International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-2, Issue-10, October 2014

Design and Optimization of 70 mm Rocket Composite Launcher

M.R.Mohammadi, M.M.Shakib

***Abstract*—Considering the military implementation prohibitions and highly developed technologies of composite materials , this project studies about increasing the power of martial and fire in Gyroplanes and light Helicopters by design, optimization and manufacturing of composite launchers instead of isotropic types. Using composite type launchers have advantage of lower weight, higher life and simplicity in manufacturing. Modeling and analysis accomplished by Abaqus Software and the fiber composite directions improved by coding in Matlab Software. The optimization process completed by linking both softwares. Till now, more than 800 successful shots have been made in several centers using composite launchers. Because of easy manufacturing of this kind of launchers, there is no need to have advanced equipments and all the works have been provided by semi-skilled workers in the simple workshops.**

***Index Terms*— Abaqus, Matlab, Genetic Algorithm, Composite.**

I. INTRODUCTION

The air battle helicopters are very common and the strategic use of fire as a frontline support and attention of many of the world's most advanced armies. Among the types of rockets by 70 mm are widely used and highly advanced helicopters in the world is. For example, Super Kobra helicopter belonging to the American Army, has two pilots and 6690 kg Weight during takeoff. This helicopter has speed of 352 kilometers per hour and an operating range of 587 kilometers. Firing time of 20 mm, 70 mm rockets, 8 anti-tank missiles and two air-to-air missiles and other advanced features of this aircraft.

Using 70-mm rockets in the most advanced helicopters in the world shows the importance and function of these rockets in the military. But with the ban imports from other countries and 70 mm rocket Launchers and needs of the country, project design, optimization and manufacturing of composite launcher for the first time at the national level were introduced. Due to security issues almost no record of this information and is not specific research on the Internet or other sources.

This type of rocket is an organizational weapon of attack helicopters and Tucano aircraft, and so on. This kind of a lot of rockets there are at military facilities. The rocket warhead containing phosphorus, anti-personnel, assembly and so on. 70 mm rocket has weight of about 11 kg. Rocket takes more than 5 km and in a distance of 5.2 km can be carefully destroyed their targets. The rockets are widespread in the Korean War, Vietnam War and other wars is used. The following general information is given about it.

Manuscript received October 10, 2014.

Mohammadreza Mohammadi, Emam Hosein University, Faculty of Aero Space, Eng., Hakimiyeh, Tehran, Iran.

Mohsen Mohseni Shakib, Emam Hosein University, Faculty of Aero Space, Eng., Hakimiyeh, Tehran, Iran.

II. SELECTION METHOD FOR THE OPTIMIZATION OF COMPOSITE MATERIALS

A. *Evaluation of Matlab code*

The composite Plate shown in Fig.1 has "a"as length, "b" as width and "α"as thickness and is under bending load of q(x,y). The shown composite surface is located in coordinates x, y, and z, and has K layers that its thickness is h_k and the angle of fibers is θ_k and k=1,2,…,k.

The material used in Composite surface is of graphite-epoxy type (T300/5208) and their specifications are as follows:

$E_1 = 181$ GPa $E_2 = 10.3$ GPa
$G_{12} = 7.17$ GPa $\upsilon_{12} = 0.28$
$X_t = 1500$ MPa $X_c = 1500$ MPa
$Y_t = 40$ MPa $Y_c = 246$ MPa
$S = 68$ MPa

The composite layers have symmetrical china layers as $[\theta_1/\theta_2/\theta_3/\theta_4||t_1/t_2/t_3/t_4]_{sys}$ and are under an even loading.

B. *Method of Plate Analysis*

For optimization of a Compound laminated using genetic algorithm and Finite element procedure, first the finite element model is created in Abaqus software, then using the link with mathlab software the process of optimization begins. In 2003, the optimization of a Compound laminated was accomplished by walker and Smith to optimize the weight and displacement using some design variables.

The design constraints are considered on the basis of Tsai failure Factor and the composite surface is symmetrical and includes 8 layers; therefore, for 4 layers of the composite surface, angle and thickness are optimized with the definition of average weight in the function and designation of it's minimum. For designation of an application china layer, the optimum angle is selected from the angles used in industry. Most of common angles in industry include 0, ± 30, ± 45, $\pm 60, 90$ which in Ref.[1] they include 0.5, 0.75, 1, 1.25, 1.5, 2, 2.25, thicknesses . In order to show the accuracy of genetic algorithm performance in this article, the results are compared to [1].

C. Design Variation in Plate Optimization

In this optimization each person has 2 chromosomes. One chromosome contains the angles of Fiber and the other one includes the thickness of layers. Panel can include at most 8 layers and at least 4 layers which are symmetric with regard to the centric axis of the panel. So, because of the asymmetry, each chromosome will contain 4 genes. Table 1, indicates the angles, thicknesses and related codes.

Table 1. Related Thickness and Angles Code's

No. Of Angle Gen.		**No. Of Thickness Gen.**	
Code	Fiber angle. (degree)	Code	Layer Thickness.(mm)
1	0	1	0.5
2	30	2	0.75
3	-30	3	1
4	45	4	1.25
5	-45	5	1.5
6	60	6	1.75
7	-60	7	2
8	90	8	2.25

D. The stoppage criterion in this problem is of two states

*The first scale is the maximum number of generation that is considered 250 and the 2^{nd} scale is the maximum number of generation without improvement of proper optimum point which is considered 125***.**

E. The entries of composite surface program

The entries of the program are as follows:
Population = 8
The number of genes For each chromosome = 4
The percentage of mutation = 1%
The percentage of layer arrangement mutation = 80%
The percentage of layer increment mutation = 4%
The Percentage of layer decrement mutation = 4%
Minimum No. of layer = 2
Code collection of Gen. thickness = [1,8]
Code collection of Gen. angle = [1,8]
Elitism factor = 80%
The maximum number of generation = 250
The maximum number of generation without improvement = 125

F. The comparison of code results and reference for Plate

In [1], optimization of the composite surface for different boundary conditions and aspect ratios has been considered. in Fig. 1, 4 edges of the composite surface are numbered. Boundary conditions for this problem include a free end (F)[3], a clamped end (C)[4] , and simple support (S)[5] which in[1] six different admixtures of boundary conditions in forms of (F,S,F,S) ،(F,S,C,S) ،(S,S,S,S) ،(C,S,C,S) ،(C,S,C,S) and (C,C,C,C)
is shown, and for a situation that boundary conditions are in the form of (F,S,C,S) , the aspect ratio $(\frac{a}{b})$ for values 0.5, 0.75, 1, 1.5 and 2 is considered. In order to show the accuracy of the written algorithm, this composite surface is considered under boundary conditions (C,C,C,C) (F,S,C,S) and in a situation in which the boundary conditions are (F,S,C,S), for aspect ratios of 1.5 and 2 are studied and the results are presented in tables 2 and 3. The out coming results portend the high efficiency of the algorithm.

Table 2. comparison between the results of genetic algorithm and reference [1] for different boundary conditions und aspect ratio 1

Analyze Method	Boundary Condition	Layup (angle(degree)‖Thickness(m))	Weight(kg)	T-sai woo	Displacement(m)
Ref.[12]	**F.S.C.S**	**(0/90/0/90‖2.25/2.25/1.5/0.75)**	**21.6**	**0.99**	**0.053**
Related Algorithm	**F.S.C.S**	**(0/0/90/90‖1.5/1/2/2.5)**	**21.6**	**1**	**0.052**
Ref.[12]	**C.C.C.C**	**(0/90/0/90‖0.75/2/0.75/0.75)**	**13.6**	**0.98**	**0.032**
Related Algorithm	**C.C.C.C**	**(0/90/90/90‖0.75/0.75/0.75/2)**	**13.6**	**0.97**	**0.032**

Table 3. comparison between the results of genetic algorithm and reference [1] for boundary conditions (F,S,C,S)

Analyze Method	Aspect Ratio	Layup (angle(degree)‖Thickness(m))	Weight(kg)	T-sai woo	Displacement(m)
Ref.[12]	**1.5**	**(60/-60/60/-60‖2/2/2.25/2.25)**	**4.08**	**1**	**0.111**
Related Algorithm	**1.5**	**(-60/60/60/-60‖2/2.25/2.25/2)**	**4.08**	**0.96**	**0.109**
Ref.[12]	**2**	**(90/90/0/0‖2.25/2.25/2.25/2.25)**	**57.6**	**0.99**	**0.152**
Related Algorithm	**2**	**(-60/60/60/60‖2.25/2.25/2.25/2.25)**	**57.6**	**1**	**0.133**

III. ABAQUS AND MATLAB GA

A. Simulation of fire conditions in Abaqus software

In this part 70mm Hydra rocket is mounted in the launcher and the rocket is ready to shoot. In this position, part of the rocket war head is out of the launcher which is shown in Fig 2. The safety factor and construction amounts are taken with regard to the standard MIL-STD-2131A [5] to exposed loads on structure.

For analyzing the failure of the launcher in Abaqus software The Tsai-Hill Failure Factor is used. Tsai-Hill failure factor is presented as equation (1).

$$\frac{\sigma_1^2}{X^2} - \frac{\sigma_1\sigma_2}{X^2} + \frac{\sigma_2^2}{Y^2} + \frac{\tau_{12}^2}{S^2} = 1 \qquad (1)$$

In above mentioned equation based on the point that the tensions δ_1, δ_2 are either tensional or compressional, X, or $1/_t$ and for compressional cases by X_c or Y_c.

B. stopping criterions in optimization of composite cylindrical (launcher)

stopping Criterion in this problem has two states as well. The first scale is the maximum number of generations which equals 400 and the second scale the maximum number of generations, without improvement of optimum spot which is considered to be 200.

C. The entries for composite cylindrical (launcher)

The entries of the program are as follows:
Population = 8
The number of genes For each chromosome = 4
The percentage of mutation = 1%
The percentage of layer arrangement mutation = 80%
The percentage of layer increment mutation = 4%
The Percentage of layer decrement mutation = 4%
Minimum No. of layer = 2
Code collection of Gen. thickness = [1,8]
Code collection of Gen. angle = [1,8]
Elitism factor = 80%
The maximum number of generation = 400
The maximum number of generation without improvement = 200

IV. CONCLUSION AND THE RESULTS OF GENETIC ALGORITHM CODE AND MATHLAB AND ABAQUS SOFTWARE LINKS FOR COMPOSITE CYLINDRICAL (LAUNCHER)

The final optimized results for composite Fiber made of graphite epoxy are presented in table 4.

Considering the point that according to Fig.3 there are 19 launchers in each tube. The comparison between the weight of Aluminum and optimized composite launchers are presented in table 5.

Table 4. Results of GA for composite fibers

Analyze Method	Aspect Ratio	Layup (angle(degree)‖Thickness(m))	Weight(kg)	T-sai woo	Displacement(m)
Ref.[12]	**1.5**	**(60/-60/60/-60‖2/2/2.25/2.25)**	**4.08**	**1**	**0.111**
Related Algorithm	**1.5**	**(-60/60/60/-60‖2/2.25/2.25/2)**	**4.08**	**0.96**	**0.109**
Ref.[12]	**2**	**(90/90/0/0‖2.25/2.25/2.25/2.25)**	**57.6**	**0.99**	**0.152**
Related Algorithm	**2**	**(-60/60/60/60‖2.25/2.25/2.25/2.25)**	**57.6**	**1**	**0.133**

Table 5. Weight of aluminium and composite launcher

Material used in launcher	Weight of each launcher	Weight of 19 launcher
Al	**2.7**	**51.3**
Glass-Epoxy	**1.27**	**24.13**

Considering the results for china layer, it is observed that the highest effects among Fibers is allocated to the Fiber with 90° angle . Furthermore the considerable weight decrement could be really important putting the military application into consideration.

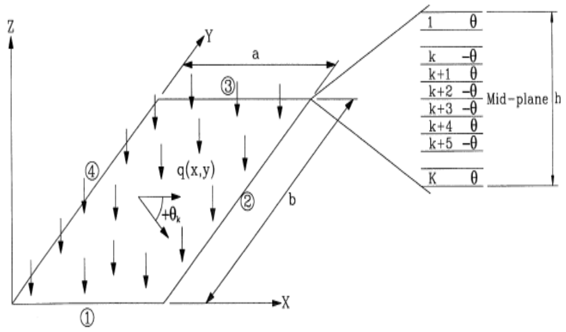

Fig 1. Geometry and Loading Condition of composite Plate

Fig 2. Launcher and Rocket Shooting Schematic

References

[1] Walker .M, Smith. R.E., "A technique for the multi objective optimization of laminated composite structures using genetic algorithms and finite element analysis" *Composite Structures 62 (2003)*, pp. 123–128.
[2] Almedia, F.s., "Design optimization of composite laminated structures using genetic algorithms and finite element analysis", *composite structures*, 2008.
[3] Akbulut M. and Sonmez F.O., ''Optimum Design of Composite Laminates for Minimum Thickness'', *Computers and Structures*, pp. 1974-1982, July, 2008.
[4] Walker M. and Reiss T. and Adali S., ''Optimal Design of Symmetrically Laminated Plates for Minimum Deflection and Weight'', *Composite Structures*, Vol. 39, No. 3-4, pp. 337-346, 1997.
[5] ''Launcher, Ejection, Guided Missile, Aircraft, General Design Criteria for'', *MIL-STD-2131A*, December, 1991