[[1]](#footnote-1)

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# INTRODUCTION

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# General assumption about the flight mission

We assume the flight from Stockholm to Los Angeles has the range of and it is completely done by cruise, i.e. the range finished by climbing and landing is ignored. The airplane A330-300 is flying with the maximum ramp mass which is [1].

The aeronautic parameters of the airplane are given in the following table. [2]

|  |  |  |  |
| --- | --- | --- | --- |
| Number of engines | 2 | Average seating | 333 |
| Ramp weight () | 230.9 | **Flight range ()** | 8880 |
| Aspect ratio | 9.26 | **Speed ()** | 465 |
| Taper ratio | 0.251 | **Altitude ()** | 39000 |
| ¼ chord sweep angle ( | 29.70 | **Fuel consumption**  **()** | 4700 |

The speed, altitude and fuel consumption are the values that corresponding to the long-range cruise.

The atmosphere condition is assumed to be an International Standard Atmosphere (ISA). Within this model the air density, temperature and sound speed can be calculated with known flight altitude. [3]

# Calculation of the fuel consumption

To establish the fuel consumption, several values are needed. First is the thrust specific fuel consumption (TSFC) and the second is the air drag force.

The TSFC is found on a report from the Technical University of Madrid [4]. It is which corresponds to which is in the unit we are using.

The air drag is assumed to be a parabolic drag polar which means that the air drag is then . So and are needed for further calculation.

**Here comes the calculation of .**

The value of is calculated with two empirical methods, one by Raymer and one by Howe. Raymer’s empirical method is given by the following equations.

Here is the aspect ratio, is the Oswald efficiency factor, is the leading edge sweep angle. The second equation is used to calculate the Oswald efficiency factor for an airplane with leading edge sweep angle . It is known that this method usually give a result that is not very accurate for the type of airplanes discussed in this project.

The second method to calculate the value of K is the Howe empirical method. This method is given by the following equations.

Here is the aspect ratio, is the cruising flight Mach number, is the taper ratio, is the thickness/chord ratio, is the ¼ chord sweep angle, is the number of engines. [5]

To calculate the fuel consumption, the following assumptions are made. First, the whole flight mission is divided into four stages, warm up and take-off, climb to cruise altitude, cruise, descent and landing. For each stage, the amount of fuel that is used is calculated by a mass ratio, i.e. ratio between the mass at the begin of the stage and the mass at the end of the stage. With these ratios, the final mass of the airplane can be calculated after the flight mission. Since the flight mission is a long-range cruising so the most important part for the fuel consumption is the cruise stage. For the other three stages, approximate values of the mass ratios can be used. These approximate values are listed here below.

|  |  |
| --- | --- |
| Mass ratio | Numerical value |
|  | 0.970 |
|  | 0.985 |
|  | 0.995 |

Here is the initial mass of the airplane, is the mass after the warm up and take-off stage, is the mass of the airplane after climbing to the cruising altitude, is the mass after the cruise stage and is the final mass of the airplane. [6]

The mass ratio at the cruise stage satisfies the following equations.

Here is the range of the cruise stage, is the density of the cruise altitude, is the wing area, is the cruise velocity. and is calculated above and for both of these parameters the values calculated with Howe’s empirical method is used. So and .

With these equations, the mass at the end of each stage can be calculated, thus the fuel usage. The total fuel consumption then can be calculated with the following equation.

Here the numerical value 1.06 comes from that the airplane always bring a reserve of fuel which we also assume used during the flight mission.

# Result

With the Howe’s empirical method, we get . With the components build-up method, we get .

With the Howe’s empirical method, we get which corresponds to the Oswald’s efficiency factor . With the Raymer’s empirical method, we get which corresponds to the Oswald’s efficiency factor .

The fuel consumption on warm up and take-off stage is 6.9 ton. It on climbing stage is 3.3 ton. The cruise part cost 60.1 ton. The landing stage cost 0.8 ton. Finally, the total fuel consumption with 6% extra is then 75.5 ton.

# Discussion

The components build-up method contains many assumptions; this can lead to inaccuracy. **More reasoning is needed here.**

A330-300 is a modern jet transport airplane, so the Oswald’s efficiency factor of the airplane should be within the range . So, the Raymer’s method for calculating is not giving an accurate answer. However, the Howe’s method gives a better result. That is why we are using this value in the calculation of fuel consumption.

# References

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| --- | --- |
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