ENG4014 Aerospace Design Project 4M

Interim Report

Group 8

School of Engineering
College of Science and Engineering
University of Glasgow

Anton Soderqvist, Fraser Morrison, Mark Sullivan, Matthew Murphy, Rafał Trzeciak, Saad Saeed and Tomas Coelho

January 19, 2022

Contents

Chapter 1

Introduction

Introduction here

Chapter 2

Market Analysis and Concept Selection

Market Analysis and Concept Selection here

Chapter 3

Concept Summary and Aircraft Layout

Concept Summary and Aircraft Layout here

Chapter 4

Design Analysis and Feasibility

4.1 Safety

Safety here

4.2 Center of gravity (Fraser and Rafał)

Seeing as the RJ100 is originally a commercial aircraft, converting it to a firefighter aircraft would result in a lot of unnecessary weight, for example passenger seats, kitchen and cabin bins ect. This allows the plane to carry more retardant, meaning better performance for this specific application. However, by removing the excess weight, the center of gravity is shifted and thus will need to be recalculated. The RJ100 has an acceptable safe range for the center of gravity as a percentage of the chord length is 28% to 44%. The plane cannot fly safely if the value of the center of gravity along the x-axis of the plane is outwith this range. The center of gravity also has to remain within this range before, during and after the ejection of retardant.

4.2.1 Method of Analysis

The process of calculating center of gravity is relatively trivial but can be time consuming if done if done by hand, especially in this case where there are lots of components being removed, greatly altering the mass. Using MATLAB instead of hand calculations greatly simplifies the process of changing individual values such as the mass, or the position of objects in the plane, to help achieve the safe center of gravity position.

According to Baker & Haynes (2020) the formula for the x,y and z value of the center of gravity are shown in the equation 4.1:

$$\bar{x} = \frac{\sum \bar{x}_i m_i}{\sum m_i} \quad \bar{y} = \frac{\sum \bar{y}_i m_i}{\sum m_i} \quad \bar{z} = \frac{\sum \bar{z}_i m_i}{\sum m_i} \tag{4.1}$$

The aircraft mass and center of gravity, before excess weight removal, can effectively be represented in equation 4.1 as a particle with known mass and position. By representing the aircraft in this way, the center of gravity after the removal of unnecessary weight can be calculated. The mass of the components to be removed are taken as negative, removing them from the original total mass.

4.2.2 Matlab code

Applying the method above, code was written in MATLAB to to calculate the new cg position through implementing equation 4.1. This can be seen in the appendix REF MATLAB CODE IN APPENDIX.

```
clc
clear
close all
format long g

Data = readtable("aircraft_items.xlsx"); %import data from excel file

starting_mass=37875; %starting mass in kg (operational empty weight 25600)(Operational zero fuel mass 37875)
absoulute_cog_to_nose=14 + 1.719; %%distance from nose to the wing start + x_mgc

cg.x=-1*(absoulute_cog_to_nose+1.239056); % starting cg x position
cg.y=0; %starting cg y position
cg.z=0; %starting cg z position

%starting moment of inertia tensor values
I_convert=1.3558179619; %slug*ft^2 to kg/m

I.xx=533965*I_convert;
I.xy=0*I_convert;
I.xz=59261*I_convert;
I.yx=I.xy;
I.yy=607525*I_convert;
I.yz=0*I_convert;
I.zx=I.xz;
I.zy=I.yz;
I.zz=1019696*I_convert;

%calculating new cg
cg_sum.x=starting_mass*cg.x;
cg_sum.y=starting_mass*cg.y;
cg_sum.z=starting_mass*cg.z;

end_mass=starting_mass;

for i=1:1:height(Data)

    %extract mass,x,y and z values from file for object
    mass=Data{i,2};
    x=Data{i,3};
    y=Data{i,4};
    z=Data{i,5};

    %take away object mass
    end_mass=end_mass - Data{i,2};

    cg_sum.x=cg_sum.x - (mass*x);
    cg_sum.y=cg_sum.y - (mass*y);
    cg_sum.z=cg_sum.z - (mass*z);

end

%calculate new cg position
cg_new.x=cg_sum.x/end_mass;
cg_new.y=cg_sum.y/end_mass;
cg_new.z=cg_sum.z/end_mass;
```

```

%print new cg position
cg_new
%print new mass
end_mass

%calculate and print value of cg position in x axis as a fraction of the
%MAC
cg_from_mac = cg_new.x + absoulute_cog_to_nose;
fraction_of_mac = cg_from_mac / - 3.404
```

The data for the components to be removed were formatted into an excel file named "aircraftitems.xlsx" and then imported to be represented in the variable "Data". This data included each component's mass and it's center of gravity position. These position's were taken relative to the standard aircraft axis with the origin at the nose of the aircraft.

4.2.3 Consequence of result of code on design decisions

The position of the tank along the aircraft was tweaked in order to find a result from the MATLAB code that allowed the position of the center of gravity in the x axis was within the safe limits of 28% to 44% of the mean aerodynamic chord. The value of the x position of the center of gravity of the tank was found to be 16m away from the nose of the aircraft. This position of the tank results in a center of gravity position of the airplane of 44% of the aerodynamic chord with the tank full of retardant and 28% when the tank is full.

4.3 Delivery release system and Tank Pressurisation (Anton and Fraser)

4.4 Structural Support

Structural Support here

Chapter 5

Draft Plans for the Preliminary Design Stage

Draft Plans for the Preliminary Design Stage here

Chapter 6

Conclusions

Conlusions here

Chapter 7

Project Plan

project plan here

References

Baker, D. W., & Haynes, W. (2020). Engineering statics: Open and interactive.