriate design modification wings.

3.10. Optimization proposal of wings arrangement

At first and foremost wing has been prolonged to the detriment of wing flaps. The following figure shows a comparison of the original aileron with aileron after the structural modifications. Modified wings size was determined based on measuring of the wing model in the wind tunnel at the premises of the Faculty of Aeronautics. Resizing of the aileron was set at 200 mm of aileron extension to the detriment of wing flaps.

There was a structural change in the arrangement and the number of aileron ribs Number of ribs is increased by two. On the end of one new rib we have placed a static mass balance to eliminate the newly emerging forces of impact of the continuation aileron. Mass balance attached to the end of the aileron rib has seen in the figure below.

Because of spar length has been increased, it has been neccesary to regulate holes to attach the ribs of aileron. By changing the layout of the ribs are moved hinge fixing and control of aileron to the central rib. At the expense of increase aileron length we have needed decrease flaps length. There we have changed length of flap spar and layout of flap ribs. By shortening the spar of flap we could to remove one rib. On the following picture we can see design changes to modified flap and a comparison of the original. We had to change layout of
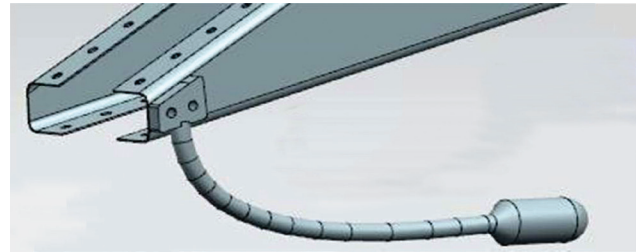
holes for decrease weight on spar too.

Figure 9 Mass balance of aileron

Enlarging of aileron was increased its surface and as result increase torsional and bending forces in the wing root. Torsional torque is transmitted by wing torsion box. It was necessary to make structural changes in the wing to eliminate these forces. There was an amplification of the torsional box of complete wing by adding one technological rib in place tip of flap. On the rib can be attached rotation hinge diminished flaps then. The following figure shows the structural adjustment of the torsion box reinforcement of wing.

After the addition of modified parts into the wing assembly was created a virtual model of the proposed wings. The following figure shown a comparison of the original and modified wing of the aircraft Viper SD-4. In the figure you can visibly recognize the modified wing with adjustments.

CONCLUSION

Adjusting of ailerons and flaps have to achieve better flight characteristics and easier control for pilots beginners by altering the ratio of the various control surfaces. From tests on a scale model result that appropriate treatment it is to increase cross helm control at the expense of reducing flaps.
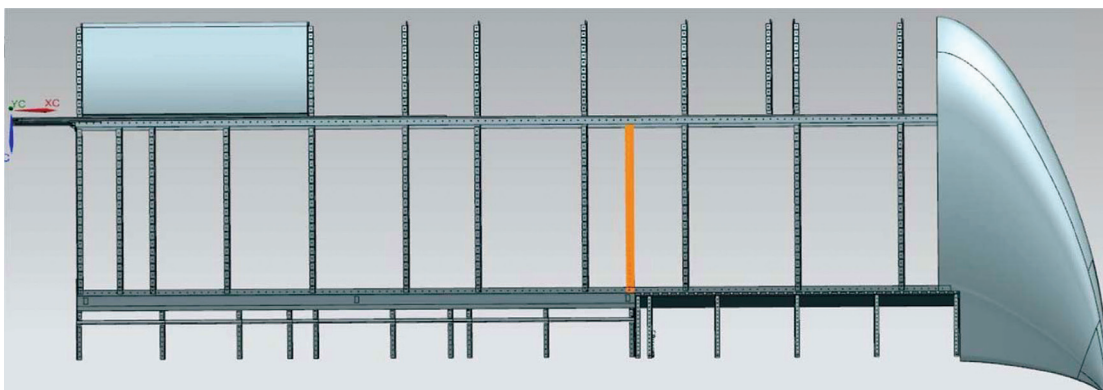

Figure 10 Comparison modified flap and original

Figure 11 Change in torsion box of wing

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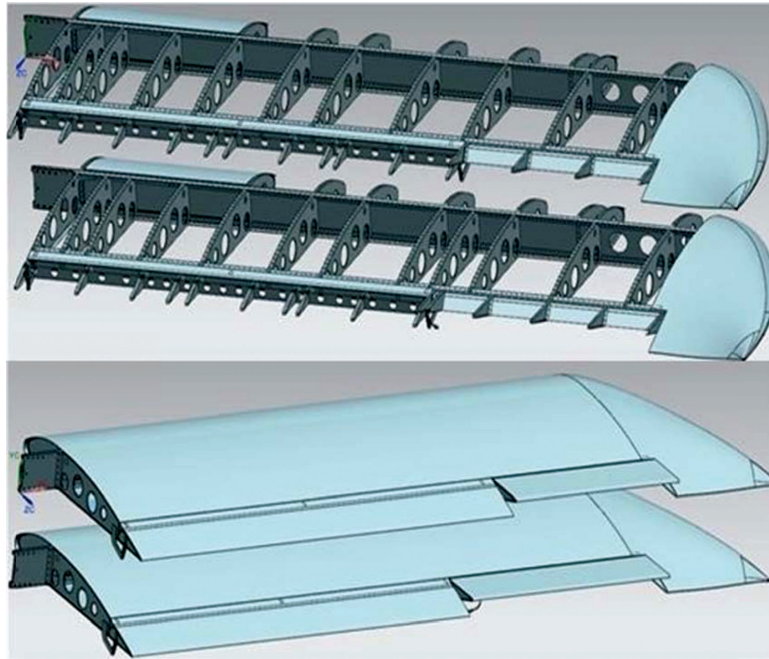D. Kužma et al: The Use of CAX Systems as a Tool for Modeling...

Figure 12 Comparison modified wing and original

The paper describes a method for creating a virtual model of the wing using reverse engineering. In this paper you can see comparision between modified wing and original.

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