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Performance Analysis of Boeing 777-200 ER

Avinash Kumar

Department of Aerospace Engineering, Gurukul Vidyapeeth Institute of Engineering & Technology (GVIET) Banur 140601, India

ABSTRACT

Performance Analysis of Boeing-777 200 ER was conducted in Research & Development section of the Department of Aerospace Engineering at Gurukul Vidyapeeth Institute of Engineering & Technology (GVIET). The main aim of this analysis was to measure performance parameters including drag coefficient, lift coefficient, engine characteristics (thrust available), stalling speed and range. We found the relation of C_L Vs C_D and other parameters

Keywords: Boeing 777-200 ER, Performance Characteristic

I. INTRODUCTION

Boeing 777-200 ER is a family of long-range twin-engine jet airliner developed and manufactured by Boeing Commercial Aircraft Company is the world largest Twinjet Aircraft The updated version of Boeing 777-200 was originally known as the 777- 200 ER. The 200 ER has additional fuel capacity and an increased maximum takeoff weight over Boeing 777- 200. In addition to breaking the eastbound great circle "distance without landing" record, the -200ER also holds the record for the longest ETOPS-related emergency flight diversion (177 minutes under one engine), on a United Airlines flight carrying 255 passengers on March 17, 2003, over the Pacific Ocean. The analysis of performance parameters of Boeing 777-200 ER is measured and recorded so that future research work on performance analysis of an airplane will be convenient and comparable. The chosen aircraft Boeing 777-200 ER has overall length 63.73 m, height 18.5 m, fuselage length 62.94 m, fuselage diameter 6.19 m, wing area 427 m^2, wing span 60.9m, maximum cruising speed 1,030 km/h maximum cruising altitude 13,100, cruise speed 900 km/h at 35000 ft. at M=0.84. The drag polar equation is calculated by taking mach no. 0.6. Once getting drag polar equation and drag polar relation, all other propertied like coefficient of lift (C_L), coefficient of drag (C_D), stalling speed (V_S), Thrust (T), Power Required, Variation of C_{D0} with K, Variation of drag coefficient (C_{D0}) with Mach.

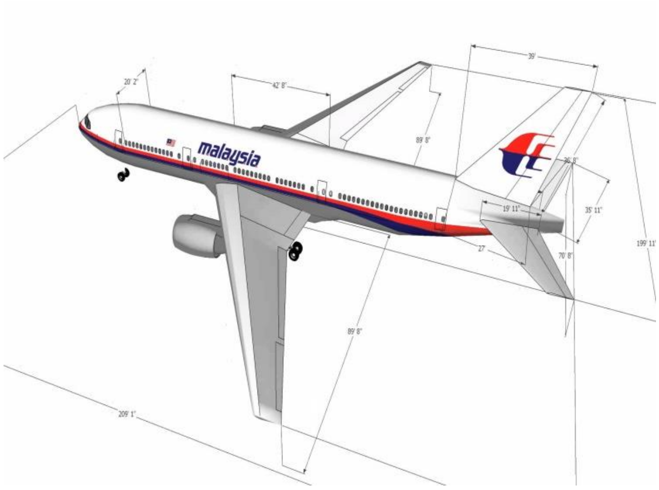

Figure 1 : Boeing 777-200 ER Aircraft number (M) were also calculated.

II. METHODS AND MATERIAL

Performance analysis is a very important part of study to analyse the performance of an aircraft. In this project, we analyse the performance parameters by taking account Boeing 777-200 ER aircraft.

The complete analysis is completed by taking the aircraft in steady level flight condition.

III. RESULTS AND DISCUSSION

To obtain the perfomance of an aircraft it is necessary to calculate the value of drag coefficient of the airplane

(C_D) when the lift coefficient (C_L) and Mach Number (M) are given. This is calcuted

by drag polar equation :-

$$(C_D) = (C_{D0}) + KC_L^2$$

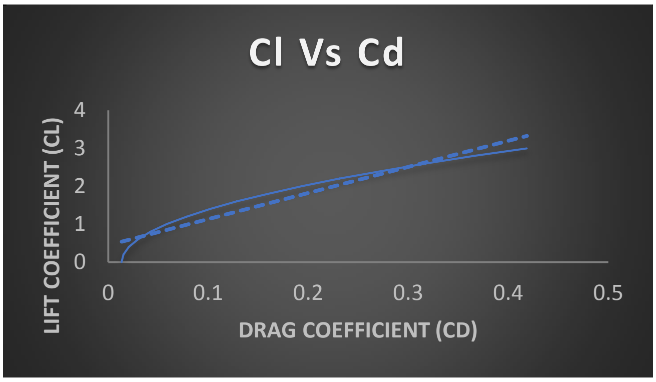

Figure 2 : Drag Polar relation

The drag polar coefficient C_{D0} and K are assumed to be constant up to the cruise Mach number (M_{Cruise}).

However, C_{D0} and K are expected to become function of Mach number above the cruise Mach number. We can use the following analytical method to find C_{D0} and K from 0.84 to 0.94 :-

$$C_{D0} = 0.01395 - 0.001(M - 0.84) + 0.11(M-0.84)^2$$

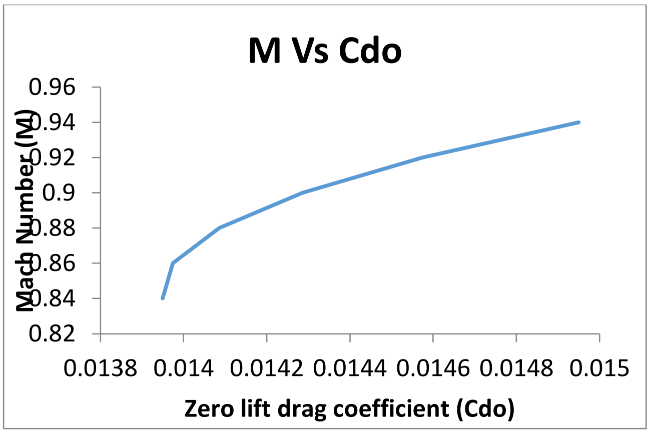

Figure 3 : Variation in zero-lift drag at different Mach Number

$$K = 0.04885 + (M- 0.84)^2 + 20\,(M- 0.84)^3$$

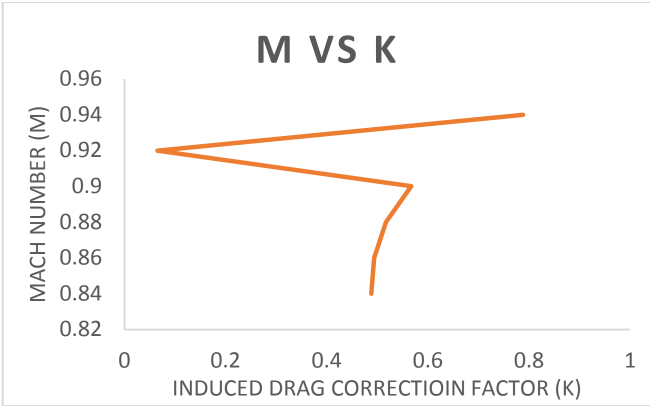

Figure 4 : Variation in induced drag correction factor at different Mach Number

For certain height, an aircraft has maximum and minimum velocity. The maximum and minimum velocity differs for different height.

Minimum Flight Velocity (V_{Min}) = ($W/S \times 2/\sigma \times 1/C_L$)

Maximum Fight Velocity;

$$V_{Max} = \{[(T_A)_{Max}/W]\,(W/S) + (W/S) \times [(T_{Max}/W)^2 - 4C_{D0}K]^{1/2}]/\,[\sigma\, C_{D0}]\}$$

Engine characteristic study gives the result Thrust Available (T_A) and Thrust Required (T_R). Thrust required is calculated by solving the basic aircraft equation of motion:-

$$T - D = 0 = T_R$$

Thrust Available is thrust provided by the engine of the aircraft.

For Steady level flight condition, Thrust available and Thrust required is same.

$$T_A = T_R$$

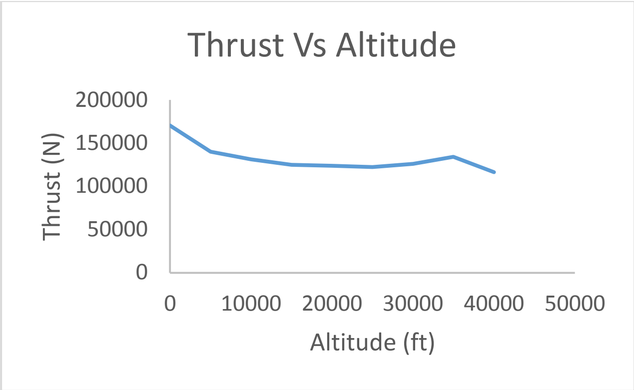

Figure 5 : Variation of Thrust at different Altitude

For aircraft operation, power is required which is produced in the power plant of the aircraft.

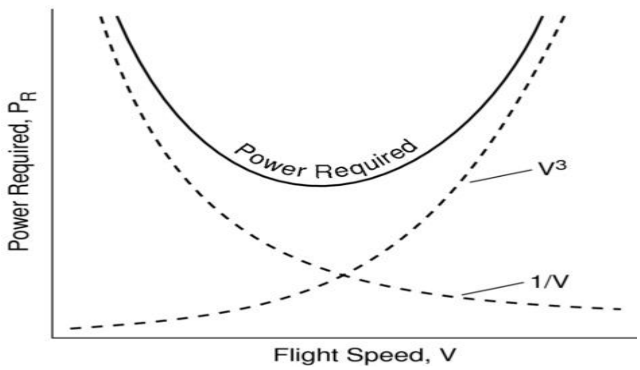

Figure 6 : Typical Power Required Curve for an Aircraft

Stalling Speed (V_S), is the speed of the aircraft in steady flight at its maximum lift coefficient (C_{Lmax})

$V_S = (2W/\sigma S\ C_{Lmax.})^{1/2}$

Value of $\mathbf{C_{Lmax}}$**:-**

- With Flap =1.4
- Without Flap =2.7

Altitude(m)	V_S with flap in m/s	V_S without flap in m/s
0	80.65390168	58.07744703
2000	88.97879834	64.07205774
4000	98.63361778	71.02432233
6000	109.9056917	79.14114323
8000	123.1774097	88.69787249
10000	138.955644	100.0594998
11000	147.9797871	106.5576254
12000	160.122706	115.3015264

Table 1: Stalling Speed at different Altitude

Climb is the operation, where there is an increase in the altitude of the aircraft to a predetermined level.

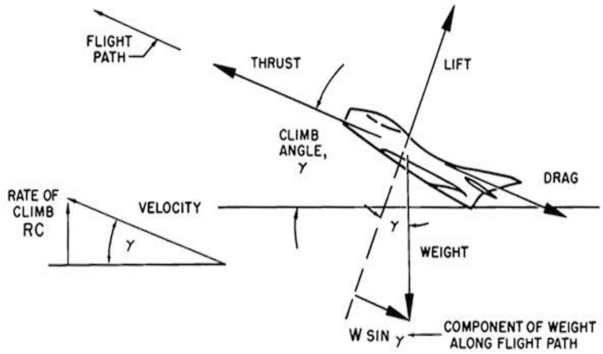

Figure 7 : Aircraft approaching in climb

This analysis would give information about the Angle of climb, Rate of climb, Climb Thrust of the aircraft.

Angle of climb (γ)

$= Sin^{-1}(T - D)/W$

Rate of climb (V_C)

$= V\ Sin\gamma = V\ (T - D/W)$

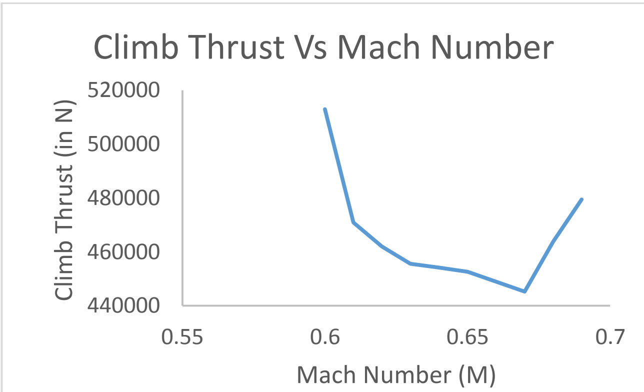

Figure 8 : Variation in climb Thrust at different Mach Number

During Descent,there is decrease in altitude of aircraft The study of descent give information about the Angle of descent, Rate of descent.

Angle of descent (γ) =

$Sin^{-1}\ (T\text{-}D)/V$

Rate of descent (V_d) =

$(D\text{-}T)\ /W \times V$

IV. CONCLUSION

Boeing 777 - 200 ER was analyzed for calculating the performance parameters as planned. From this analysis , it is found that the drag coefficient is function of zero lift drag coefficient and induced drag correction factor are assumed, to be constant up to cruise Mach number equals to 0.84. After cruise mach number ($M>0.84$) they are expected to become function of Mach number. Thrust available & Thrust required are same for steady level flight but, it may vary in accelerated flight condition. Maximum lift coefficient have value 1.4 and 2.7 both for flap and without flap respective. For Boeing 777-200 ER aircraft typical value of angle of climb is between $7^0 – 9^0$. During both climb and descent the centre of gravity of the airplane moves along the line inclined to the horizontal at an angle which is called angle of climb (in climb) or angle of descent (in descent).

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