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FUNDAMENTALS OF ROTOR AND POWER TRAIN MAINTENANCE – TECHNIQUES AND PROCEDURES

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PREFACE

This manual is a guide for Army repairers on aircraft rotor and power train maintenance. It includes descriptions, construction features, operating principles, elementary repair procedures, and basic repair shop allied subjects.

Rotor and power train information presented herein is general. For detailed information and specific repair procedures on a particular aircraft, refer to the technical manual for that aircraft or component.

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CHAPTER 1

PRINCIPLES OF HELICOPTER FLIGHT

Basic flight theory and aerodynamics are considered in full detail when an aircraft is designed. The rotor repairer must understand these principles in order to maintain aircraft safely and to make repairs that are structurally sound and aerodynamically smooth.

AERODYNAMICS

Aerodynamics deals with the motion of air and with the forces acting on objects moving through air or remaining stationary in a current of air. The same principles of aerodynamics apply to both rotary-wing and fixed-wing aircraft. Four forces that affect an aircraft at all times are weight, lift, thrust, and drag:

- Weight is the force exerted on an aircraft by gravity. The pull of gravity acts through the aircraft's center of gravity, which is the point at which an aircraft would balance if suspended. The magnitude of this force changes only with a change in aircraft weight.
- Lift is produced by air passing over the wing of an airplane or over the rotor blades of a helicopter. Lift is the force that overcomes the weight of an aircraft so that it can rise in the air.
- Thrust is the force that moves an aircraft through the air. In a conventional fixed-wing aircraft, thrust provided by the propeller moves the plane forward while the wings supply the lift. In a helicopter both thrust and lift are supplied by the main rotor blades.
- Drag is the force of resistance by the air to the passage of an aircraft through it. Thrust force sets an aircraft in motion and keeps it in motion against drag force.

Any device designed to produce lift or thrust when passed through air is an airfoil. Airplane wings, propeller blades, and helicopter main and tail rotor blades are all airfoils (Figure 1-1).

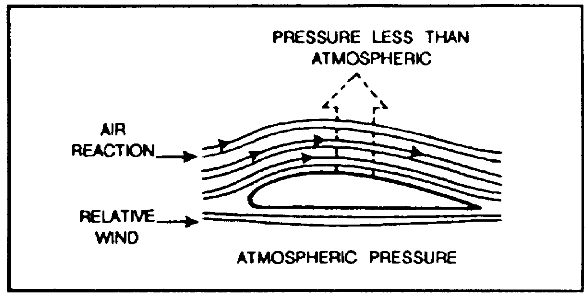

Figure 1-1. Example of an airfoil

Chord is the distance, or imaginary line, between the leading and the trailing edge of an airfoil. The amount of curve, or departure of the airfoil surface from the chord line, is known as the camber. Upper camber refers to the upper surface; lower camber refers to the lower surface. If the surface is flat, the camber is zero. The camber is positive if the surface is convex (curves outward from the chord line). The camber is negative if the surface is concave (curves inward toward the chord line). The upper surface of an airfoil always has positive camber, but the lower surface may have positive, negative, or zero camber (Figure 1-2).

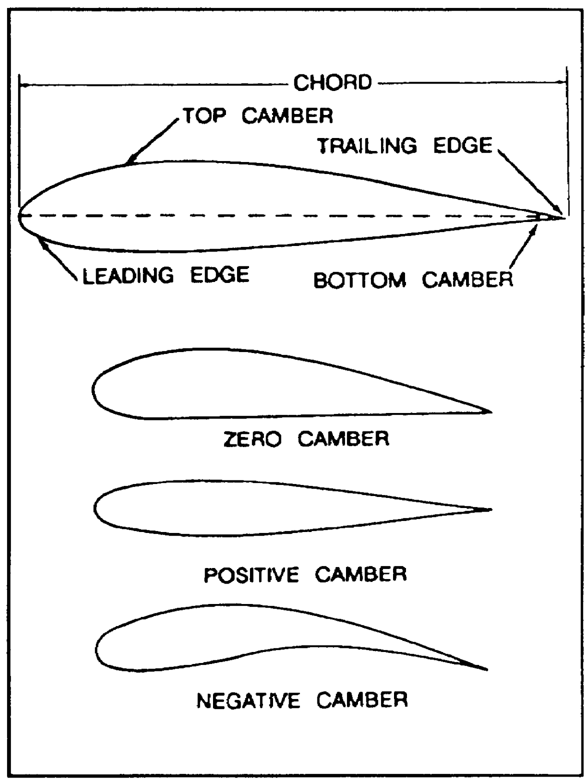

Figure 1-2. Airfoil features

BERNOULLI'S PRINCIPLE

Bernoulli, an eighteenth century physicist, discovered that air moving over a surface decreases air pressure on the surface (Figure 1-3). As air speed increases, surface air pressure decreases accordingly. This is directly related to the flight of an aircraft. As an airfoil starts moving through the air, it divides the mass of air molecules at its leading edge. The distance across the curved top surface is greater than that across the relatively flat bottom surface. Air molecules that pass over the top must therefore move faster than those passing under the bottom in order to meet at the same time along the trailing edge. The faster airflow across the top surface creates a low-pressure area above the airfoil. Air pressure below the airfoil is greater than the pressure above it and tends to push the airfoil up into the area of lower pressure. As long as air passes over the airfoil, this condition will exist. It is the difference in pressure that causes lift. When air movement is fast enough over a wing or rotor blade, the lift produced matches the weight of the airfoil and its attached parts. This lift is able to support the entire aircraft. As airspeed across the wing or rotor increases further, the lift exceeds the weight of the aircraft and the aircraft rises. Not all of the air met by an airfoil is used in lift. Some of it creates resistance, or drag, that hinders forward motion. Lift and drag increase and decrease together. They are therefore affected by the airfoil's angle of attack into the air, the speed of airflow, the air density, and the shape of the airfoil or wing.

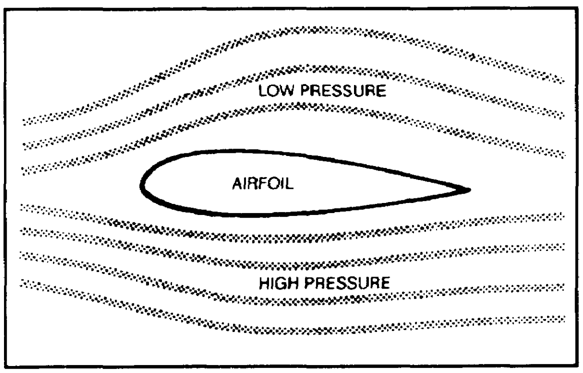

Figure 1-3. Bernoulli's principle

LIFT AND THRUST

The amount of lift that an airfoil can develop depends on five major factors:

- Area (size or surface area of the airfoil).
- Shape (shape or design of the airfoil sections).
- Speed (velocity of the air passing over the airfoil).
- Angle of attack (angle at which the air strikes the airfoil).
- Air density (amount of air in a given space).

Area and Shape

The specific shape and surface area of an airfoil are determined by the aircraft manufacturer. An airfoil may be symmetrical or unsymmetrical, depending on specific requirements. A symmetrical airfoil is designed with an equal amount of camber above and below the airfoil chord line. An unsymmetrical airfoil has a greater amount of camber above the chord line. An airfoil with a smooth surface produces more lift than one with a rough surface. A rough surface creates turbulence, which reduces lift and increases drag.

Speed

The speed of an airfoil can be changed by the speed of the engine or by the angle of the blade. The lift developed by an airfoil increases as speed increases. However, there is a limit to the amount of lift because the drag (resistance) of the airfoil also increases as speed increases.

Angle of Attack

The angle of attack is the angle between the airfoil chord and the direction of relative wind. Direction of airflow in relation to the airfoil is called relative wind. Lift increases as the angle of attack increases up to a certain point. If the angle of attack becomes too great, airflow over the top of the airfoil tends to lose its streamlined path and break away from the contoured surface to form eddies (burbles) near the trailing edge. When this happens, the airfoil loses its lift, and it stalls. The angle of attack at which burbling takes place is called the critical angle of attack.

Air Density

The density (thickness) of the air plays an important part in the amount of lift an airfoil is able to make. The air nearest the earth's surface is much denser than air at higher altitudes. Therefore, an aircraft or helicopter can achieve more lift near the ground than at a high altitude. While keeping at the same speed and angle of attack, an airfoil will slowly make less lift as it climbs higher and higher.