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Relationships between some common intake parameters

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Mr P.C.H. White	— Plessey Co. Ltd, Dynamics Group
Mr W.F. Wiles	— Rolls-Royce Ltd.

The construction and subsequent development of the Data Item was undertaken by

Mr A.J. Ward Smith	— Head of Fluid Mechanics and Thermodynamics Group
Mrs K.M. McCreath	— Fluid Mechanics and Thermodynamics Group.

RELATIONSHIPS BETWEEN SOME COMMON INTAKE PARAMETERS

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RELATIONSHIPS BETWEEN SOME COMMON INTAKE PARAMETERS

1. NOTATION

A	cross-sectional area normal to flow	m^2	ft^2
a	speed of sound = $\sqrt{(\gamma RT)}$	m/s	ft/s
M	Mach number = V/a		
m	mass flow	kg/s	slug/s
p	static pressure	N/m^2	lbf/ft^2
p_H	total pressure	N/m^2	lbf/ft^2
R	gas constant	J/kg K	ft lbf/slug K
T	static temperature	K	K
T_H	total temperature	K	K
V	mean velocity	m/s	ft/s
γ	ratio of specific heat capacities		
η_{ad}	adiabatic efficiency		
η_r	ram efficiency		
λ	total pressure loss coefficient		
ρ	density	kg/m^3	slug/ft^3
<i>Suffixes</i>			
0	free-stream conditions		
1	conditions at downstream end of duct		

2. NOTES

A number of parameters are commonly used to denote intake performance and this Item presents graphs to facilitate conversion from one to another.

The parameters are defined as follows:

Adiabatic Efficiency, η_{ad}

$$\eta_{ad} = \left[(p_{H1}/p_0)^{\frac{\gamma-1}{\gamma}} - 1 \right] / \left[T_{H1}/T_0 - 1 \right]. \quad (2.1)$$

Ram Efficiency, η_r

$$\eta_r = \frac{p_{H1} - p_0}{p_{H0} - p_0}. \quad (2.2)$$

Total Pressure Loss Coefficient, λ

$$\lambda = \frac{p_{H0} - p_{H1}}{\frac{1}{2} \rho_1 V_1^2}. \quad (2.3)$$

It is convenient to express Equations (2.1) and (2.2) in terms of total pressure ratio, p_{H1}/p_{H0} , Mach number, M_0 and γ giving:

$$\eta_{ad} = \left[\left(1 + \frac{\gamma-1}{2} M_0^2 \right) (p_{H1}/p_{H0})^{\frac{\gamma-1}{\gamma}} - 1 \right] / \left[\frac{\gamma-1}{2} M_0^2 \right] \quad (2.4)$$

$$\eta_r = \left[\left(1 + \frac{\gamma-1}{2} M_0^2 \right)^{\frac{\gamma}{\gamma-1}} (p_{H1}/p_{H0}) - 1 \right] / \left[\left(1 + \frac{\gamma-1}{2} M_0^2 \right)^{\frac{\gamma}{\gamma-1}} - 1 \right]. \quad (2.5)$$

Figures 1 and 2 show the variation of η_{ad} with p_{H1}/p_{H0} , for $\gamma = 1.40$, for $0 \leq M_0 \leq 1.0$ and $1.0 \leq M_0 \leq 4.0$, respectively. The corresponding variations of η_r are shown on Figures 3 and 4, respectively. The variation of η_r with η_{ad} and Mach number is shown on Figures 5 and 6 for the same two ranges of M_0 . Figure 7 shows the variation in total pressure loss coefficient, λ , with pressure ratio for a range of values of the mass flow function $m\sqrt{(RT_{H1})}/A_1 p_{H1}$. This parameter is chosen instead of M_1 to ease reference to standard engine brochure presentations. The relationship between the mass flow function and Mach number can be found in Item No. 81004. The Mach number range of Figure 7 is about $0 < M_1 < 0.65$ which covers the speeds at which λ is normally of interest.

All Figures are plotted assuming $\gamma = 1.40$. For $M_0 > 3.0$ the assumption that γ is constant may no longer be valid so care must be taken in using the data in the high speed range.

Similar definitions of efficiency are sometimes used for diffusers and the curves may be useful for diffusers as well as intakes.