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Moderation and Weight Reduction of a Bomber Aircraft (Tupolev Tu-160)

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Abstract:-
The present paper focuses on the effective weight reduction of Aircraft to descend the operating cost of commercial flights. In Recent years, fuel prices have been increased gradually that counts for about 30% of the total cost for airplanes which imposes them to adopt some weight reduction strategies for better fuel efficiency and lower costs, hence conceived briefly in the contents of this paper. By capitalizing the Aircraft Design procedures especially the weight estimation and reduction techniques of Bomber Aircraft. By exploiting the weight estimation technical procedures to Redeem optimal solutions as Corroborate Surplus Weight to be Zero. To authenticate the ***Surplus weight*** *to be Zero, and aimed to reducing the weight of the Airplane. By knowing the value of Landing weight, Fuel Weight, Empty Weight is used to estimate Final takeoff weight. The effect of a very small amount of reduction in the Aircraft mass is examined and expressed in terms of smaller runway for takeoff and landing, Lower stall speed, approach high speed, Lower fuel consumption, Lower cost and so on. By keeping the Bomber Aircraft TUPOLEV TU-160 as reference, aiming to moderate the weight calculation. The comprehensive datasheet Bomber Aircraft TUPOLEV TU-160 has final takeoff weight as 275000 kg (606271.221 lbf); hence it can be feasible to reduce the weight as 251545.51kg (554562.921bf). It is aid to reduce the cost and enhance the fuel efficiency.*
By capitalizing the procedures for reducing the aircraft weight, especially in Bomber Aircraft namely engine start up and takeoff, Climb, Cruise out to destination, High speed intercept, Combat, Cruise back, Loiter, Landing, Fuel Weight, Available empty weight, required empty weight, Final takeoff weight. These stages are holistically engrossed about to reducing the Aircraft weight. This insightful study aims to help and encourage airline strategic planners to adopt effective strategies to save cost and increase revenue. This complete conceive about weight reduction concept is holistically authentication through possessing the calculation parts and graphs.
Keywords:- *Final Takeoff Weight, Surplus Weight, Operating Cost, Empty Weight, Fuel Weight, Fuel Price*

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I. INTRODUCTION

This paper engross about the technical solutions enable to concentrating for reducing the Airplane weight by keeping the reference Aircraft TUPOLEV TU-160 as shown in Fig. 1.1. The effect of reducing Aircraft weight is to minimize the operating cost of commercial flights. Think about the fuel, which is increasing and consumption rate also doubled due to augmenting the weight So, must reduce the weight of Airplane and retrieve the fuel efficiency. Reducing weight can be pretty important to airlines as it saves up on fuel costs. Design new strategies to ensure reducing the weight, like lighter seating arrangements, redesigning lavatories and reducing the weight of other equipment also. This can significantly alter the weight of the Airplane. Trip costs have been gradually increasing factor for Aircraft manufacturing companies in current trends which has been achieved by reducing Aircraft fuel consumption. The main reason for that is fuel, which is largest section of Airplane operating costs. According to IATA, the above information is expected to about at $180 billion in 2018, 23.5% of operating cost at $73 (bB).

This is an increase of 20.5% over 2017 and it is almost twice the $91 billion fuel cost for 2005, which equivalent to 22% of operating costs as $54.5 (bB). In 2020, the fuel bill is expected to $200 billion, around 24.2% of operating cost at $65 (bB). In order to help Airline operators to investigate the effect of small scale weight reduction, a precise aircraft performance model is needed which will result in inaccurate estimation of fuel savings because of weight reduction per flight. Thus, this paper dealt with the procedures of reducing weight of the Aircraft with particular Aircraft design weight estimation stages as shown in Fig. 1.2. Difference between available weight to require weight is called **Surplus weight.** To substantiate the surplus weight as Zero is the main aspect for this technical workout to discern the prelude Takeoff weight. By assuming the reference

Aircraft data sheet parameters as shown in Table. 2.1. and do the iteration as shown in Table. 3.1. to get ambitious surplus weight to be Zero. Then comparing the estimated weight and reference assume weight. Imagine how to find out the surplus weight by capitalizing the eight stages for Bomber Aircraft. Also we should perceive of fuel weight, Available empty weight, required empty weight, final takeoff weight.

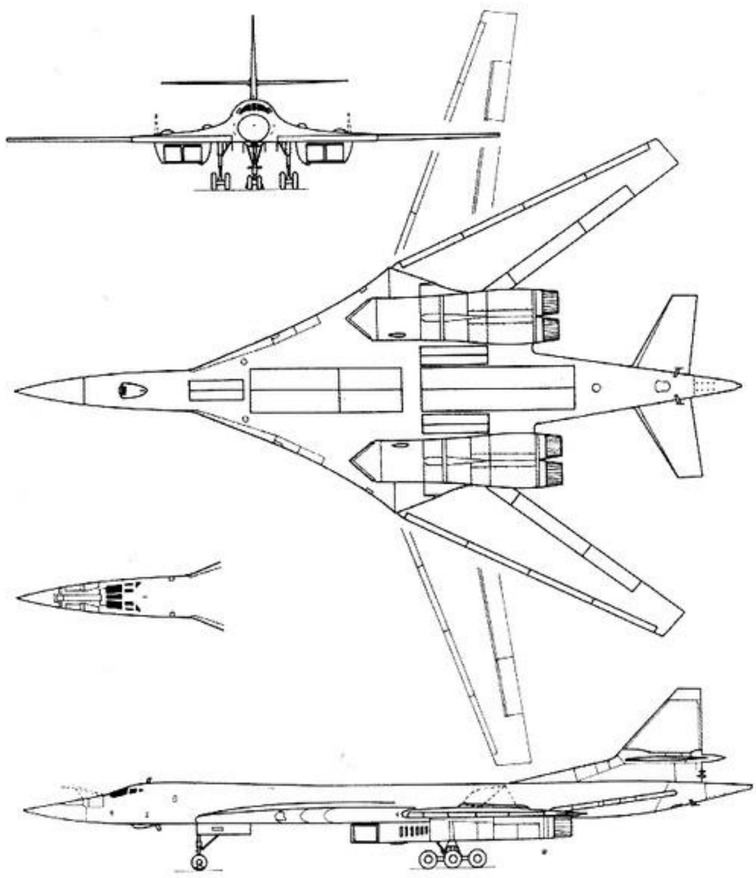


Fig. 1.1 Reference Aircraft (BOMBER) TUPOLEV TU-160

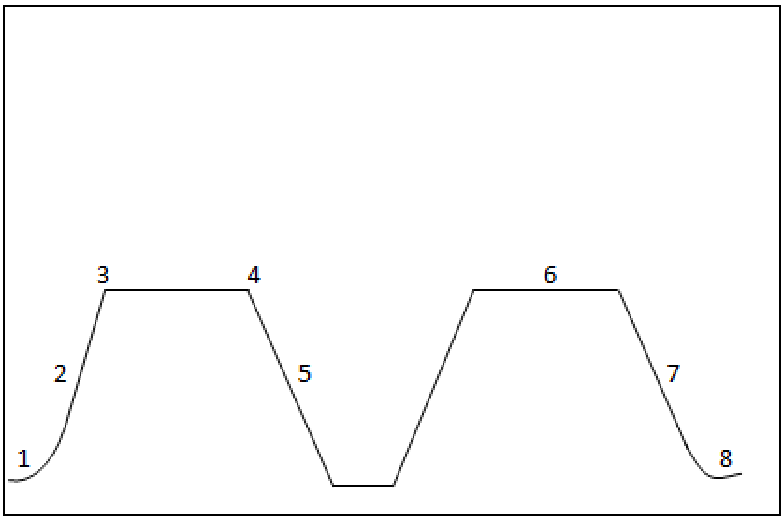


Fig. 1.2 Shows 8 stages of BOMBER Aircraft

1. Engine Startup and takeoff 2. Climb 3. Cruise out to destination 4. High Speed intercepts 5. Combat 6. Cruise back 7. Loiter 8. Landing

II. ESTIMATION OF W_O FOR AN AIRCRAFT

First and foremost data sheet for the reference Bomber Aircraft (TUPOLEV TU-160) is known. Some of the components of weight such as empty weight or structural weight, Fuel weight, Crew weight, Pay load weight. Weight may be either divided into two types namely expandable weight and Non-expandable weight. Weight which remains constant from takeoff to landing is known as Non-expandable weight (especially in passenger, Cargo) and weight that will change during different phases of flight is known as Expandable weight (Bombers, Rockets). Initially let we go ahead with aware of w_o (estimated weight)

$$w_o = w_c + w_p + \left(\frac{w_e}{w_o}\right) w_o + \left(\frac{w_f}{w_o}\right) w_o$$

w_c denotes Crew weight, w_p denotes Pay load weight, w_f be fuel weight, w_e denotes Empty weight. Fuel weight fraction is the item which defines the ratio of landing weight to takeoff weight. Reference Aircraft would be Bomber (Military concern), here go with military aircraft weight estimation procedures. Point of departure will be different for Military and commercial aircraft. For military, it should land where it has been takeoff.

For commercial, it should land at the destination place. According to military aircraft there are eight phases during flight namely engine start up and takeoff, Climb, Cruse, High speed intercept, Combat, Cruise back, Loiter, Landing

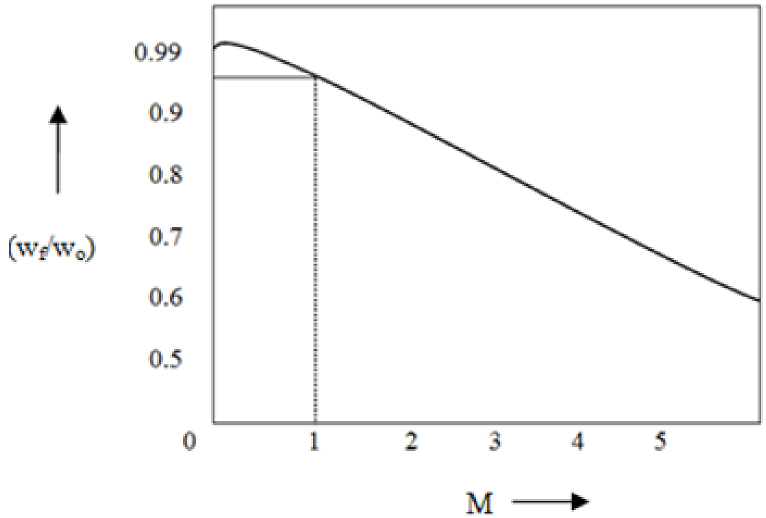
Crew	4
Range	12300km (6641.46) nautical miles
Endurance	15 hr
TSFC	0.9
A.R	3.52
Number of Engines	4
Rate of Climb	70 m/s
Mach Number	2.05
Cruise Speed	960km/hr (518.359 knots)
(L/D)	18.52
T/W	0.37
Thrust	137.3 kN
Takeoff weight	275000 kg
Empty weight	110000 kg
Length	177.49 feet
Height	42.979 feet

Table. 2.1 Data sheet for the reference Aircraft TUPOLEV TU-160

To determining the w_o (estimated weight) by using formula

$$w_o = \frac{w_c + w_e}{1 - \frac{w_f}{w_o} - \frac{w_e}{w_o}}$$

For an each phase we have to finding out (w_f / w_o) (fuel weight fraction), (w_e / w_o) (structure weight). Incipient phase is engine startup and takeoff, assumed w_f / w_o be 0.97 for military aircraft. Then climb phase has (w_f / w_o) be 0.95. 0.95 is the value which is approximately took form Nicolai Graph has shown in graph. 2.2.



Graph. 2.2 Nicolai Graph

Moving up to third phase, cruse out to destination. Let the Aircraft has turbofan engine, here Range (R) = V/ TSFC x L/ D x ln ($w_{o\,/}\,w_f$). By using this formula, finding the required ($w_{f\,/}\,w_o$). By applying all the known values to get $w_{f\,/}\,w_o$ be 0.9537. High speed Intercept is fourth phase has $(w_{max/}w_{0.1})_f$ = ($w_{max/}w_{0.1}$) x ($w_{0.1/}w_c$).

First we should find ($w_{max\,/}\,w_{0.1}$) and ($w_{0.1/}\,w_c$) by using Nicolai Graph to get ($w_{f\,/}\,w_o$). w_{max} be find out by Maximum Mach number, w_c be find out by cruise Mach Number. $w_{f\,/}\,w_o$ in the fourth phase be 0.915. Fifth phase is combat phase which has 1-$w_{f\,/}\,w_{o\,=}\,t_{combat}$ x T_{max} x $(TSFC)_{max.}$ By assuming and apply all values, we get ($w_{f\,/}\,w_o$) be 0.998. Sixth phase is cruise back, which is assumed to be ($w_{f\,/}\,w_o$) as 0.9537. Next phase is Loiter has dealt with endurance, E = 1/TSFC x L/D ln ($w_{o\,/}\,w_f$). By substituting all values we get ($w_{f\,/}\,w_o$) be 0.998. Last phase is Landing, assumed $w_{f\,/}\,w_o$ as 0.97. By having fuel fraction weight,

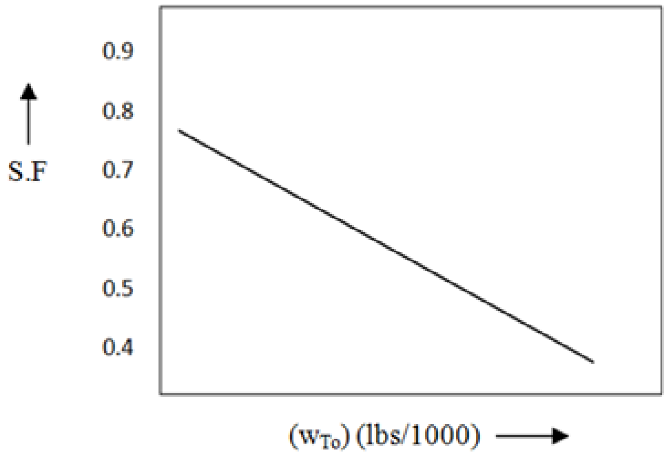
$$\left(\frac{W_{Landing}}{W_{takeoff}}\right) = \left(\frac{W_n}{W_{n-1}}\right) = \left(\frac{W_2}{W_1} \text{ X } \frac{W_3}{W_2} \text{ X} \ldots\ldots \frac{W_n}{W_{n-1}}\right)$$

$$W_{f0/}W_{o} = 1.0 \left(1 - \left(\frac{W_{Landing}}{W_{takeoff}}\right)_{fuel}\right)$$

By substituting all phases ($w_{f\,/}\,w_o$) in fuel fraction weight to get ($w_{f\,/}\,w_o$) be 0.741. By substituting, fuel fraction weight as 0.27. Structure weight is defined as ratio of empty weight to the takeoff weight. ($w_{e\,/}\,w_o$) be the structure factor. By substituting the known value of reference Aircraft get structure factor as 0.399. w_o is to find,

$$W_o = \frac{W_c + W_p}{1 - \frac{W_e}{W_o} - \frac{W_f}{W_o}}$$

By substituting all values, to get w_o as 260639.0882 (lbf) approx.
The value of structure factor is to take approximately by using graph (S.F vs w_{To}) structure factor for commercial Aircraft is 0.50 to 0.53 and structure factor for military Aircraft is 0.6 (Refer graph. 2.3.)



Graph. 2.3. Shows (S.F vs w_{To})

III. SUBSTANTIATE FOR OBTAINING SURPLUS WEIGHT AS ZERO

By making the surplus weight becomes Zero. Surplus weight is the difference between available empty weight and required empty weight. Available empty weight has $(w_e) = (w_o)_{estimated} - w_f - w_p$. Required weight has (w_e) required $=$ S.F x (w_o). Then we have w_{fuel} (weight of the fuel) is to find with the help of formulae, $(w_{fuel}) = w_o - w_p - w_{Landing} + 0.06\, w_f$. Then $(w_o)_{final}$ is estimated by, $(w_o)_{final} = (w_e)_{required} + w_f + w_p$. By having the iteration techniques, to get the fuel weight, available empty weight, required empty weight and find takeoff weight.

Stages	**$(w_o)_{estimated}$ Approx. 260639.0882**	**Iteratition 1 200000**	**Iteratition 2 251544.55**	**Iteratition 3 251545.51**
Engine Startup & Takeoff	252819.83	194000	243998.2	243999.1
Climb	240178.8	184300	231798.30	231799.17
Cruise	228890.3	175637.9	220903.78	220904.61
High Speed Intercept	209434.7	160708.6	202126.96	202127.72
Combat	209015.8	160387.26	201722.71	201723.46
Cruise Back	199192.09	152849.05	192241.74	192242.46
Loiter	198793.7	152543.36	191857.26	191857.98
Landing	192829.9	147967.0	186101.54	186102.24
Fuel weight	67810.06	52033.06	65443.073	65443.31
Available empty weight	104829.91	59967	98101.482	98102.452
Required empty weight	101649.24	78000	98102.37	98102.45
Final takeoff weight	257459	218033	251545.65	**251545.51**
Surplus weight	3180.0882	-18033	-1.1	**0**

Table. 3.1. (Iteration Table)

IV. RESULT

In this paper, Aircraft design procedures (ADP) is performed to calculate the changes and moderate the weight of the airplane. TUPOLEV TU-160 is the reference aircraft as shown in fig. 1.1. having 275000 kg of final takeoff weight, and it had been further reduced and modify the weight as 251545.5 kg as shown and proved in Table.3.1. Therefore the difference between reference takeoff weight and modified weight to be 23454.5 kg. This amount of weight reduction is more advantages for airplane manufacturing industries and make the cost Lesser. Hence it is an military (Bomber) aircraft has point of departure is same, hence lesser the weight, performance will be efficient. Nowadays, the main discussion is about how to make economical and reliable. According to financial investment, it will be gradually decreasing and make trip cost will be more. Therefore, reduction of weight is more significant role in all airline strategies. Cost of the airplane design which will be reducing slightly when decreasing the weight of airplane. Another effect of enhancing weight which will result in more fuel consumption. Full prices too increasing, in that case, we should reduce the weight of airplane. The takeoff weight of the reference plane (TUPOLEV TU-160) is higher when compared to the optimal solutions from the results of the iteration, when surplus weight becomes zero. Table. 3.1. (Iteration table) shows the result and examined surplus weight as zero. In this probe, shows 23454.5 kg of weight reduction by exploiting the all reference value of original aircraft datasheet and comprehensive weight reductions methodology.

V. CONCLUSION

It can be concluded from the result of this paper that the weight is the most significant factor affecting the aircraft performance and its fuel consumption. Lighter the aircraft, performance and fuel efficiency will be more. Hence, it possess ambitious and feasible for reducing one's aircraft weight by using this weight estimation procedures. The corroboration and optimal solution give comprehensive overview to reduce the mass of the airplane. This paper aimed to dispense some light on the impotence of airplane weight reduction by very small amount even, with the comparison of reference aircraft takeoff weight. Fig.No.1.1. Weight estimation procedures and stages aid to conceive about weight reduction in Bomber / Military aircraft by obtaining the difference of original and estimated weight and also substantiate for proving surplus weight to be zero. It is strongly recommended for future studies to consider more reliable approach and suggestions for weight reduction techniques and employing them with the aid of enhancing the aircraft performance like high speed, Lower stall speed, Lower Fuel consumption and minimize the direct operating cost and make the flight as more efficient.

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