Application of Thermoplastic Composite Propellants in Production of Propellant Grains and Rocket Motors

Boris Jankovski* · Vladica Bozic* · Marko Milos** · Bok Jik Lee***

ABSTRACT

The technology of production of the thermoplastic composite rocket propellants is based on a two-phase production procedure. The first phase represents the production of a semi-product in the sheet (foil) form (thickness: 0.5 mm ~ 5 mm), whereas the second phase is realized independently from the first one and it is based on the semi-produced product and thus the final form of the propellant grain is realized in relation to the defined geometry.

Well done mechanical characteristics of the propellant grain enable that the same thing could be used as a mandrel in the filament winding procedure in creating the motor chamber of the composite material.

Key Words: Thermoplastic Composite Propellant, Propellant Grain, Rocket Motor

1. Introduction

The wide range of polymeric materials and additives designed for the polymeric materials' modification that have been available on the market in the last couple of years, as well as the their processing technology, has enabled the production of the highly developed mechanical features which posses the highest degree of the reception of the filler, thus providing – from the aspect of the rocket technology needs – wide range of possibilities for its application in the production of the rocket propellants.

The technology of production and of processing of polymeric materials has become quite available, thus enabling, with the use of unconventional methods in its processing, a wide spectrum of geometries of the propellant grain and with it, the wider opportunities of modeling the geometry of propellant grain, which may also influence the wider opportunities for the modeling of the geometry of propellant grain, thus enabling the influence on the final characteristics of the rocket motor.

Technological equipment for the production of the propellant is based on the standard machinery and the processing of thermoplastic elastomers that are slightly modified, and that is very significant from the aspect of the technological independence and the rapidity of adjusting to their needs

* VEDA Design&Production Enterprise
** University of Belgrade, Faculty of Mechanical Eng.
*** LIG Nex1, PGM R&D Lab
Corresponding Author, E-mail: bjlee.snu@gmail.com

Apart from its usage in the production of the propellant, this technological equipment is also used to produce other materials; it is used in the production of inhibitors, thermo-insulation materials, then in the production of elastic liners, simulating testing materials for defining of technological production process, education of employees and in the production of samples used for demonstration.

The fact that the production process of the final product is based on two independent technological phases – the first of which produces the propellant as a semi-product, with defined features and the other, independent phase of the finalization of the propellant grain – should also be considered as the significant technological and strategic breakthrough. On one hand raw materials are linked to the final product, while on the other, the finalization could be realized in other location at any given point in time.

Thermoplastic binders and the fact that they could be processed in more than one cycle has the direct influence on the capacity of the technological equipment, namely, that it is not linked to the scopes of the finalized product and that even on the small capacity plants the large range products could be realized, which is especially significant in the developing stages of a project.

Mechanical characteristics of the final product further enable the production of various types of propellant grain. In the production of the free standing propellant grain, the finalization of the propellant grain, the inhibitor and the binding elements (made of metal or plastic materials) are produced in a single operation, which is very significant from the aspect of the compact of final propellant grain. In order to make case bonding, the final propellant grain can be used as a mandrel in the filament winding thus gaining all of the elements of the rocket motor in their compact structure, without the bonding elements between the nozzle or upper closure, thus significantly simplifying the finalization process of the rocket motor. Provided that the metal motor chamber is used, the finalization of the propellant grain could be performed in the chamber itself, which is similar to the casting technology.

The process of production of the propellant, both as a semi-product and the finalized propellant grain, solely represents the transformation of the basic material's form (thermoplastic elastomer) where no additional chemical reaction do not take place and influence the final product's characteristics.

2. PROCEDURE OF PRODUCTION

2.1 Procedure of the production of propellant, inhibitors and dummy materials as semi-products

The basic orders of activities that are used to produce propellant as a semi-products are as follows (Fig. 1):

(1) Control of the quality of the defined thermoplastic elastomer
(2) Control of the other raw materials' qualities
(3) Measuring of the raw materials
(4) Preparing of the polymer
(5) Production of the propellants' mixture (using mixer machine)
(6) Production of the semi-product in a sheet form on the two roll-mill
(7) Packing and storage of the semi-products

The procedure of the inhibitor production, dummy materials and other laminar materials is identical to the production of the propellant.

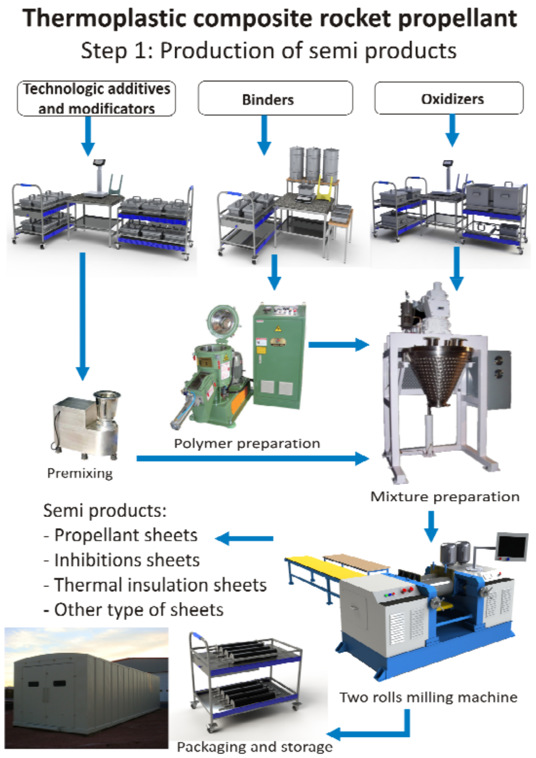

Fig. 1 Production of a semi-product in the form of sheet

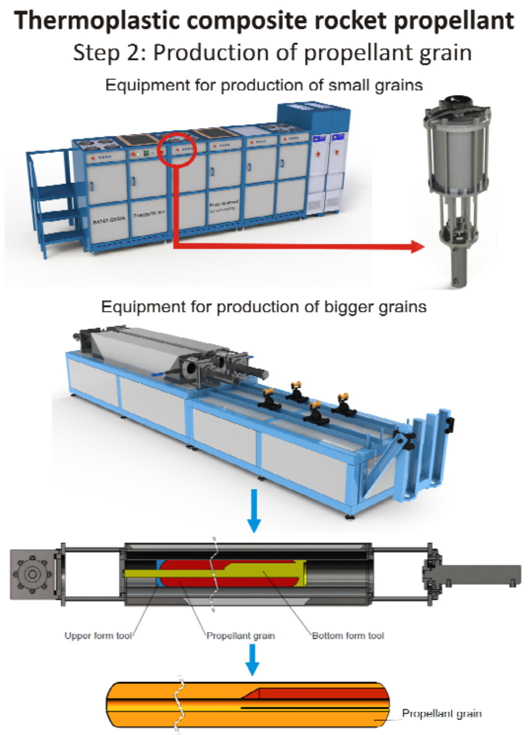

Fig. 2 Production of propellant grain

2.2 The procedure of the final propellant grain production

Schedule of the activities for the production of the final propellant grain is as follows(Fig. 2):

(1) Inspection of the quality of the propellant, as a semi-product
(2) Altering the propellant to the needed width on a specially designed desk
(3) Drafting of the preform of the propellant grain along with the inhibitor and the element conjunctions based on the desired final form
(4) Processing of the propellant grain with the coordinative temperature, pressure and vacuum actions, in the time function and in the specially designed plants
(5) The extraction of the propellant grain and the possible mechanical finishing touches.

2.3 The production of the case bonding motors using the filament winding technology

In order to realize this conception, propellant grain is used as a mandrel. An imbedding is placed at the head of the motor, which follows its geometrical features, while on the end - follows the nozzle subassembly. The central thorn forms a compact unit, which is placed on the filament winding of the machine, and the entire scope is winded by carbon fibers covered in resin(Fig. 3, 4).

2.4 Production of free standing grains & motors

Propellant grain with linked elements can be fixed to the aft closure by thread connection or using special bolts(Fig. 5, 6). The distance between combustion chamber and the propellant grain can be ensured with longitudinal elements.

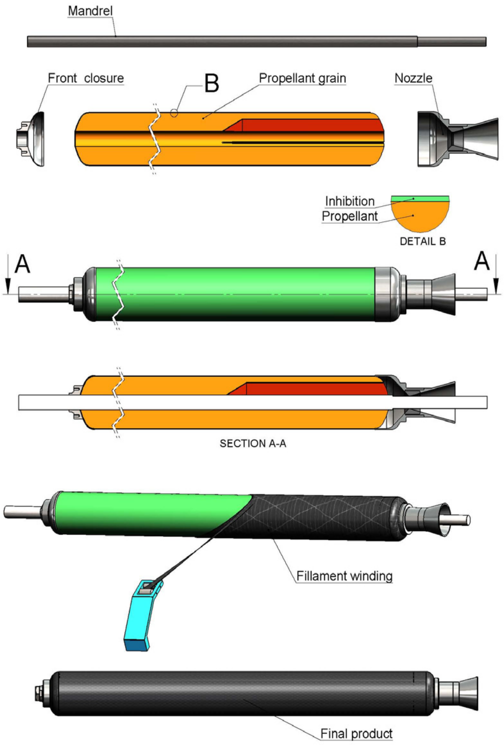

Fig. 3 Production of case bonding grains

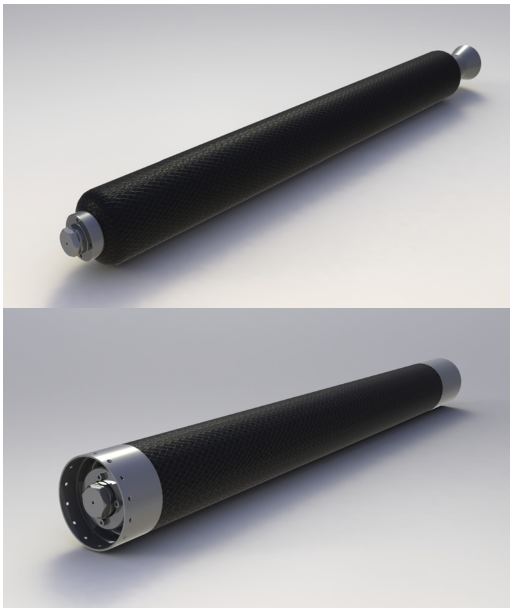

Fig. 4 Final Products

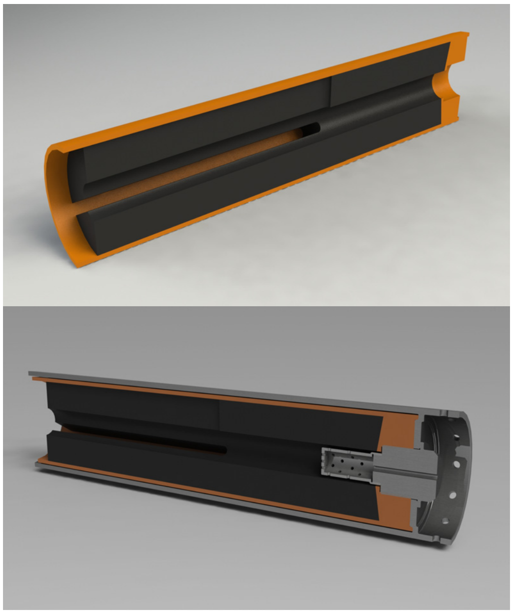

Fig. 5 Propellant grain type A

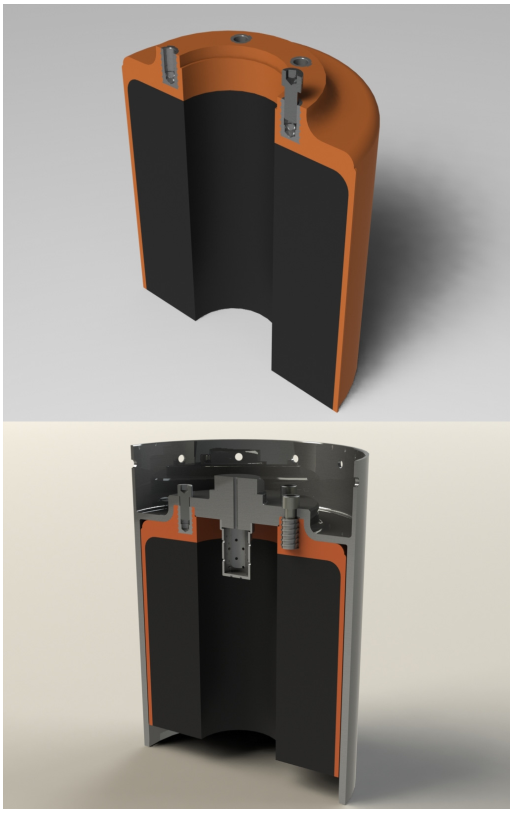

Fig. 6 Propellant grain type B

3. CONCLUSION

Production technology based on thermoplastic elastomers makes possible use of various types of non-standard methods (procedures) in manufacturing of propellant grain and completion of rocket motor as a whole. The process of manufacturing becomes more practical due to use of standard equipment which is part of technology processes for manufacturing of the polymers.

This technology enables the wider opportunities secured by the optimal geometry of the propellant grain that are allocated in accordance with the engineer's needs.

Also, using the method of filament winding the final integration of the rocket motor together with subassemblies like aft closure and nozzle could be possible immediate after finalization of the manufacturing.

REFERENCES

1. Vladica Bozic, Marko Milos, Djordje Blagojevic and Boris Jankovski, "Examination of AP/KN Composite Propellant Thermal Wave Structure Under Steady-State Burning," Advancements in Energetic Materials and Chemical Propulsion, edited by Keneth Kuo, and Juan de Dios Rivera, Begell House, Inc., USA, 2007, pp. 195-210.
2. Vladica Bozic, Boris Jankovski, Marko Milos, and Djordje Blagojevic, "Production of Gas Generators in Airbag Inflators Using Propellants With Thermoplastic Binders," Proceedings of the EUROPYRO 2003, 30th International Pyrotechnic Seminar, Saint Malo, France, 2003, pp. 688-695.
3. Marko Milos, Vladica Bozic, Djordje Blagojevic, and Boris Jankovski, "Production of High-Energy Propellants Using Thermoplastic Elastomer Binders," paper 36, Proceedings of the Ninth International Workshop on Combustion and Propulsion, Lerici (9-IWCP), Italy, 2003.
4. Boris Jankovski, prof. dr Ljuben Dudeski, "New Material And Technology For Fire Extinguishing," Proceedings of the International conference Manufacturing and Management in 21st century, Ohrid, Macedonia, September 16-17, 2004.