C.P. No. 281
(18,343)
A.R C. Technical Report

C.P. No. 281
(18,343)
A.R C. Technical Report

MINISTRY OF SUPPLY

AERONAUTICAL RESEARCH COUNCIL

CURRENT PAPERS

Report of the Pressure Panel on the Definitions of Quantities having the Dimensions of Pressure

LONDON . HER MAJESTY'S STATIONERY OFFICE

1956

ONE SHILLING NET

C.P. No. 281

Report of the Pressure Panel on the Definitions
of Quantities having the Dimensions of Pressure

7th August, 1956

1. Introductıon

In a recent publicatıon[1] the problem of defining the thrust of a jet engıne, or the internal drag of a ducted body, is consıdered in some detail. This Report was compiled by a spocial Panel of the A.R.C. and, during its discussions, concern was oxpressed at the position regarding the definitions of certain quantities having the dimensions of pressure; ın some cases the most widely-used definitions were not rigorous, in others a varıety of names wero ın use. In addition, some quantities of consıderable value ın fluid dynamics were either unnamed or had been given misleading namos. This state of affairs was felt to be undesırablo. As a result, tho A.R.C. set up a small Panel to consider the matter more fully. The Panel contained representatıvos from both of tho two ımportant groups ınterestod ın obtaining unıformıty in thıs field, those concornod with extornal aerodynamics end those primarily interested ın internal flow probloms.

Tho mombors of the Panol were:-

Prof. W. A. Maır	Chairman)
Mr. I. M. Davidson	IN.G.T.E.)
Mr. F. B. Greatrex	(S.B.A.C.)
Mr. C. H. E. Warren	(R.A.E.)
Prof. A. D. Young	
Mr. E. W. E. Rogers	(N.P.L., Secrotary).

In tho following paragraphs, the recommendations agreed by the Panel aro set out; for convenıenco, tho formal definitions of the various quantıtios are gathorod together ın an Appendix. Tho defınıtıons have been framed so that thoy arc applicable to tho flow of a continuous fluid. For low-densıty (i.o., froo molocular) gases, different definitions would be required.

2. Quantıtıos having tho Dımensıons of Prossuro

Tho prossuro at a point within a fluid can bo formally defıned as the moan of tho normal components of stress on throo mutually-porpendıcular olements of surfacos at that point, at rest relative to the fluid. For a fluid ın motion the prossuro is usually callod static pressure to distinguish it from othor quantities also having the dimensions of pressure, and tho Panel recommends that tho uso of this torm should contınuo. The static prossuro is tho pressure mcasurod by an infinıtosimal instrument at rost relative to tho fluid, or by a correctly desıgnod and aligned static tube. If the fluid is considered as boing composod of discrete moloculos, tho static prossure can bo regarded as arising from tho random motion of thcso moloculos, a motion whioh is superımposed on tho general directed motion of tho fluid.

If/

If tho fluid is brought to rest by a process which is both isentropic and adiabatic+, tho pressure increases to a maximum value. The Panel recommends that this maximum value be called tho total pressure of tho fluid. Roservoir pressure may bo used as en alternative name, whero this is more descriptive or is 'preferred.

In tho past, tho term 'stagnation pressure' has sometimes been used synonymously with total pressure. The Panel recommends that stagnation pressure bo usod only to describe tho pressure at a stagnation point on a body, defined, for the purposes of this Report, as a point whore the velocity of tho fluid is zero relative to the body, and where the streamlines divide and continue downstream to follow the contour of the body,

The Panol recommends that the term dynamic pressure be used for the differenco botwcen the total and static pressures. Bernoulli's equation shows that for an incompressible fluid this is equal to half the product of tho density and the square of tho velocity, i.e., the kinetic energy per unit volume of the fluid. For a compressible fluid this equality is no longer valid and the Panel recommends that the kinetic energy por unit volume should be called the kinetic pressure, to distinguish it from tho dynamic pressure.

In subsonic flow the total pressure is measured by a pitot tube if this is correctly aligned, provided tho Roynolds number of the tube is not very small. When tho flow is supersonic, howcver, a *normal* shock wave oxists ahead of tho tube end the measured pressure is then tho total pressure downstream of the shock wave; this is smaller than the total pressure upstream of the shock wave. The Panel recommonds that the pressure measured by a correctly-aligned pitot tube should be called the pitot pressure for both subsonic and supersonic flows.

The difference between tho pitot and static pressures is commonly used to determine the speed of an aircraft. Whon the speed is subsonic tho quantity measured is tho dynamic pressure, but at supersonic speeds tho observed pressure difference is smaller than tho dynamic pressure. It may bo convenient in certain types of work (e.g., the determination of position error) to have a name for tho difference between tho pitot end static prcssuros, end tho Panel suggest that indicated dynamic pressure should then bo used.

A quantity which often arises when changes of momentum are being considered is the product of tho density and tho square of the velocity. This quantity is the momentum flux per unit area across a surface normal to tho streamlines, and at present has no well-established name. The Panel suggests that it should bo called tho momentum pressure! if a need is felt for a more explicit form of this name momentum-flux pressure is suggested.

Tho sum of tho static pressure and the momentum pressure arises naturally in applying the momentum equation to determine the force on a body; for this reason the Panol suggests that this quantity bo called the reaction prcssuro.

3./

+It is possiblo for an irreversible process to maintain constant entropy (i.e., to bo isentropic) by transferring heat across tho boundaries of the flow. In the process being oonsidcrod this heat transfer must not bo allowed to occur; honco tho nood for the doublo condition of isentropic and adiabatic flow.

3. Concluding Remarks

It is hoped that a general adoption of the names and definitions contained in this Report will reduce the present ambiguity in the field of fluid dynamics and will encourage uniformity betwocn tho various branches of the subject, each of which has hitherto tended to develop its own nomenclature.

APPENDIX

Definitions of Quantities having tho Dimensions of Pressure

The following definitions relate to a continuous fluid.

1. Static pressure.- The moan of the normal components of stress on three mutually-perpendicular elements of surface, at rest relative to tho fluid. It is the prossurc measured by an infinitesimal instrument at rest relative to the fluid.

2. Total pressure.- Tho prcssure which would arise if the fluid were brought to rest isentropically and adiabatically.

3. Stagnation pressure.- Tho pressure at a stagnation point on a body.

4. Dynamic pressure.- The difference between the total prcssure end the static prcssuro.

5. Indicated dynamic pressure.- The difference between the pitot pressure end the static prcssuro.

6. Kinetic pressure.- Tho kinetic energy per unit volume of the fluid. It is equal to half tho product of tho fluid density and the square of tho velocity.

7. Pitot pressure.- The pressure measured by a pitot tube correctly aligned with tho stream. At a point where tho flow is subsonic it is equal to tho total pressure+; at a point whore the flow is supersonic it is equal to the total prcssure behind a normal shock wave.

8. Momentum pressure.- The momentum flux per unit area across a surface normal to the local flow. It is equal to tho product of the fluid density and the square of tho velocity

9. Reaction pressure.- The sum of the static prcssure end the momentum pressure.

References/

+The exceptional caec of very small tube Reynolds number is not considered here.

References

No.	Author(s)	Title, etc.
1		Report of the Definitions Panel on the definitions of the thrust of a jet engine and of the internal drag of a ducted body. C.P. 190. 20th May, 1954. J. R. Ae. Soc., Vol. 59, pp. 517-526. (August, 1955.)

Printed and published by
HER MAJESTY'S STATIONERY OFFICE
To be purchased from
York House, Kingsway, London W C 2
423 Oxford Street, London W.1
P O Box 569, London S E 1
13A Castle Street, Edinburgh 2
109 St. Mary Street, Cardiff
39 King Street, Manchester 2
Tower Lane, Bristol 1
2 Edmund Street, Birmingham 3
80 Chichester Street, Belfast
or through any bookseller

Printed in Great Britain

S O Code No. 23-9009-81