Bernoulli's Principle and the Theory of Flight

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Abstract. There seems to be disagreement within the scientific community as to whether or not Bernoulli's Principle explains why aeroplanes fly. It will be explained below that aeroplanes fly for the singular reason that the air pressure under the wings is greater than the air pressure above the wings.

Air Pressure and Lift

I. Pressure is dimensionally equivalent to energy per unit volume. If we increase the volume of a sample of gas, the pressure will reduce. When an aeroplane is rising, the wings are at such an angle that the air below the wings becomes compressed and the air above the wings becomes rarefied. These respective volume changes result in the pressure below the wings being greater than the pressure above the wings and hence giving rise to lift. This same effect can be brought about by horizontal motion if the wings possess aerofoil sections with a camber on the upper side.

An additional factor is the deflection of the air downwards by the underside of the wings when they have an angle of attack. This will result in an upward reaction force on the wings.

Bernoulli's Principle

II. Bernoulli's Principle is essentially a statement of the principle of conservation of energy. When the pressure or potential energy decreases, the kinetic energy will increase proportionately provided that only irrotational forces are involved. With air molecules it is commonly believed that only the irrotational Coulomb force is involved. What is actually much more likely is that it is the repulsive centrifugal force between air molecules that is involved in air pressure. The centrifugal force is ultimately yielded at microscopic level by the expression grad (**A**.**v**) where **A** is essentially the aether field velocity. See section **III** of 'Gravitational Induction and the Gyroscopic Force' at,

http://www.wbabin.net/science/tombe5.pdf

A is more commonly referred to as the magnetic vector potential hence obscuring its greater significance as centrifugal potential energy when in the combination (**A**.**v)**. The curl of a gradient is always zero and so the centrifugal force is irrotational. (see **Appendix A**)

Bernoulli's Principle is involved in the theory of flight because in the rarefied region of air above the wings, potential energy has converted to kinetic energy. This kinetic energy can be linear as in the case of aerofoil sections with a large upper camber, or it can be in the form of vorticity in the case of thin aerofoils.

This faster flow of air above the wings, in line with Bernoulli's Principle, is not however the cause of the reduction of the air pressure.

When an aeroplane is rising, the reduction in the air pressure above the wings, and the speeding up of the air molecules above the wings, are both equally a consequence of the increase in volume and hence the rarefaction of the air above the wings. This rarefaction of the air above the wings is a direct consequence of the forward motion of the aeroplane.

Appendix A

III. The gradient of a scalar product of two vectors is given by the standard vector identity,

$$\text{grad}\,(\mathbf{A}.\mathbf{v}) = \mathbf{A}\text{X curl }\mathbf{v} + \mathbf{v}\text{X curl }\mathbf{A}$$

$$+ (\mathbf{A}.\text{grad})\mathbf{v} + (\mathbf{v}.\text{grad})\mathbf{A} \qquad \textbf{(1A)}$$

Since **v** represents arbitrary particle motion, the first and the third terms on the right hand side of equation **(1B)** will vanish, and from the relationship curl **A** = **H**, we obtain,

$$\text{grad}\,(\mathbf{A}.\mathbf{v}) = \mathbf{v}\text{X}\mathbf{H} + (\mathbf{v}.\text{grad})\mathbf{A} \qquad \textbf{(2A)}$$

Since curl **A** = **H**, taking the curl of equation **(2A)** yields,

$$\text{curl grad}\,(\mathbf{A}.\mathbf{v}) = \text{curl}\,(\mathbf{v}\text{X}\mathbf{H}) + (\mathbf{v}.\text{grad})\mathbf{H} \qquad \textbf{(3A)}$$

It will now be shown that curl (**v**X**H**) is equal to − (**v**.grad)**H**.

$$\text{curl}\,(\mathbf{v}\text{X}\mathbf{H}) = \mathbf{H}(\text{div }\mathbf{v}) - \mathbf{v}(\text{div}\mathbf{H}) + (\mathbf{H}.\text{grad})\mathbf{v} - (\mathbf{v}.\text{grad})\mathbf{H} \qquad \textbf{(4A)}$$

Since **v** represents arbitrary particle motion, the first and the third terms on the right hand side of equation **(4A)** will vanish. The second term containing div**H** will vanish also because the magnetic field is solenoidal. This leaves us with the fourth term which exactly cancels with the +(**v**.grad)**H** term in equation **(3A)**. Hence centrifugal force is irrotational.