The Gelled Propellant Rocket Motor Technology of MBDA Bayern-Chemie

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Abstract
Since 2001 Bayern-chemie and the German institutes Ict & Dlr are developing the gelled propellant rocket motor. This paper presents the achievements of the technology demonstration phase that was finished successfully in 2006. The focus of this paper are system aspects and particularly the feeding system. In addition results on gel propellant combustion and thrust modulation are presented. The adaptation of an ammonium nitrate based composite propellant for use as gas generator is shown.

1. Introduction

Established in the year 2000 by the German authorities the national gel propellant team (Bayern-chemie, Institut of Chemical Technology Ict & Deutsches Luft- und Raumfahrtzentrum DLR) generated the concept for a gelled propellant rocket motor.

Based on theoretical considerations (regarding functional aspects) and experimental pretests (regarding propellant gelatinization and spraying) a motor system was preselected in order to meet the identified requirements.

Aimed to gain flight readiness on motor level the development was structured in motor hardware, injection system, gelled propellant and feeding system. All components have been tested separately and in combination.

This paper focuses on the aspects of the gelled propellant and the gas generator feeding system.

2. System overview

The motor mainly consists of a 1 or 2 -chamber tank (optional diergole – monergole) containing the respective gelatinezed propellant ingredients (oxidator & fuel). Feeding of the gels into the injection system is carried out by a piston which is driven by a gas generator. The subsequent spraying is guaranteed by special injectors taking into account the rheological properties of the used gels.

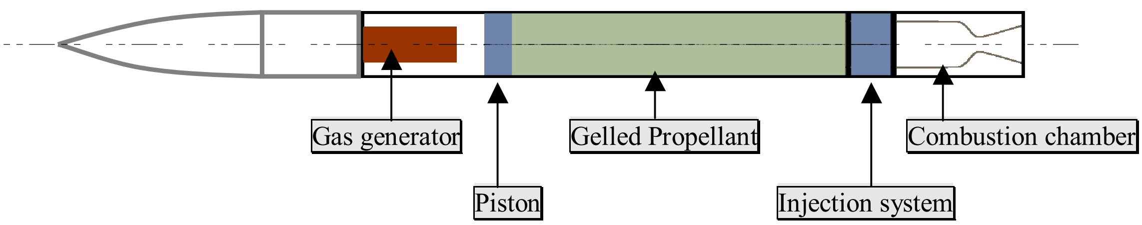

Figure 1: Motor overview (monergol)

3. Combustion and thrust modulation

The general mission profile 'fire and forget – non line of sight' requests a selfcontrolled thrust modulation with a previously unknown number of thrust and sustain phases of different durations. Fig. 2 shows a typical mission profile with an initial boost phase and a terminal boost phase. The goal was to cover all possible thrust histories with one gas generator while keeping the gas pressure within the limits set by

a) requirements for an effective feeding

b) requirements to limit the maximum pressure in order to allow light weight structures

Chapter 4 shows more details about the gas generator design.

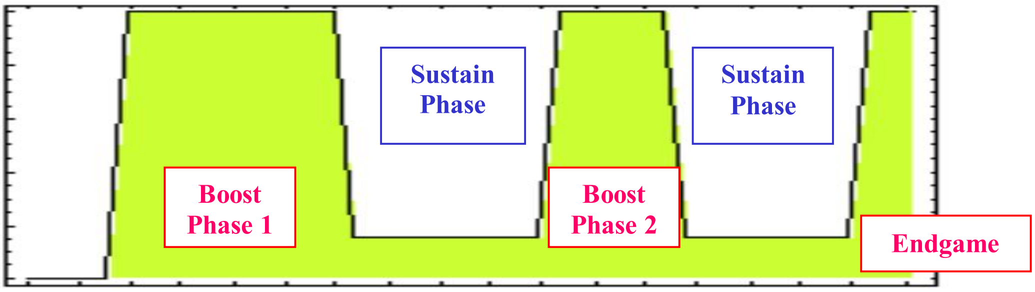

Figure 2: Mission profile –example with 3 boost phases

Successful trials at motor level (monergolic gel injection by a compressed air driven piston) demonstrated a constant gelled propellant combustion at ambient temperature and validated the feasibility of the thrust modulation. Notice that the combustion is very smooth and that the thrust modulation shows a linear behaviour. The oscillations of the thrust histories are caused by mechnical vibrations of the test set-up. The specific impulse of the experimental rocket motor meets the predictions.

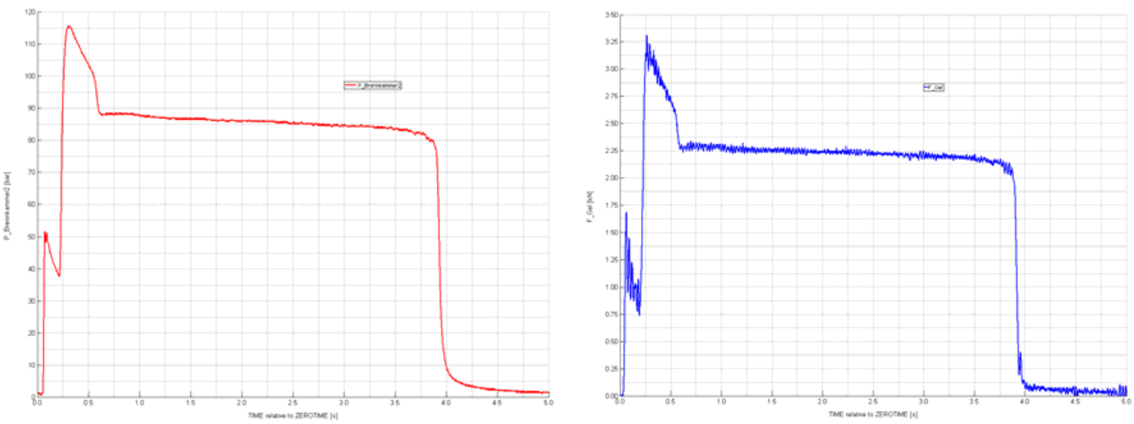

Figure 3: Pressure and thrust curve of an initial boost phase

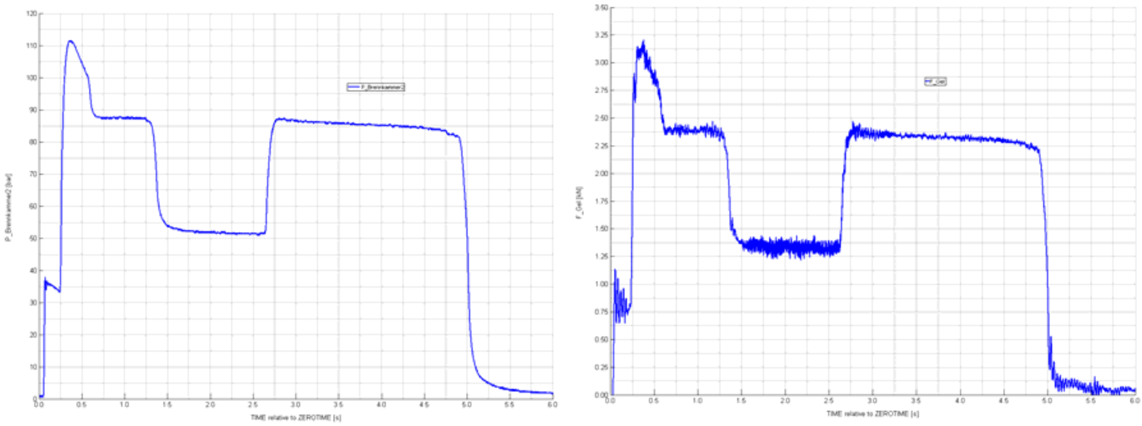

Figure 4: Pressure and thrust curve of a boost – sustain - boost mission

4. Gas generator feeding system

Three composite propellants with different burning rates have been developed to gain such gas production history that is needed to cover the various mission profils. Our simulations showed, that a triple gas generator will be able to fullfill these requirements and to keep the gas pressure within the required limits. The variable parameter is the gel mass flow, which is regulated by adjustment of the injection system.

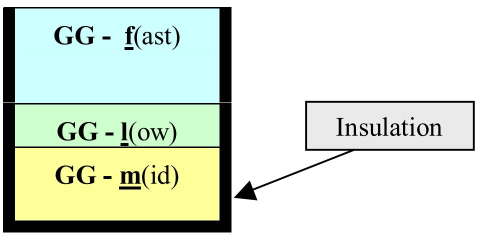

Figure 5: Gas generator 'triple grain' with insulation

Based on an existing ammonium nitrate composite propellant the gas generators burning rates were taylored by modification of the oxidator / burning rate catalyst content and material. To achieve the lowest burning rate at the calculated working pressure a coolant was added to the formulation.

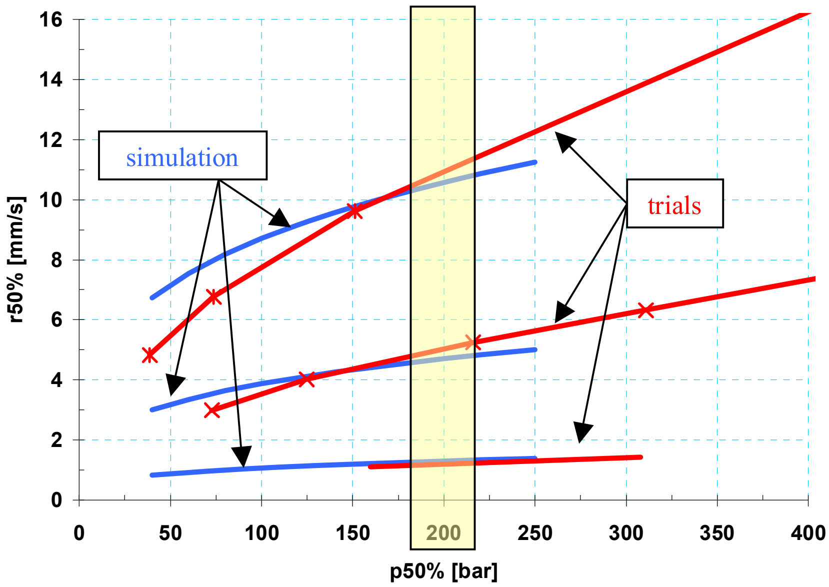

Figure 6: Pressure vs burning rate of the gas generators

Several tests validated the gas generators correct function by ejecting water. A typical mission profile with three boost phases was selected and sucessfully demonstrated on motor level.

Fig. 7 shows the valve action profile, Fig. 8 shows the resulting pressure history which is a results of the combustion of the gas generator and the increasing void volume of the tank. Fig. 9 shows the comperison of prediction and experiment.

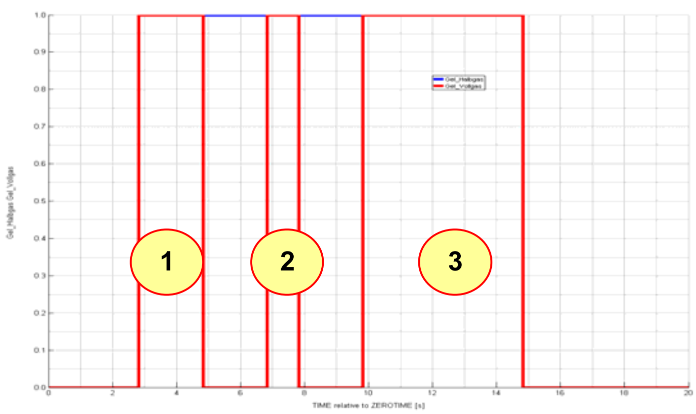

Figure 7: Action times and positions of the two parallel valves

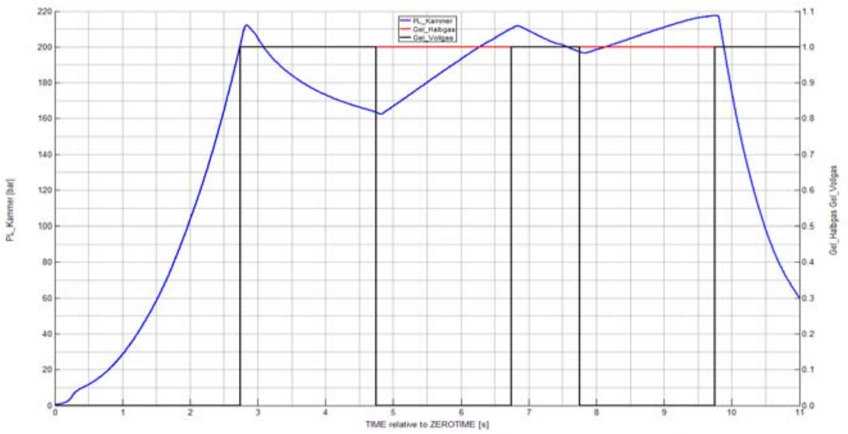

Figure 8: Gas generator pressure curve and valve action

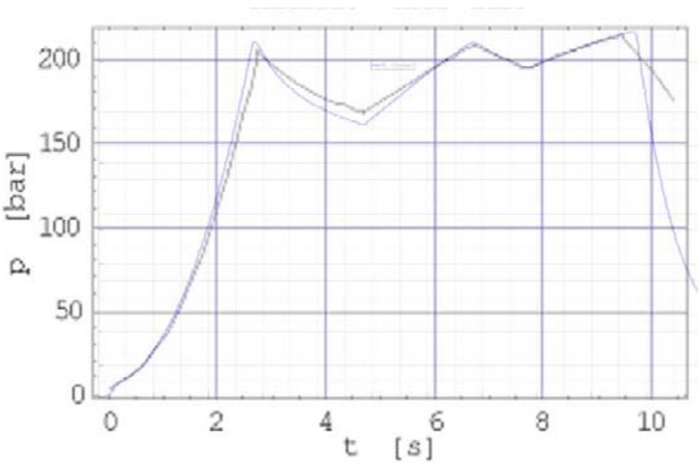

Figure 9: Gas generator pressure curve prediction and experiment

5. Summary and future steps

Combustion and thrust modulation of a gelled propellant rocket motor is validated on motor level with very good results both for the combustion properties and for the performance parameters. The gas generator feeding system is developed and also successful tested. The concept to use a single gas generator design for all possible mission profiles within a given time frame is confirmed and will contribute to a significant simplification of this component of a gel propulsion system.

Next trials will cover the combination of gas generator and gel propellant combustion in a light weight structur of the flight demonstrator.

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National Team:

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