Sound barrier

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Abstract

This article examines the phenomenon of the sonic boom and the confusions that are often related to the breaking of sound barrier. It also describes the processes that impact the body moving with the speed greater than the speed of sound and the changes that accompany its movement.

1 Introduction

In aerodynamics, the sound barrier usually refers to the point at which an aircraft moves from speed smaller than the speed of sound to the speed greater than the speed of sound. The air forces have conducted faster-than-sound test flights since 1947, and today a lot of fighter aircraft are capable of supersonic speed.

Some common objects such as the bullwhip are also able to move faster than sound.

2 Speed of sound

Sound is a vibration that travels through an elastic medium as a wave. Sound can propagate almost through all forms of matter: gases, liquids, solids, and plasmas as a wave. However, sound cannot propagate through vacuum. The matter that supports the sound is called the medium. [1]

The speed of sound describes how much distance such a wave travels in a certain amount of time. In dry air at 20 °C, the speed of sound is 343 m/s (1235 km/h, or 770 mph). The speed of sound is variable and depends mainly on the temperature and the properties of the substance through of which the wave is traveling. Sound travels faster in liquids and non-porous solids than it does in air.

3 Sonic barrier and sonic boom

Sonic boom is an impulsive noise similar to thunder. It is caused by an object moving faster than sound. At sea level the speed of sound is about 1,200 km per hour, and at 11,000 meters it is about 1,050 km per hour.

If an aircraft flies at somewhat less than sonic speed, the pressure waves (sound waves) it creates outspeed their sources and spread out ahead of it. Once the aircraft reaches sonic speed the waves are unable to get out of its way. Strong local shock waves form on the wings and body; airflow around the craft becomes unsteady, and severe buffeting may result, with serious stability difficulties and loss of control over flight characteristics. [2]

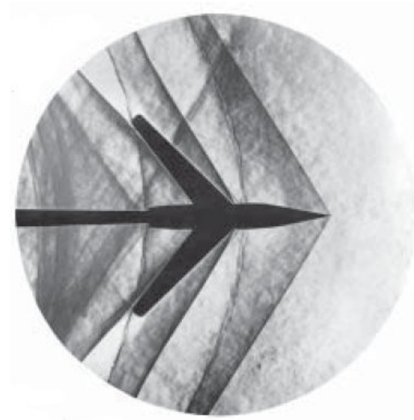

Fig.1: wave drag on the surface of the aircraft

These shock waves cause the wave drag. On the limit of the shock wave the properties of the stream suffer cardinal changes – its speed relating to the body decreases and becomes subsonic, pressure in the stream and the temperature of the gas increase a lot. A part of kinetic energy of a stream turns to internal energy of gas. All these changes are more prominent, the greater is the speed of a supersonic stream.

At supersonic speeds the temperature of the gas reaches several thousand degrees that creates serious problems for devices, moving with such speeds, (for example, Space the Shuttle "Columbia" crushed on February, 1st, 2003 because of damage of the thermodefending environment, arisen during flight).

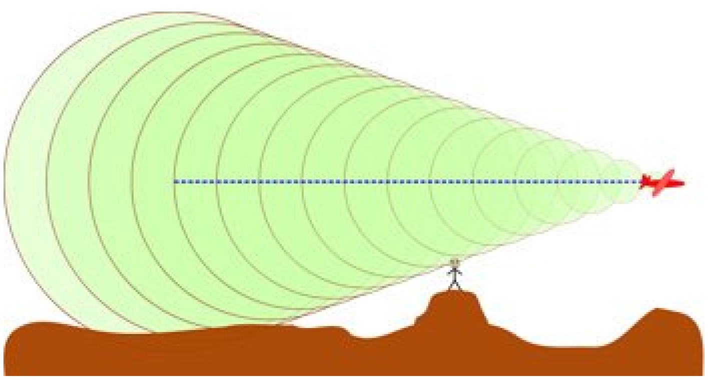

Fig.2: A sonic boom produced by an aircraft

Concerning the sound that accompanies the breaking the sound barrier there are several peculiarities. Normally, for a plane that is going at subsonic speeds (lower than that of sound), the sound of the plane is radiated in all directions. However, the individual sound wavelets are compressed at the front of the plane and further spread at the back of the plane because of the forward speed of the plane (Doppler effect). Now, if the plane is traveling at the supersonic speeds, it is going faster than it's own sound. As a result, a pressure (sound is variation in pressure) wave is produced in the shape of the cone whose vertex is at the nose of the plane, and whose base is behind the plane. The angle opening of the cone depends on the actual speed the plane is traveling at. All of the sound pressure is contained in this cone.

So imagine now this plane in a level flight. Before the plane passes you, you can only see it but you cannot hear anything. The pressure cone is trailing behind the plane. Once your ears intersect the edge of this cone, your will hear a very loud sound - the sonic boom. Therefore you will hear the sonic boom once your ears intersect this cone, and not when the plane breaks the sound barrier (as it is commonly misunderstood). [3]

The greater an aircraft's altitude, the lower the overpressure on the ground. Greater altitude also increases the boom's lateral spread, exposing a wider area to the boom. Depending on the aircraft's altitude, sonic booms reach the ground two to 60 seconds after flyover.

The scientists continue to expand their knowledge of sonic boom. Continuing research specifically addresses modeling the generation of a sonic boom and its impact on the environment people, domestic animals, wildlife, and historical, unconventional and conventional structures.

Literature

[1] http://en.wikipedia.org/
[2] http://www.sky-flash.com/boom.htm
[3] www.answers.com/topic/sonic-barrier