University of Ottawa

MCG4322

RE3 - Wildcat Engineering

Analysis Dossier

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Nomenclature

E_p Modulus of elasticity of considered plastic hub or boss $[N/mm^2]$

F_R Keel to assembly arm connector reaction, $[N]$

F_T Thruster force, $[N]$

F_g Force of gravity, $[N]$

F_{GR} Reaction force of gondola, $[N]$

F_{K1} Keel reaction force 1, $[N]$

F_{K2} Keel reaction force 2, $[N]$

F_{LA} Linear actuator force, $[N]$

F_{NB} Normal force applied to bearing, $[N]$

F_{RSF} Force of snap fit bearing $[N]$

F_α Force on fastener α (hinge to gondola), $[N]$

F_β Force on fastener β (hinge to gondola), $[N]$

F_a Force on fastener a (hinge to gondola), $[N]$

F_{bolt} Bolt pretension force, $[N]$

F_{brake} Normal braking force keel reaction, $[N]$

F_b Force on fastener b (hinge to gondola), $[N]$

F_{c1} Connector moment couple force 1, $[N]$

F_{c2} Connector moment couple force 2, $[N]$

F_{ffric} Friction force acting on friction wheel, $[N]$

F_{nfric} Normal force acting on friction wheel, $[N]$

F_{s1} Force on friction wheel motor fastener 1 , $[N]$

F_{s2} Force on friction wheel motor fastener 2 , $[N]$

F_{spring} Force applied by hinge spring, $[N]$

H_{keel} Height of the bearing arm contact point on the keel, $[m]$

L_G Width of gondola, $[m]$

L_a Length from pivot point of hinge to fastener a , $[m]$

L_b Length from pivot point of hinge to fastener b , $[m]$

L_m Length from side of gondola to gondola drive motor hinge, $[m]$

L_s Length from fastener to fastener of gondola motor to hinge, $[m]$

L_{SF} Length to snap fit bearing, $[m]$

L_{ac} Length from centerline of gondola to fastener a, $[m]$

L_{bc} Length from centerline of gondola to fastener b, $[m]$

L_{cm} Length from gondola wall to center of mass of gondola, $[m]$

$L_{contact}$ Length from contact to contact of bearings on keel, $[m]$

L_{drive} Length of gondola hinge to friction wheel contact, $[m]$

L_{hs} Distance from the pivot of the hinge to the gondola motor fastener, $[m]$

L_{hw} Distance from the gondola motor fastener to the contact point of the friction wheel, $[m]$

L_{rx} Friction wheel motors shaft length, $[m]$

M_1 Reaction moment on bearing arm, $[Nm]$

M_R Connector moment reaction, $[Nm]$

R Reaction force, $[N]$

$S_{compressive}$ Compressive strength of gondola material, $[Pa]$

T_w Friction wheel motor torque, $[Nm]$

T_{spring} Torque of hinge spring, $[Nm]$

W_A Weight of thruster assembly arm, $[N]$

W_E Weight of thruster enclosure, $[N]$

W_T Weight of thruster, $[N]$

W_c Weight of connection piece, $[N]$

W_{LA} Weight of linear actuator, $[N]$

η Safety Factor

μ Coefficient of friction

σ' Von Mises Stress, $[Pa]$

σ_{washer} Compressive force of washer, $[Pa]$

σ_x Principle stress, $[Pa]$

σ_a Hoop stress, $[N/mm^2]$

σ_s Allowable design stress for plastic, N/mm^2

$a_{airship}$ Acceleration of airship, $[m/s]$

$a_{gondola1}$ Acceleration of Gondola 1 , $[m/s^2]$

$a_{gondola2}$ Acceleration of Gondola 2 , $[m/s^2]$

c Distance from neutral axis to stress location, $[m]$

d_i Interference diameter, $[mm]$

d_s Hub outer diameter, $[mm]$

d_s Shaft diameter, $[mm]$

i_a Allowable interference, $[mm]$

$m_{airship}$ Mass of airship, $[kg]$

$m_{gondola1}$ Mass of Gondola 1, $[kg]$

$m_{gondola2}$ Mass of Gondola 2, $[kg]$

r_{fw} Radius of friction wheel, $[m]$

w_{armx} Width of the bearing arm in the x direction, $[m]$

w_{army} Width of the bearing arm in the y direction, $[m]$

1 Problem Statement

1.1 Project Mandate

The goal of the project is to overcome the current limitations involved with the control and landing of unmanned airships in adverse outdoor conditions. The airship consists of a helium filled envelope, external keel, and gondola which will act as a ballast. The moving ballast will control the pitch by the controlled displacement of the centre of mass. Propulsion will be provided by propellers in the X-Y plane of the airship. The system will have vector thrusting to allow for altitude change independent of pitch change.

1.2 Group Problem Scope

The research project led by Dr. Eric Lanteigne involves designing a system to allow for the control of an unmanned airship. The goal of the project is to create a system that controls the airship by changing the position of the centre of mass to initiate pitch change. This pitch change, along with forward propulsion, will drive the airship in a given direction. The design team will be responsible for creating a system, where a gondola that acts as a ballast, will move along a nonlinear, diamond-shaped keel in order to initiate pitch change of an airship. Ideally, the system will be able to incur a pitch change of up to ninety degrees, allowing the airship to descend straight downwards. Currently, all designs must be scalable as specifications of the airship envelope have yet to be finalized. The unmanned airship must be capable of flying outdoors and be able to carry a payload of between 0.2kg and 0.5kg. The main components of the design can be split up into: Gondola Design, Gondola Movement, Securing Gondola to Keel, Gondola Position Measurement, Securing the Propellers, Thrust Vectoring, Batteries, and Wire Management.

1.3 Criteria and Restrictions

The propellers will be in the X-Y plane, in line with the centre of volume. This eliminates any moments from the propellers that lead to imbalance and unwanted pitch variations. The gondola will be able to move along the varying curvature of the keel using a hinged-gondola. The driving mechanism will be two friction wheels with the additional support of 4 driven bearings. The cross-section of the keel is diamond-shaped, however it is not torsionally constant, therefore the vertexes are not coincident on the curved section. Once the airship has been constructed, a Special Flight Operations Certificate (SFOC) issued by Transport Canada will be necessary in order to fly the airship lawfully.

References

Appendix

A Thrust Force