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PROJECT OF HELICOPTER TAIL ROTOR COMPOSITE BLADE

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ABSTRACT
This paper presents the design of helicopter tail rotor composite blade. The requirements which govern the design of the tail rotor are: strength, power efficiency, low weight, avoidance of vibrations and additional noise, and easy controllability. The design of the tail rotor is expressed by the main design parameters: diameter, tip speed, solidity, number of blades. Length of machine, ground clearence and weight considerations will all favour the small antitorque rotor. Avoidance of resonance frequencies may affect the choice of tip speed. This maximum is assumed to be equal to twice the thrust for compensation of maximum rotor torque. Normally this will cover the criterion of avoidance of tip stall in forward flight. The number of blades may be chosen from the point of view of vibration. The safest number is three or more, but two-bladed tail rotors have been employed even without a special resilient mounting by tuning the flexibility of the tail.
Design and modeling are carried out by the use of program moduli connected with the airfoil data base. There are specific parameters which define blade geometry and allow saving necessary data in the files, which are, later on, used in certain estimations and analyses. In the final stage of the design it has been applied a system for automatic delivery of of technical documentation of composite fan blade. This system uses several different moduli. Geometric description is supported by program package AutoCAD.
Keywords: tail rotor blades, composite materials, designing, development

1. INTRODUCTION

Helicopter main and tail rotor blades are the key structure elements which affect the helicopter performance and its good characteristics from the aspect of reliability and safe operation.
The design of a helicopter rotor blade requires close attention to aerodynamic, dynamic, structural and mechanical considerations, and manufacturing methodology.
Unidirectional fiberglass and other reinforced plastic have significant advantages over metals for blade construction. The characteristics of the available materials - principally fiberglass, Kevlar 49, and Graphite - can be used to construct blades with improved geometry, dynamic tuning, strength, safety, service life, and damage tolerance.
The plastic nature of the materials permits molding of a precise aerodynamic shape. These advanced shapes are primarily used for aerodynamic advantages but can also be used to optimize the blade's natural frequency placement.
The composite materials have high static strength and high fatigue strain capability. These characteristics can be used to design blades with unlimited fatigue lives, and long service life with

little maintenance. The gradual failure modes, particularly of unidirectional fiberglass, can result in fail safe structure, where changes in vibration level or large, obvious crack would result long before the blade became incapable of carrying limit loads.

2. WHY COMPOSITE MATERIALS?

Basic characteristics of composite material are:

- directed load distribution through large number of fibers and compact structure enable forming of a construction that is highly resistant even after partial distractions;
- composites enable optimal designing of a construction and satisfy requirements from the aspect of the load magnitude and stress direction;
- composite materials are highly resistant to concentrated stresses and crack distribution is very small;
- the composite construction can be produced of smaller number of components (then metal construction);
- composite structures can be designed to keep their proper aerodynamic shape even when exposed to very high loads;
- composites have good anticorosive properties;
- composites have high structural dumping (specially in case of multi-ply parts) which gradually reduces vibrations and noise;
- composite materials have low thermal conductivity;
- they are highly resistant to impacts and local damages;
- composite material surfaces are very smooth and do not require additional treatment;
- smaller repairs can be done on composite constructions even in operational conditions.

The fact that helicopters can be used economically in hover flight, can fly in perfect safety and be easily maneuvered near the ground, can attain areas otherwise difficult to reach without requiring elaborate and costly ground installations has meant that the use of these aircraft has been widely extended over the past years.

In order to meet requirements better, helicopter designers have three main aims, the implications of which on the aircraft are summarized in the following table:

Main Aims	**Implications on the helicopter**
Reduced direct operating costs	• Reduction in empty weight • Reduction in purchase price and maintenance cost
Improved performance	• Reduction in engine specific consumption • Reduction in parasite drag • Improved rotor performance
Improved operational capabilities	• Safety • Comfort (Vibrations and noise) • All-weather flight • Military aspects: 1. reduction in I.R. and radar detectability 2. reduction in vulnerability

Amongst the solutions adopted to achieve this aims, **the use of composite materials in helicopter construction has been and will continue to be decisive.** General helicopter performances in particular are in this way enhanced while production and operating costs are reduced and safety is improved.

3. DESCRIPTION OF THE MI-8 TAIL ROTOR BLADE

Tail rotor blades are made of composite materials (glass plies, roving, epoxy resin and Rohacell filler or Honeycomb) merged in polymerization process. The blade consists of three main sections: root section, central section and tip section.

Root section consists of:

- the spar roving (glass fiber strips) which is wrapped around steel shell,
- the wedges which direct roving after wrapping around the steel shells,
- the root section cap made of glass plies and roving slices,
- the filler made of Rohacell 71,
- the leading and trailing edge strips made of impregnated glass plies and
- the steel fitting fixed to the blade root by three bolts passing through steel shells, which connects the blade to the rotor hub.

Central section consists of:

- the roving spar (glass fibers impregnated with epoxy resin),
- the Rohacell 45 filler or Honeycomb,
- the skin which consists of six glass plies impregnated with resin,
- the rubber strip with metal reinforcing strip which cover the leading edge and protect it from impacts and
- the trailing edge reinforcement made of carbon fibers impregnated with resin.

Tip section consists of:

- the balance weights (static and dynamic) fixed to the clevis bolts (one is inbuilt in the spar and another in the inset at the trailing edge) and
- the tip cap fixed by screws to the nuts inbuilt in the blade tip section.

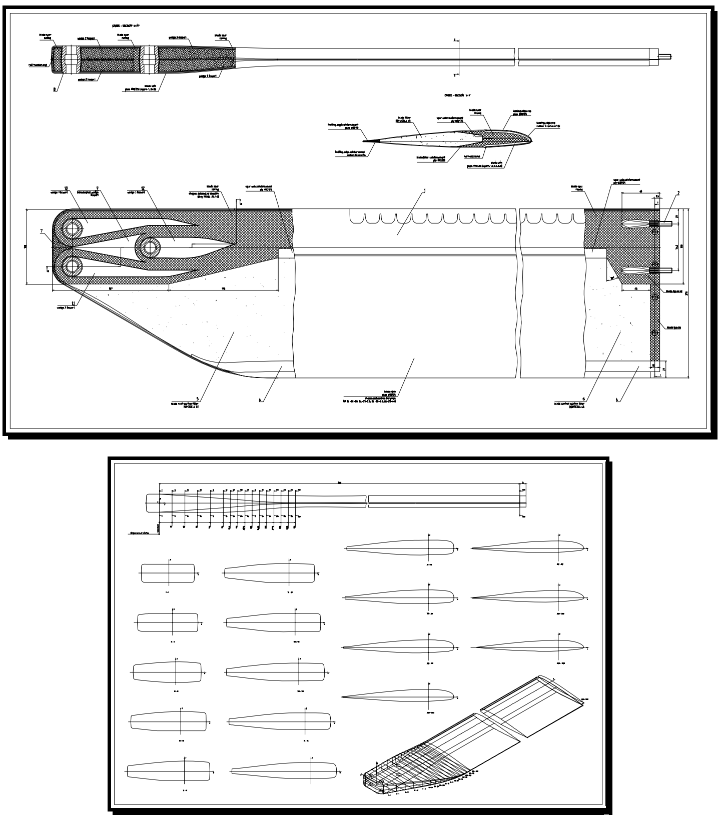

Figure 1. Some drawings

The variable pitch tail rotor is used to balance the reactive moment of the main rotor and to produce directional control during the flight. It is powered through the main gearbox by transmission shafts, intermediate and tail gearbox. Pitch is varied by application of pedals in the cockpit. The tail rotor (Figure 2) consists of the rotor hub (1) and three blades (2) connected by bolts (3).

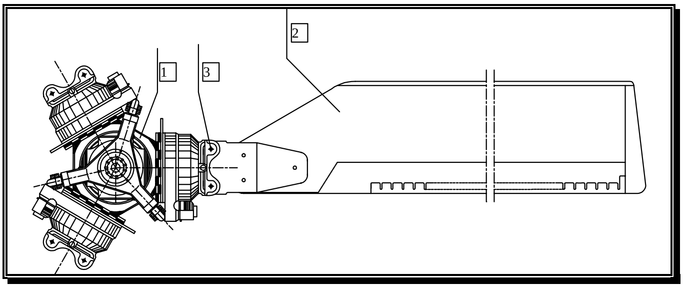

Figure 2. Tail rotor

4. HELICOPTER TAIL ROTOR COMPOSITE BLADE MOULD

Composite helicopter rotor blades are produced in moulds in which they are polymerized in furnaces or autoclaves. This technology gradually reduces the production costs. Very high accuracy of aerodynamic shape is achieved by blade production in moulds, which enables their replacebility without potential affecting of aerodynamic characteristics. Reduction in maintenance price of composite blades, according to the experiences, reaches even 30% or more.

5. PRODUCTION FACILITY FOR HELICOPTER ROTOR BLADES

Production, testing, repair and overhaul of main and tail rotor blades is done in a production facility. It must consist of: production workshop, workshop for homologation and control, workshop for static and dynamic testing, warehouse with refrigerated chambers, department for production technology development and auxiliary rooms.

6. TECHNICAL DOCUMENTATION

This chapter presents a developed system for automatic generation of technical documentation of helicopter rotor composite blades. System realization is provided by application of program modules. Design and modeling are performed under a program linked with a database consisting all types of airfoils. Databases are developed using AutoLISP. Certain program parameters define the blade geometry and allow storage of data. The program was developed in the programming languages C abd FORTRAN. The second part accomplishes the plotting of technical documentation within AutoCAD programming packages. This task is developed by implementing the AutoLISP programming language.

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