NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

SPECIAL REPORT 3-A

ESTIMATED EFFECT OF RING COWL ON THE CLIMB AND CEILING OF AN AIRPLANE

By F. A. Louden
Bureau of Aeronautics

Washington
June, 1931

Special Report 3A

ESTIMATED EFFECT OF RING COWL ON THE CLIMB AND CEILING OF AN AIRPLANE

By F. A. Louden

Although the application of a ring cowl to an airplane with an air-cooled engine increases the maximum L/D and the high speed to an appreciable extent, the performance in climb and ceiling is not increased as much as one would expect without analyzing the conditions.

When a ring cowl is installed on an airplane, the propeller is set at a higher pitch to allow the engine to turn its rated r.p.m. at the increased high speed. V/nD is increased and the propeller efficiency at high speed is increased slightly. The ratio of r.p.m. at climbing speed, V_c, to the r.p.m. at maximum speed, V_m, is dependent upon the ratio of V_c to V_m. The increase in V_c for an airplane with ring cowl is not as great as the increase in V_m, so that the ratio V_c/V_m is less than for the airplane without ring. Consequently the r.p.m. and full throttle thrust power available are less at V_c for the airplane with ring cowl and in spite of the increase in L/D due to the installation of the ring, the excess thrust power available for climbing is not appreciably changed.

The same method of reasoning accounts for the small increase in absolute ceiling in spite of a large increase in L/D maximum.

To illustrate the above conditions, suppose we have given an airplane with the following characteristics:

	Without ring cowl	With ring cowl
Power loading W/hp	6.0	6.0
Stalling speed V_s	60.0	60.0
High speed V_m	165.0	178.0
Approximate L/D max	8.0	9.0
Speed range V_m/V_s	2.75	2.97

Equation 173 in Diehl's "Engineering Aerodynamics" for estimating the initial rate of climb, C_o, is as follows:

$$C_o = 33000 \left[\frac{K_2 \eta_m}{(\frac{W}{hp})} - \frac{V_c}{375(\frac{L}{D})} \right].$$

Using this formula and estimating the initial rate of climb for the above airplane gives the following values:

	Without ring cowl	With ring cowl
Speed range V_m/V_s	2.75	2.97
$K_2 = (V_m/V_s)^{-.27}$	.761	.745
Approx. max. prop. eff. η_m	.82	.83
Climbing speed $V_c = \frac{2V_s + V_m}{3}$	95.0	99.3
$\frac{K_2 \eta_m}{(\frac{W}{hp})}$	.1040	.1030
$\frac{V_c}{375(\frac{L}{D})}$	.0317	.0294
	.0723	.0736
Initial rate of climb C_o (ft./min.)	2390.	2430.

The absolute ceiling is estimated with the use of Diehl's new chart. (N.A.C.A. Technical Report No. 368.) The ratio of minimum thrust power required to maximum thrust power available is given by the formula

$$\frac{\text{min Thp}_r}{\text{max Thp}_a} = \frac{V_s \dfrac{W}{\eta_m \text{ hp}}}{K \dfrac{L}{D}} .$$

Using this formula for the above airplane and the chart for obtaining the absolute ceilings gives the following values:

	Without ring cowl	With ring cowl
Effective aspect ratio assumed	4.5	4.5
K	307	307
$\frac{\text{min Thp}_r}{\text{max Thp}_a}$	.179	.157
V_m/V_s	2.75	2.97
Absolute ceiling	25400	26700

Thus it is seen that for the assumed airplane there is but a small increase amounting to less than 2% in the initial rate of climb and an increase of but 5% in absolute ceiling although the high speed has increased 13 m.p.h. and the L/D maximum has increased from 8.0 to 9.0.

F. A. Louden,
Bureau of Aeronautics,
Washington, D. C., Jan. 2, 1931.