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A GUN POD FOR A TRAINING AIRCRAFT
- AN INITIAL ANALYSIS

Abstract

The manuscript presents an initial analysis of a gun pod for a military training aircraft. The described model was dedicated for the PZL-130 „Orlik” aircraft, which is used in a basic military training at the Polish Air Force Academy. CAX tools were used during the designing process which is described in the first part of the paper. The following parts present the strength and aerodynamic tests and explanation of the gun pod construction project. The paper ends with the research results and conclusion.

Keywords: gun pod, training aircraft, CAX software

Introduction

Nowadays old methods of design like a drawing board and pencil, faded into oblivion. Currently, in order to solve design problems, an engineer needs not only a specialized operating unit and software like CAX tools, but also electronic databases associated with the project. Due to the occurrence of more complex structures and devices, whether it is in the field of construction, aviation or electronics, proficiency in engineering design software is essential. Also, a growing demand for accuracy and precision is on a very high level. Nonetheless, CAX software is still only a supporting tool. The specialized workshop experience is the most important.

Assumptions and an initial design of a gun pod parts

If the database is insufficient or simply has not been created yet, the engineer has to make some assumptions. During designing process of a training aircraft gun pod, the first problem is to determine which aircraft gun should be used. The next step is to create a gun model in CAX software [3][4] with all indispensable parts. It is an example of reverse engineering. Therefore, such a project pioneers and may constitute the foundations of the database in a particular area. When working on future projects, there will be no need to perform tedious measurements in order to create the model as they will be available in the database. For the purpose of the project, the GSz-23 gun was chosen [1][2][6][7][10]. It is a quite complicated design. While designing parts, it should be remembered that it is important to minimize the number of operations so as not to overweigh the operating unit.
Because of the lack of data in the database or any previous attempts to create such a gun pod in the training aircraft, it was necessary to implement many innovations which have not been put into use yet. The gun pod housing general construction and its parts are presented on Fig. 1. The GSz-23 gun pyrotechnic reload has been replaced by pneumatic reload (Fig. 2). Also, the ammunition box has changed (Fig. 3). The construction changes caused modifications in the gun control system (Fig. 4).

**Fig. 1. Gun pod housing general construction [8]**

Parts description: 1 – forward down cover, 2 – aft down cover, 3 – forward right cover, 4 – forward left cover, 5 – aft right cover, 6 – aft left cover, 7 – end plate.

**Fig. 2. Gun reload pneumatic system [8]**

Parts description: 1 – ammunition supply bottle, 2 – ammunition box cover wire, 3 – ammunition box connector, 4 – pneumatic reload bottle, 5 – pneumatic reload cassette, 6 – reload cassette power supply, 7 – bottle valves, 8 – bottle loading nipples.
Fig. 3. Gun ammunition box [8]

Fig. 4. Gun control system schematic diagram [8]
Gun pod completion

When all gun pod parts are created, they can be composed into one cooperating unit (Fig. 5). This is important when performing strength calculations, because it allows for a preliminary check of the model. As regards very complex projects, it would be almost impossible to create a single assembly of all parts. While creating the unit, nodes should be added. Each node must be chosen carefully because it has a crucial influence on the working unit as a whole.

Fig. 5. View of a complete gun pod (with cross-section view – top figure) [8]

Selected research model results and analysis

Implementation of the gun pod as a virtual model allowed to make changes throughout the design phase, rebuilding the model and making corrections at the
preliminary stage of research. The research performed in the engineering software will never replace testing in the wind tunnel and fatigue tests, but it can shorten the testing phase on prototypes. Due to this research, it was possible to bring the model closer to the optimal build without the necessity of producing multiple prototypes. This makes for a significant reduction in the costs which is a crucial consideration nowadays. Using the program SolidWorks as a research community provides a huge amount of research that can be used in performing tests on the model such as a static analysis, and fatigue tests on the study of flow and warming. The gun pod has undergone some of these tests.

The first test concerned testing beams and nodes. In order to complete this, it was necessary to pre-measure the resistance forces acting on the gun pod. Nodes have been tested statically, but also during flight with maximum speed and while shooting. The results made it possible to correct errors in construction. The housing of the gun pod was tested for deflection (fig. 6÷11).

![Fig. 6. Air speed analysis [8]](image1)

![Fig. 7. Aerodynamic trail [8]](image2)

![Fig. 8. Stream speed inside the pod [8]](image3)
An aerodynamic study is difficult due to the complexity of the model. Hence, a decision was made to perform a test on the gun pod, not the whole aircraft with gun pods. This resulted in a decrease in the accuracy of the results. PZL-130 aircraft model was made by Kamil Franczak [5] and was even more problematic that might have been expected. When exporting objects with a large surface area, the number of errors was much greater. This resulted in the need to rebuild 80% of the model. However, the method of data presentation is clear and the recipient can choose one out of three options: numerical, diagrammatical and graphical. During the processing of the results in a graphical method,
A range of functions can be used, allowing the best results to be achieved. The selected results were presented in Table 1 and Fig. 12-15 below.

Table 1. Aircraft aerodynamic force with or without a gun pod (angle of attack - 15°)

<table>
<thead>
<tr>
<th>Name</th>
<th>Unit</th>
<th>Value</th>
<th>Averaged value</th>
<th>Minimum value</th>
<th>Maximum value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerodynamic force (with gun pod)</td>
<td>[N]</td>
<td>96201,43</td>
<td>95398,00</td>
<td>94751,70</td>
<td>96225,08</td>
</tr>
<tr>
<td>Aerodynamic force (without gun pod)</td>
<td>[N]</td>
<td>112194,83</td>
<td>112460,55</td>
<td>112096,14</td>
<td>112884,43</td>
</tr>
</tbody>
</table>

Fig. 12. Average force acting on an aircraft with a gun pod [8]
Fig. 13. Average force acting on an aircraft without a gun pod [8]

Fig. 14. Aircraft pressure difference with or without a gun pod [8]
Conclusion

The authors have demonstrated how to solve the structural problem of a gun pod in a model of a training aircraft (the project was based on the PZL-130 Tc-2 „Orlik” aircraft [9]). It is only a proposal to introduce the gun pod in the initial stage of training, but nevertheless creates the basis for further modifications of the aircraft or the gun pod. Any model that is created can be used in future projects. It is also possible to make animated instructions, including video tutorials for using the gun. The use of the model when studying "Engineering Graphics" can be important from a didactic point of view and it encourages students to create more projects and improvements. The model that is designed can also initiate the creation of a database, which would include all the CAD aircraft and aircraft equipment designed at the Polish Air Force Academy.
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