DESIGNING AND ANALYZING PRELIMINARY PARTS OF AN AEROSTAT

MOHD. EZUWAN BIN KASSIM

This report is to be present as criteria to fulfill a part of bestowal stipulation for
Bachelor's Degree in Mechanical Engineering (Design & Innovation)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

MARCH 2008

I/we* admit that have read this work and in opinion of mine/ours* this work was adequate from the aspect of scope and quality significantly to be awarded Bachelor Degree of Mechanical Engineering (Design & Innovation)

Signature:………………………
Supervisor Name:………………
Date:……………………………

Signature:………………………
Supervisor Name:………………
Date:……………………………

“I declare that this report is done by my own unless the citation with the mentioned references for each.”

Signature:…………………….

Author: MOHD EZUWAN BIN KASSIM

Date: 27 MARCH 2008

PREFACE

If you take a moment to observe your surroundings, you will see examples of technological creativity. The physical objects you see, whether they are telephones, automobiles, or even high end engineering equipments, all came into being through the creative application of technology. These everyday inventions did not miraculously appear but originated in the minds of human beings and took time to develop. This project is somehow considered another step forward in gaining better designs and solutions. The project is about creating and analyzing an aerostat and the main method are; software simulation and calculation based on derived equation. The usage of software such as CAD, ANSYS, COSMOSWORK is practically crucial for engineering designs. In this project, the initial step is about determining a suitable design for an aerostat. Due to the main goals, a research was conducted (internets and journals) in order to claim this project as a success. However, the author consider this project as a surface-orientated suggestions and not as detailed as a complete published journals. The lack of knowledge and experiences are the main factor to what-so-called unrefined piece of works. After all, we cannot determine a solution just by observing to the input without any guidance and self-thought articulations.

ABSTRACT

Aerostats are lighter-than-air vehicles tethered to the ground by a cable and used for broadcasting, communications, surveillance, and drug interdiction. The dynamic response of tethered aerostats subject to extreme atmospheric turbulence often dictates survivability. This report develops a theoretical model that predicts the planar response of a tethered aerostat subject to atmospheric turbulence and simulates the response any other aspects that occurred due to pressure, temperature, and etc. The aerostat dynamic model assumes the aerostat hull to be a rigid body with non-linear fluid loading, instantaneous weathervane for planar response, and a continuous tether. The hull needs a simple yet reliable design in order to estimate steady state effectiveness while floating on air. Bachelor's Final Project is perhaps achieving the objective of choosing the best conceptual sketches in order to minor the spaciousness of aerostat's engineer analyzing method. A methodology that was used in order to expand the analysis method is predominantly explained by the skills of gaining the interconnected information and software usage. The result for this project in the initial phase is the champion concept for aerostat design. The consequential stage in this report is the results that consists main analysis constituent such as pressure, streamline and any other aspects to be shown and translated in engineering point of view.

ABSTRAK

Aerostat adalah sejenis pengangkutan terapung yang lebih ringan dari udara, dipaksi pada tanah menggunakan kabel dan berfungsi untuk penyebaran maklumat, pemerhati (tinjauan) dan pengawasan sempadan. Responsif dinamik aerostat yang mempunyai kabel, bergantung pada keadaan dan keseimbangan atmosfera dan kemampuan untuk bertahan lebih lama diudara merupakan suatu objektif yang dikehendaki. Laporan ini akan mengemukakan model aerostat secara simulasi dan teori serta akan dianalisis menggunakan grafik berbantu computer (CAD). Antara analisis yang dilakukan ialah tindak balas tekanan, daya, suhu dan pergerakan kelajuan angin yag menerjah pada bentuk aerodinamik aerostat tersebut. Walaupun terdapat pelbagai elemen luaran yang penting, dalam repot ini, sebahagian pemboleh ubah akan dianggap tidak berkaitan secara terus. Model dinamik ini akan dianggap mempunyai keupayaan apungan yang berterusan, tidak berkaitan secara terus dengan pelancar dan beban yang sekata. Projek Sarjana Muda ini diharap akan memenuhi kriteria yang dikehendaki iaitu memilih rekabentuk konsep yang bersesuaian. Metodologi yang diguna untuk memastikan kelancaran projek diterangkan melalui kajian ilmiah yang kemudiannya diterjemah kepada kepada pengunaan perisian analisis yang terlibat. Keputusan yang akan dicapai ialah analisis utama pada elemen-elemen yang terlibat dan perspektif kejuruteraan mengenainya.

ACKNOWLEDGEMENT

I would like to express an immense gratitude to the God All-Mighty Allah s.w.t and the true idol of ours; Rasulullah s.a.w. who gave me the will to pursue this report until it finished, the courage to hold on to my thoughts, and the astuteness to think wisely whenever I need it the most. I also want to dedicate a special appreciation to my parents whose always stand by my side and keep encouraging me until the end of whatever I am doing. Special thanks also to my respected lecturer and supervisor, Mr. Faiz Redza bin Ramli for his ideas and willpower of making this report as something can be touched and observed physically, not just being articulated by words and speeches. His guidance, experiences and the method of teaching were really useful for me in the future and I undeniably think that it will somehow affect my opinion in a very positive way, indeed. I also want to say thanks to all my friends for their helps and opinions because all of it was functional to me in many kind of way. Hope fully this report is a piece of written-work that meets the decisive factor and worth to be observed by others because somehow, the endeavor to finish this task was something I wish it to be worth my effort.

TABLE OF CONTENTS

LISTS OF FIGURES

LISTS OF TABLES

CHAPTER 1

INTRODUCTION

1.0 Background of the project

Aerostat is a ship which can fly like an airship. Since the duration of its flight is considered long, it is not suitable for any crew to control it. The aerostat, in the other words, is known for its un-manned functionality and work independently once the generator that pumps in the helium completed its task. Helium is practically the best choice possible to make the so called 'airship' floating in the air since it is the lightest gas that is not flammable. Even though the aerostat invention is useful and compulsory by certain parties, there are still certain parts that need to be modified and upgraded. This thesis will somehow explain my general ideas on creating better solutions. The major problems that can be detected are;

i. Aerostats sometimes do not emerge to its equilibrium condition when it reached to certain height. This is due to the air pressure that will raise proportion to the level of atmosphere. The wind movement has also brought consequences where the steady states of aerostat will somehow being effected because of the aerodynamics design do not considered the environment capability.

ii. Aerostat steady state depends on how the flow movement, pressure, stress and any other factor thus the disability to understand the basic principal to fly an air ship will cause failure in many ways.

1.1 The significances of the project

This project was initially conducted to understand the preliminary design of aerostat and analyzing it in the aspect of temperature, pressure, and the state of any exchange that occurred in the hull or the other parts. However, the ideas have developed into more advance thinking-thanks to the internet observations and the will of creating things better, invention after invention. This project will include the literature review about the aerostats, the enhancement for tether in order to create better on-air stability, to create equilibrium state between payload and hull, and redesign the preliminary parts.

1.2 Objectives

1. Conduct preliminary designs for aerostat. The preliminary designs are the envelope (hull) and the fin. The design will be consider roughly according to the writer's common sense in the initial stage. There will be a few design concepts to be chosen and will taken further ton analyzed it using computer aided software

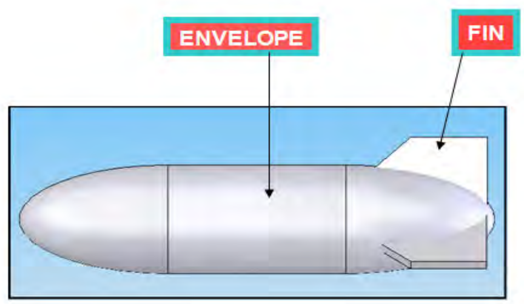

Figure 1.1: Aerostat's major parts

2. To study and understand the aspects that involves with the major part of hull and envelope such as the pressure, air flow, temperature, aerodynamics, and the other aspect that will be reveal in detail in the 'result chapter'. The design will be analyze by calculations and software simulations.

3. To choose the best reliable design that has been successfully accomplished through software simulations. The fin shape will be determined by conducting an analysis regarding to stress, displacement and strain that occurred due to force while on the air.

1.3 Scopes of the projects

The project can only be held in general point of view since the writer himself is considered lack of knowledge or even experiences. The related scopes are;

i. The analysis will only relate to the mathematical equation without any certain sum. In the other words, this proposal only acquired the assume value regarding to the writer's assumption and logical self-thought.

ii. The simulation of analysis will be accomplish using software (Ansys CFX, Cosmos) including the experiment of finding the pressure values, temperature values, and other aspects that relates to it. The environmental influences will be neglected and considered not important.

iii. The designs are limit to two ways of sketching; hand-sketching and software (Catia VSR, Solidwork).

iv. The design only include the aerostat itself without considering the point of launching platform, generator to pump in the helium, and also the consideration of any electrical or electronic devices.

CHAPTER 2

LITERATURE REVIEW

2.0 What is aerostat?

Figure 2.1: Aerostats "The Modern 64K" (Source: www.blimpinfo.com)

Aerostat is a ship which is can fly like airship. The aerostat is not used the crew to do any task. Aerostat can carry instruments and sensors for long durations that are impractical for humans and other aircraft. The aerostat is a large fabric envelope filled with helium. It can rise up to 15,000 feet while tethered by a single cable, which has a maximum breaking strength of 26,000 pounds. The aerostat network consists of three sizes of aerostats and three varieties of radar. The smallest aerostat is about twice the size of the Goodyear Blimp. The 275,000 cubic foot, aerodynamically shaped balloon measures 175 feet long by 58 feet across the hull, with a tip-to-tip tail span of 81 feet. The aerostat system lifts a 1,200 pound payload to operating altitude for low-level radar coverage.

The term “aerostat” has two meanings. In the first, broader sense, it includes all lighter than air aircraft. The expression lighter than air refers to objects that are buoyant in air because they have an average density that is less than that of air (usually because they contain gases that have a density that is lower than that of air). The opposite expression, heavier than air, refers to aircraft, such as aero planes and helicopter that have a greater density than air.

The term “aerostat” comes from the fact that buoyancy is technically said to provide aerostatic lift in that the force upwards arises without movement through the surrounding air mass. This contrasts with aerodynamic lift which requires the movement of at least some part of the aircraft through the surrounding air mass. The second, narrower and more technical usage refers only to moored balloons. This article focuses on the narrower use of the term. Thus, in the narrower sense, an aerostat is a tethered or moored balloon often shaped like an airship and usually filled with helium. Aerostats differ from airships and balloons in that airship and balloons are both free flying whereas aerostats are tied to the ground.

2.1 The function of aerostat

Aerostats are commonly used to carry instruments and sensors for long durations that are impractical for humans and other aircraft. Surveillance aerostats have also been used in the 2004 American occupation of Iraq. Utilizing a high tech optics system to detect and observe enemies from miles away and have been used accompanying foot patrols in Baghdad.

2.2 How the aerostats fly?

How do aerostats fly is explained by the Principle of Archimedes:

"Bodies submerged into a fluid receive from it a lifting force which is equal to the mass of the displaced fluid." (This is the same principle that explains why boats float on water.) The aerostat is filled with a lifting gas (Hydrogen, Helium, hot air or natural gas). The air in which the aerostat finds itself has a higher specific weight than the lifting gas. The envelope filled with the light gas generates a lift that is equal to the weight of the displaced air. Like a (light) kork floating in (heavier) water, a helium or hydrogen filled balloon floats in the heavier air. (Clark-Maxwell J., 1961)

Figure 2.2: Rapid aerostat deployment
(Source: www.defenseindustrydaily.com)

2.3 The examples of aerostats

Aerostat system can be configured for many different uses including detection and tracking of small aircraft, small ships, and ground vehicles. They can also be outfitted for communications relay and broadcasting.

The aerostat is a large fabric envelope filled with helium. It can rise up to 15,000 feet while tethered by a single cable, which has a maximum breaking strength of 26,000 pounds. Normal operating height is 12,000 feet mean sea level.

The current aerostat network consists of two sizes of aerostats (275,000 cubic feet and 420,000 cubic feet) and two varieties of radars. The average aerostat is about two times the size of the Goodyear Blimp, i.e., the 420,000 cubic foot, aerodynamically shaped balloon measures 208 feet long by 65 feet across the hull, with a tip-to-tip tail span of 100 feet.

The aerostat system lifts a 1,200 pound or larger payload to operating altitude for low-level radar coverage. The aerostat consists of four major parts or assemblies: the hull, the windscreen and radar platform, the airborne power generator, and the rigging and tether assembly.

Examples of products

Used for Sea-Based Border Patrol, Drug Interdiction

56K Aerostat

- Volume: 56,000 cf.
- Major Diameter: 36.5 ft
- Length: 109.5 ft
- Payload/Altitude: 800 lb. to 3000 ft
- Fabricated to date: 14 ea. w/two on contract

Figure 2.3: Water platform (Source: www.ilcdover.com)

Used for Border Patrol, Drug Interdiction, TV Marti (Television to Cuba)

- Volume: 275,000 cf.
- Major Diameter: 62.5 ft
- Length: 187.0 ft
- Payload/Altitude: 1000 lb. to 12,000 ft
- Fabricated to date: 12 ea. with two on contract

275K Aerostat

Figure 2.4: Manufacturing an aerostat (Source: www.ilcdover.com)

Used for Border Patrol, Drug Interdiction

420K Aerostat

- Volume: 420,000 cf.,
- Major Diameter: 69.5 ft
- Length: 208.5 ft
- Payload/Altitude: 2000 lb. to 15,000 ft
- Fabricated to date: 8 ea.

Figure 2.5: Specifications (Source: www.ilcdover.com)

2.4 The components of Aerostats

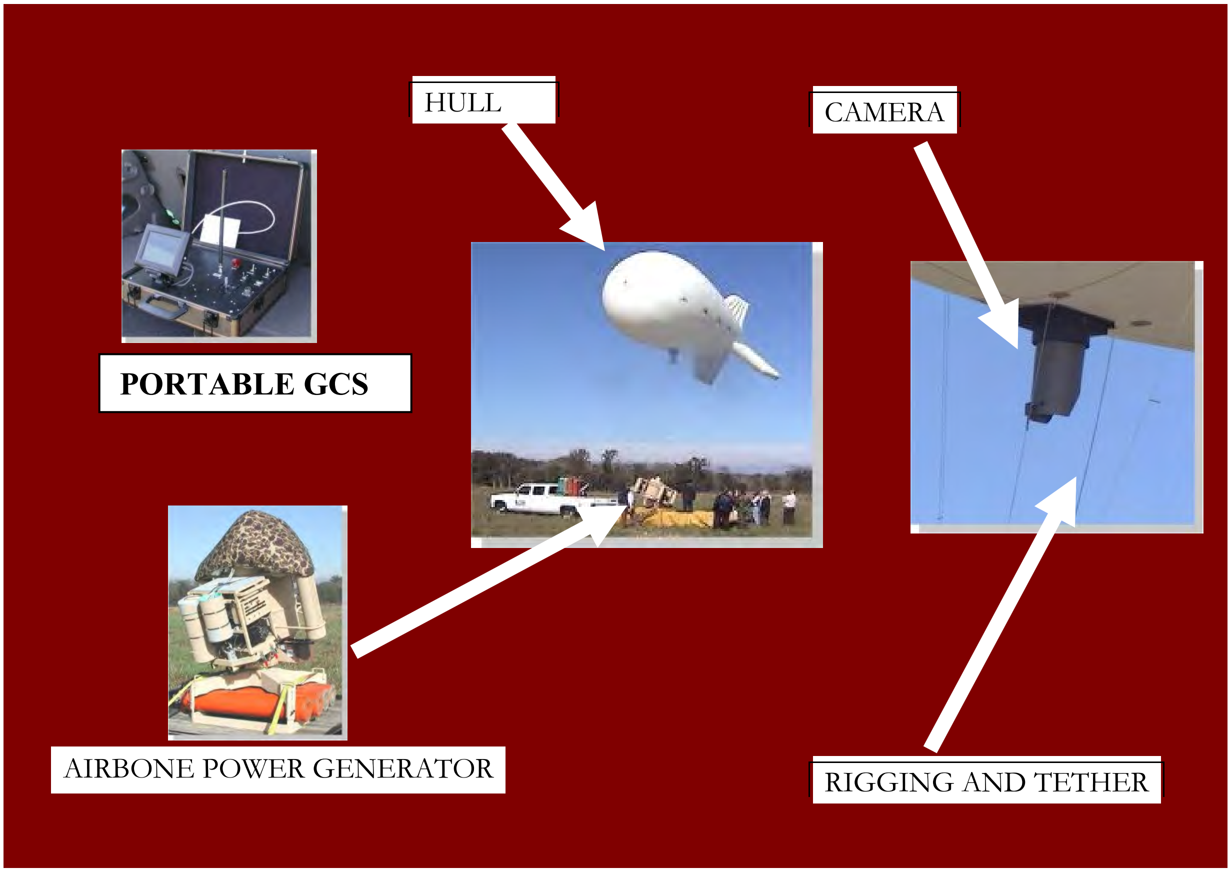

Figure 2.6: components of tethered aerostat (Source: rosaerosystems.pbo.ru)

2.4.1 An Aerostat System

Basically tethered blimps, aerostats are non-rigid aerodynamic structures manufactured of composite laminates and high-tech materials in combinations that have been refined over years of testing. The aerostat and its ground support equipment have evolved into the present state-of-the-art system over two decades of on-station operations. Aerostats have demonstrated an overall availability unmatched by any other aircraft in the history of aviation.

2.4.2 Primary components

- Aerostat
- Tether
- Mooring System
- Payload

Figure 2.7: The aerostats inflated (Source: www.hia-iha.nrc-cnrc.gc.ca)

The aerostat consists of a flexible structure hull filled with helium (an inert, lighter-than-air gas that is safe and non-burning) and air (in an internal compartment called a ballonet) and associated power and control equipment. The hull is an aerodynamically-shaped balloon up to 71 meters in length, fabricated from a high-strength multi-layer fabric and designed for long term use in all types of environments. Thermally bonded together, the completed flexible structure exhibits an exceptionally low helium loss rate. The multi-layer laminate provides significant resistance to ultraviolet radiation, chemicals and oxidation, while offering a field-proven life expectancy of 10 plus years with minimum maintenance. An automatic system of sensors, switches, blowers and valves controls the super-pressure within the hull to maintain the external aerodynamic shape.

During the aerostat ascent to altitude**,** expanding helium forces air from the ballonet chamber to the atmosphere through automatic valves. As the aerostat is retrieved from altitude, the helium contracts will reduce hull pressure. This triggers an