Investigation of raw materials candidates to solid fuel grain formulation applied in ducted (hybrid) rocket motor

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Abstract - Satellite launchers demand new technologies applied to Defense Systems, like new studies on thrusters applied to missiles. There is a lack of information about hybrid thrusters research in Brazil. Studies on the operation and working of MBDA METEOR missile are needed. In order to contribute to this research area this work focuses to kick start these meter and pointed out some procedures to increase the national technology knowledge in research of solid fuel formulations for ducted propellants application applied to national hybrid rocket motor.

I. INTRODUCTION

Recent news on the acquisition of war equipment by countries that have their actions focused on their national security demonstrate how high the cost of acquiring this latest generation equipment is, considering the alignment of effectiveness and efficiency of the expected result. Countries who have the technology and knowledge to design and build such equipment controls the rules and costs, in addition to mastering state-of-the-art technologies, embarrassing other competitors. This work was based on the preliminary research of literature that deal with last generation missile thrusters such as the Meteor from MBDA (Figure 1). Development of hybrid propulsion technology (ducted rocket motor) by obtaining solid fuel grains formulated with chemical species may have their ballistic properties evaluated. Specimens such as boron, aluminum and magnesium, among other metals, agglomerated by polymeric matrices based on polyurethanes may be studied. This research brigs information from a combustion chamber of a bench top hybrid motor and compares to a full scale naturally ducted rocket motor. In these fixed-point tests, oxygen from atmospheric air will be used instead of pure oxygen (GOX) conventionally used for this purpose. Using the solid fuel with oxygen from the atmospheric air in motor burning, there is no need for oxidizing chemical species in the fuel grain. Thus, the available payload will increase.

This work aims to investigate and evaluate proportional parts of boron, magnesium, aluminum and polyurethane binder, among other elements, in order to prepare samples of solid fuel grains to be tested in a test bench for burning with atmospheric air. The aim of the study is the research of national solutions, with totally independent technology, for the operation with missiles propelled by ducted rocket motors using fuels capable of operating in atmospheres with low oxygen concentration. Than, will be seeked the determination of suitable formulations for burning solid fuels with atmospheric oxygen for application in different launchers. The increased payload available in these ducted motor configurations is the next research step.

Figure 1: METEOR
Source: https://www.fab.mil.br/noticias/mostra/38377

II. METHODOLOGY

Researching in specific bibliography is the adopted methodology, to bring knowledge for the composition possibilities of the solid fuel grain to be tested in a motor test bench, see Figure 2.

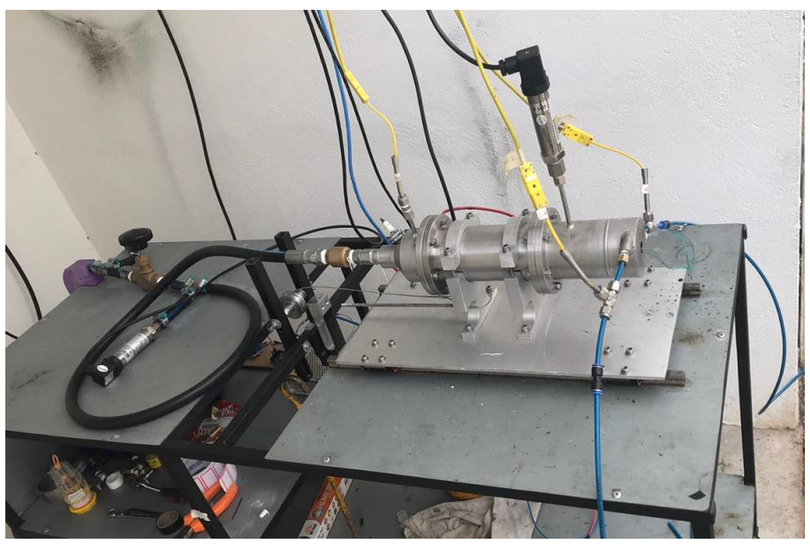

Figure 2: Motor Test Bench

Knowing which chemical components may be used it will be sought the rate of each on in a better composition. Than, the conformation process of the fuel grain will be established for its installation in the motor test. With the experiment reaching the desired objective, the burning of the grain, the data obtained and collected by a free hardware electronic prototyping platform, such as Arduino for example, can be analyzed for use in the carry on studies. It will be possible to predict a motor test in full-scale hybrid rocket. Figure 3 shows an output of data by Arduino.

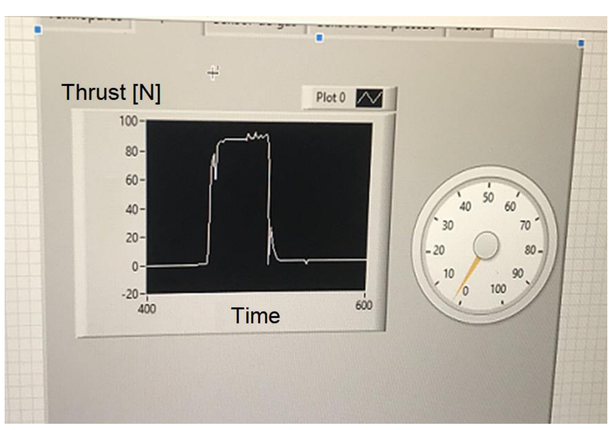

Figure 3: Thrust curve from bench test

The use of boron, magnesium, tungsten and aluminum is shown to be a good alternative. This fact is due to the high energy potential of these materials, which previous studies showed good performance through a spectrometer. An example of the comparison between some of the chemicals is shown in Figure 4.

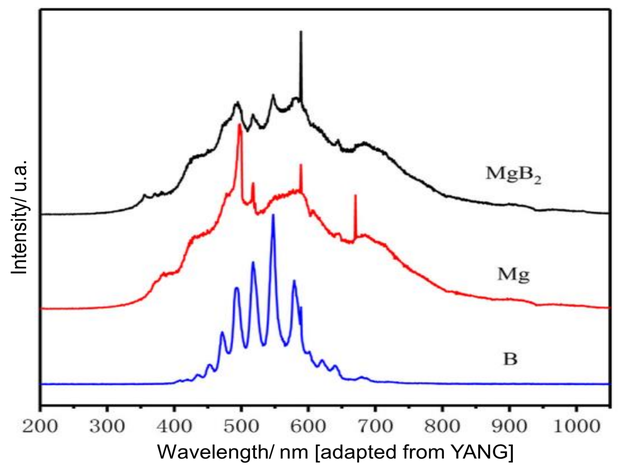

Figure 4: Comparison of combustion spectrogram of MgB2, amorphous boron and magnesium

III. CONCLUSIONS

After several investigations in existing studies on possible formulations of solid propellant grain for ducted hybrid motor to long-range missile rocket motor, was observed that the use of some metallic additives such as boron, magnesium, tungsten and aluminum appear to be credible alternative to the formulation of fuel grains.

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