THEORY, METODOLOGY OF DESIGN AND CONSTRUCTION OF BASIC EXPERIMENTAL ROCKETS AND SOLID ROCKET MOTORS

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Abstract. *The purpose of these work is to present an overview on the basic theory and methodologies for design and construction of solid rocket motors and basic experimental rocket that is an assembly of recent works found in literature. This project has a web site - Yacamim.net – and in this paper is investigate the statistical data from visitors.*

Keywords*: experimental rocketry, solid rocket motor*

1. INTRODUCTION

It is necessary to Brazil to have professionals of space technology to guarantee its slice on this emergent market. There is a lot of information about the project of basic experimental rockets, however, they are fragmented and mostly in English. This paper presented an Mechanical Engineering Final Project (Porto, 2007) developed to realize a synthesis of the basic theory and methodologies to the design and construction of solid rocket motors (also referred as SRM) and experimental rockets, in Brazilian Portuguese language, and is directed to enthusiastic and future engineers who want be a small step forward. The purpose was then converted to a website with the aid of the open source Joomla CMS (*Content Management System).* The website also has updated news content, multimedia gallery, forum, links, news, etc. All pages have Google Analytic's (for now on it will be referred as GA) script for statistical data gathering and posterior analysis (date range from 03/12/2007 to 26/06/2008) and uses Google Ad Sense for sponsoring the web site costs. Figure 1 shows an actual view of the web site.

Figure 1. General view of the actual web page

2. REGULATION AND SAFETY

There are no regulation laws, in Brazil for experimental rockets. There is an effort from our small group of hobbyists to create an organization to fulfill this gap and control the activity for better safety. Up to now there are no accidents registered; all the static tests and flights are made following international organizations safety codes. The thesis work on this subject is a result of an extensive research, and adaptation for Brazil, from these international organization safety codes. The GA results showed that this page is the 15º page most viewed but have very good acceptance (i.e. lower bounce rate than the average) and long time on page, 59% better than the average time of the entire website. The main source of visitors is from search tools, 60%, with common rocketry words, leading to the right public.

3. SOLID ROCKET MOTOR THEORY AND DESIGN

In the website it can be found a general discussion about solid propellant needs and aspects and comments about some amateur tested, safe and easy to find propellant formulations. Than the combustion physical aspects are discussed. The burn rate and how this information is obtained are heavily discussed as this is one of the most important aspects of SRM design. After, the grain geometry design is presented and the simplest to manufacture geometry are so presented. These topics end the gas generator part of the rocket motor and leads to the nozzle design, thrust, total and specific impulse, characteristic velocity of the gases and pressure calculation. After the theory, some correction factors are presented and also how to obtain these values from testing. Figure 2 shows the equipment for solid propellant characterization designed by Porto (2007).

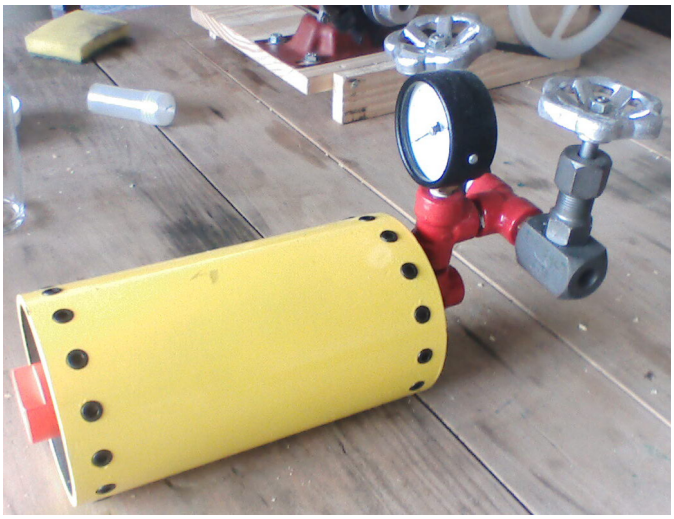

Figure 2. An equipment for solid propellant characterization, developed by the author, and presented on the website (Porto, 2007).

The correction factors values comes mostly from Eng. Richard Nakka's website, who design, build and test these amateur engines for more than thirty years in a very scientific, documented and serious way. On the design of SRM topic it is explained about stress and strength calculations of the tube casing, bulkhead, nozzle and fixture systems. These design calculations consider safety factors, stress concentrations, etc. The end part of the theory and design of SRM is about ignition system design, used both for motor and recovery systems. On Figure 3 it is possible to see the distribution of unique page views by SRM theory topics.

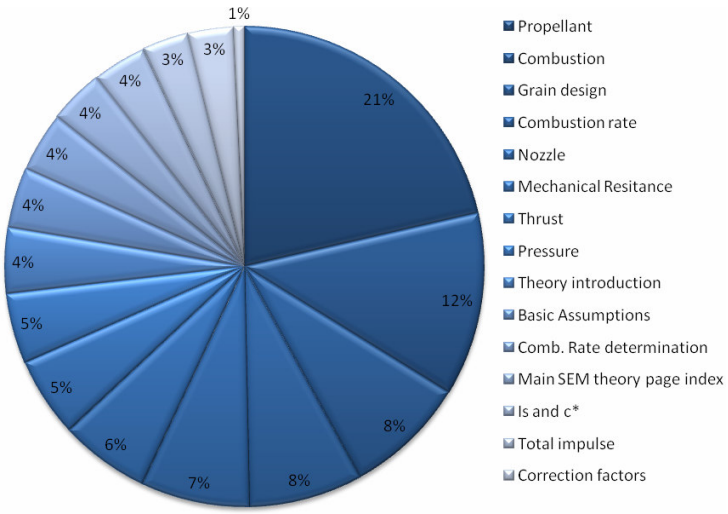

Figure 3. SRM theory and design page views distribution by sub topic.

4. ROCKET AERODINAMICS, STABILITY, DRAG, STRUCTURAL LOADS AND DESIGN

This part cover the rocket design itself and use a combination of 3D CAD and freeware rocketry trusted software for stability and structural analysis. The software Aerolab from the Danish Amateur Rocket Club, showed on Figure 4, is used for drag and stabilty calculation.

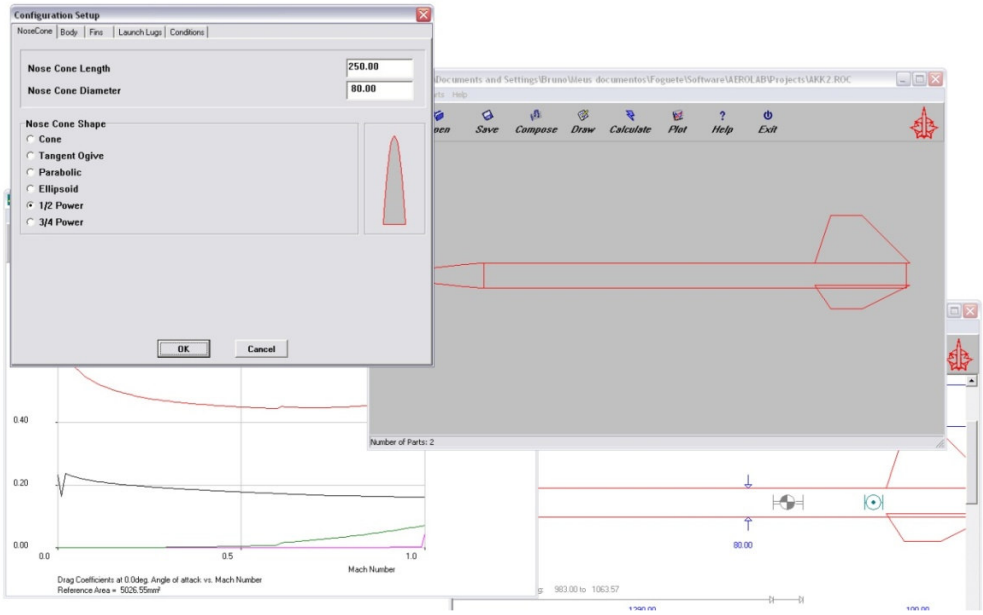

Figure 4. Aerolab software for stability and drag calculation (Nakka, 2007).

A graphic methodology for best stability geometry configuration was developed by Porto (2007). It consist on the generation of several geometric configurations (fins dimensions, aspect ratio and relative ogive position) that are tested using the Aerolab software, than the stability coefficient for a range of the rocket speed are put on a graphic that shows, using colors, relatively to the rocket calculated maximum speed, when the rocket shows unstable, stable and super stable behaviors. The best geometry is the one with does not shows any unstable and have the smaller super stable portion. On the Figure 4, from the original thesis, the best configuration is EE24 for example. Figure 6 shows the page website views distribution by sub topic.

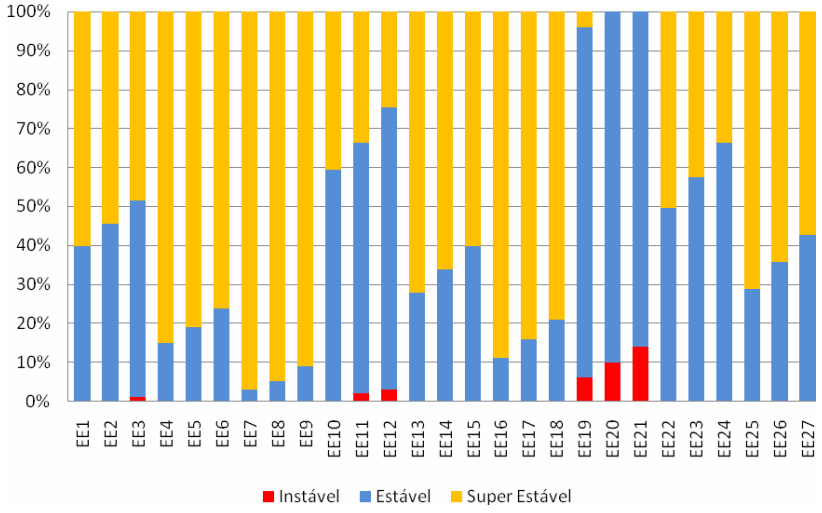

Figure 5. Graphic method for best aerodynamic geometry selection (Porto, 2007).

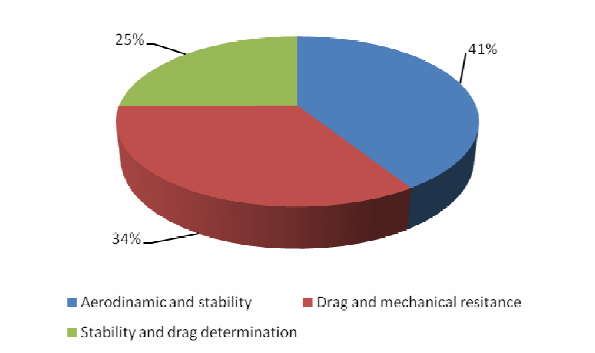

Figure 6. Page views distribution by sub topic.

6. RECOVERY SYSTEM

The recovery systems design is the second most viewed topic land page and have the smallest bounce rate from the entire website. It shows two original design methods for simple recovery systems. The first is related to the tether length design by a very simple method as showed on Figure 7.

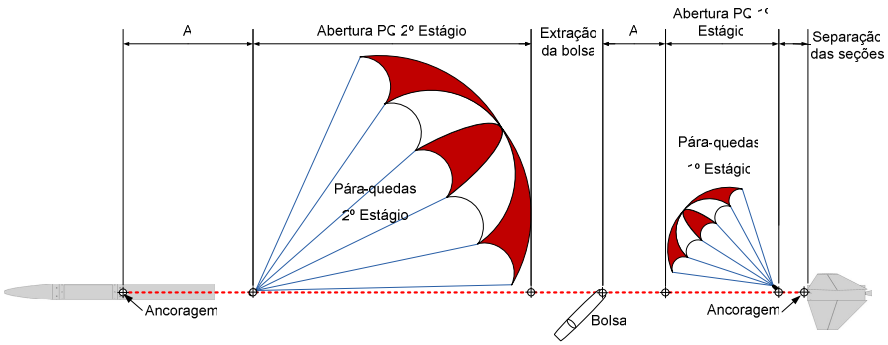

Figure 7. Tether length design.

Another design method regards about the determination of the energy necessary to extend the recovery systems. An easy way to calculate the amount of kinetic energy that the rocket parts must have to pull out tethers and parachutes, this is directly related to the joint and pyrotechnic charge design. With this technique it will be necessary less recovery system tests and a smaller chance of destroying rocket components during recovery system ground tests. The method compares the time necessary to pull out the system with a weight and compares it to the free fall of the same weight, considering the weight of the recovery system components, as shown on Figure 8.

7. ONBOARD ELECTRONICS

The electronics responsible to activate the recovery systems, if it is not a purely pyrotechnic device, are divided in two groups, the passives that are the simple timers and the active systems The second one is a flight computer that can be easily made with a simple micro controller, barometric pressure sensor and an accelerometer. Thanks to the automotive industry these sensors, that are the main critical components, are chap and easily accessible today. With this system is possible to detect the main events on a rocket flight and use this information to trigger the recovery systems, even if the flight conditions change. The main flight events and the relation with the sensors signals are showed on Figure 10. These topics are discussed; some commercial flight computers and an optical isolated electronic ignition system to use with a computer design are presented on the web site. This page is the 12º on the page rank and besides to be a short page have the best average time from the entire web site, it is also one of the main entering pages when the source of the visit are search engines.

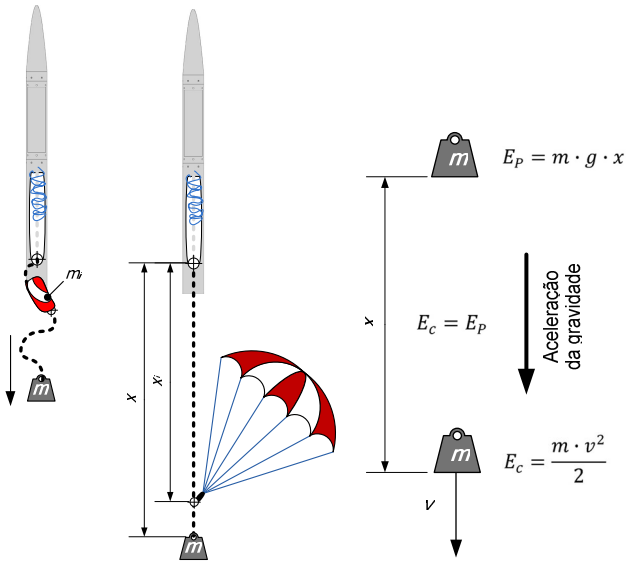

Figure 8. Determination of the energy to extend the recovery system

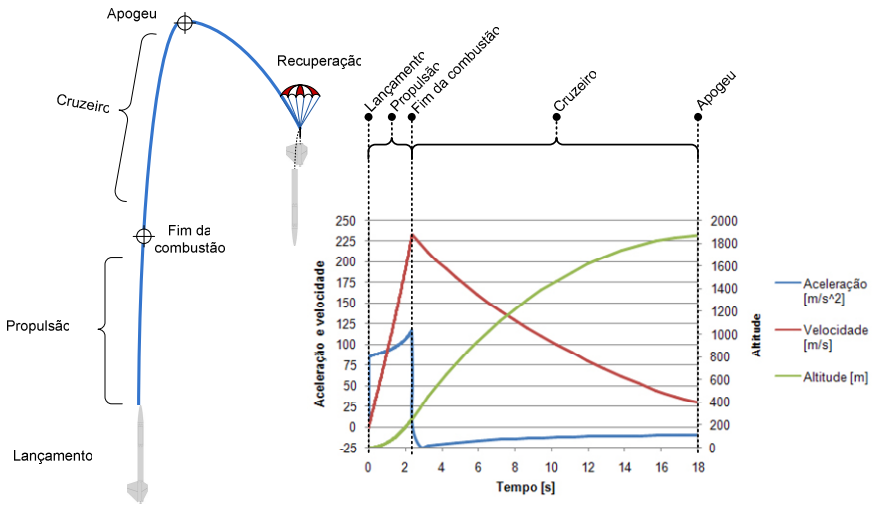

Figure 9. Free flight rocket main events and the relation with aceleration, speed and altitude.

8. CONCLUSIONS

The web site is well connected to the right key words on search engines and the absolute unique visitors graphic on Figure 10 shows that exists a constant, but low rate, growing of visitors. They come from more than 160 cities from Brazil, which represent 93% of the visits considering all other 27 countries. The ten main cities representation of the unique visitors and a map overlay from Brazil is showed at the Figure 11.

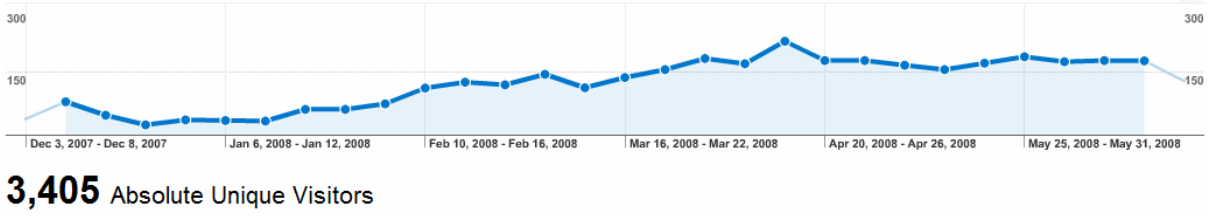

Figure 5. Absolute unique visitor on the web site beween December 3 of 2007 and June 26 of 2008

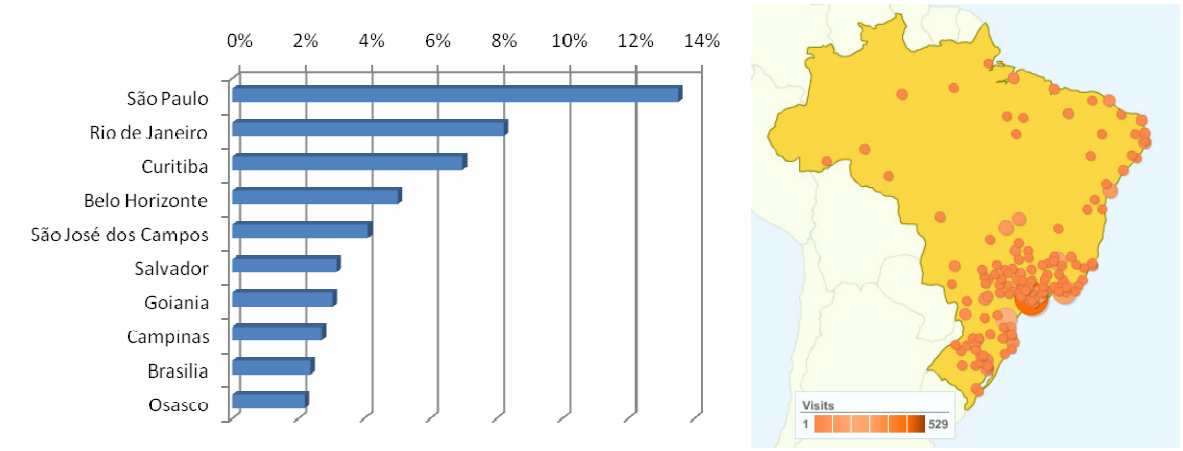

Figure 6. Ten main cities visits

The main purpose of this work is to allow access to the SRM and rocket theory and design, the website certainly fulfill this objective and reaches a much higher number of enthusiasts, mostly with the help of the search engines. The forum, at the time of this paper publishing, is starting to have interesting posts and more people are coming to create a rich discussion. It's possible to see on figures 12 and 13 that the visitors remain a good time studding and come back for consulting. New projects are been developed and soon the website will have new articles with more practice information.

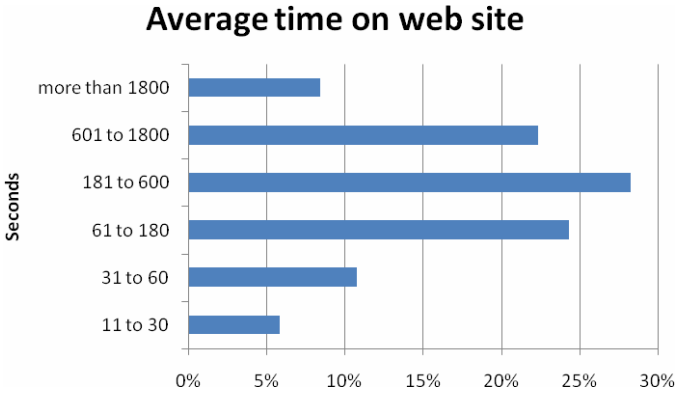

Figure 7. Average time on web site

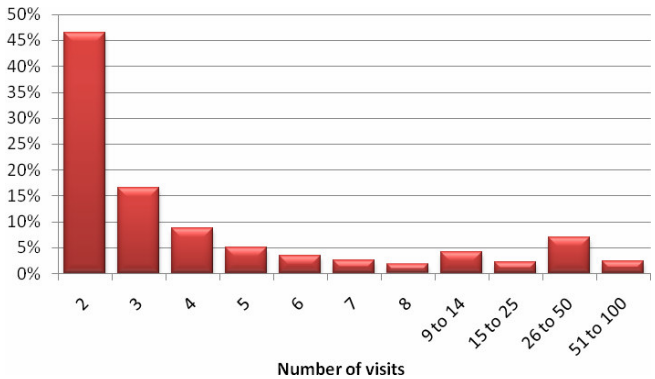

Figure 8. Loyalty of visitors

Together with the interaction possibilities that the CMS system provides to the website it will continue to create interest from enthusiast and future engineers to create the critical mass of specialist so necessary to Brazil to reach its highest level of technology on the space technology market, that is literally a market with huge horizons for expanding.

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