The Total Impulse Study Of Solid Propellants Combustion Containing Activated Carbon From Coconut Shell As A Catalyst

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Abstract

This study investigates the capabilities of thrust, burn time, and total impulse from solid propellant materials. Attempts to increase the three variables are quite difficult because the thrust value is inversely proportional to the value of the burn time, it requires the catalyst as a regulator of the composition to produce an optimal variable value. The activated carbon from the coconut shell is used as a catalyst on a composite solid propellant material containing ammonium perchlorate (AP), hydroxyl terminated polybutadiene (HTPB) and aluminum (Al). The effect of adding coconut shell activated carbon may affect thrust parameters, burn time and total impulse rocket. The method of measuring parameters using rocket thrust test equipment. The mass of the test sample is 250 grams, the diameter of the test chamber is 20 mm, the length of the chamber is 200 mm. After going through the combustion process, it produces a graph and thrust value, total impulse and burning time. The thrust test results show that the test propellant 3 produces the best characteristic composition of 70% AP, 15% HTPB, 10% Al, and 5% activated carbon of 400 mesh with average thrust: 148.67N, total impulse: 637, 5 Ns, burn time: 4,288 s.

Keyword : , AP, HTPB,Al, thrust,total impulse,burn time

1. Introduction

Propellants is the chemical mixture that burned to produce thrust in rockets and consists of a fuel and an oxidizer. A fuel is a substance that burns when combined with oxygen producing gas for propulsion. An oxidizer is an agent that releases oxygen for combustion with fuel. The ratio of oxidizer to fuel is called the mixture ratio and for this case it is 65/35 according to Nakka. The Thrust is the force that propels a rocket or spacecraft and is measured in pounds, kilograms or newton. Total impulse is found by summing up all themeasured thust values and multiplying this by the time increment.[Nakka,2001]. There are two type of solid propellants : homogeneous and composite [O.S.Olaoye et al:2014]. Composite solid propellant composition

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are generally made up of some oxidizer such as ammonium perchlorate, hydroxyl terminated polybutadiene as a binder [G.Singh et al, 2010]. The transition metal oxides are often used for catalyzing the thermal decomposition of ammonium perchlorate, hydroxyl terminated polibutadiene and alumminium as fuel based composite solid propellants and to adjust their burn rates. The various factors such as the amount of catalyst and the particle size have been known to play important role for the burn rates alteration [K.Kishore et al:1977]. This study investigates the capabilities of thrust, burn time, and total impulse from solid propellant materials. Attempts to increase the three variables are quite difficult because the thrust value is inversely proportional to the value of the burn time, it requires the catalyst as a regulator of the composition to produce an optimal variable value. The activated carbon from the coconut shell is used as a catalyst on a composite solid propellant material containing ammonium perchlorate (AP), hydroxyl terminated polybutadiene (HTPB) and aluminum (Al). The effect of adding coconut shell activated carbon may affect thrust parameters, combustion time and total impulse rocket. Oxidizers are principle ingredients, which produce the high energy on combustion. One of the most commonly used oxidizers is AP. AP dominates the oxidizer list because of its good characteristics that include compatibility with other propellant ingredients, good performance, and availability. AN and KN are also used in some applications. Although the inorganic nitrates are relatively low-performance oxidizers compared to perchlorates, they are used because of low cost and smokeless and non-toxic exhaust [Chaturvedi and Dave, 2011, 2012; Meda et al., 2007]. Binders provide structurally a matrix in which solid granular ingredients are held together in a composite propellant. The raw materials are liquid prepolymers or monomers. The binder impacts the mechanical and chemical properties, propellant processing and aging of the propellant. Binder materials typically act as a fuel, which gets oxidized in the combustion processes. Commonly used binders are HTPB, CTPB, and NC. Sometimes GAP is also used as energetic binder, which increases the energy density and performance of the propellant. HTPB has been abundantly used in the recent years, as it allows higher solid fractions (total 88–90% of AP and Al) and relatively good physical properties [Galfetti et al., 2006; Meda et al., 2005]. Metal fuels such as aluminum and boron are frequently added to propellant mixtures [Galfetti et al., 2003, 2004]. Aluminum, one of the widely used metal additives, is used in the form of small spherical particles (5–60 μm) in a wide variety of solid propellants. Aluminum particles usually comprise 14–20% of the propellant weight. Addition of metal fuel enhances the heat of combustion, propellant density, combustion temperature, and hence the specific impulse. There are some compounds, which can act as both fuel and oxidizer such as NG and AP. The burning rate catalyst helps increase or decrease the propellant burning rate. It is sometimes also referred to as burning-rate modifier. It can be used to modify the burning rate of specific grain design to a desired value.

Substances such as iron oxide increase the burning rate, while lithium fluoride decreases the burning rate [Sutton and Biblarz, 2001].

In This work, we have investigated the catalytic effect of activated carbon of coconut carbon is canbe to add the thrust, the burning time and the total impulse of composite propellant.

2. MATERIAL AND METHODS

2.1. Materials

Solid propellant that was used in this work is ammonium perchlorat(AP) as oxidizer, hydroxyl terminated polybutadiene(HTPB) as binder, aluminium(Al) as fuel, and actived carbon of coconut shell(ACCS) as catalyst. Komposisi propelan padat umumnya terdiri dari AP 60%-84%, PBN 12%-16%, Al 2-20%, curing agent 0,2%-1%, stabilizer 0-1% [Kishore and Sridhara,1999]. Komposisi lain dibuat dengan AP 65%-70%, Al 15%-20%, Binder HTPB 10%-15% dengan curing agent TDI [Ramesh et al, 2012]. Formula ukuran yang lain AP 68% (AP partikel trimodal, 24% 200μm; 17% 20μm; 27% 3μm), 19% Al 30μm; HTPB 12% dan curing agent, dan 1% katalis laju bakar Fe_2O3. [Hinkelman dan Heister,2011]. This study, the propellant materials had been tested as shown in the table1. composition of the propellant materials.

Table 1. Composition of the propellant materials.

Materials Name	AP	HTPB	Al	ACCS
C1	70 %	15%	15%	-
C2	70%	12%	15%	3%
C3	70%	15%	10%	5%
C4	70%	8%	15%	7%
C5	70%	10%	15%	5%
C6	70%	15%	12%	3%
C7	70%	10%	15%	5%
C8	70%	15%	8%	7%
C9	70%	20%	5%	5%

2.2. Processing of Solid Propelants

The composite solid propellants were formulated by using AP as asolid oxidizer, HTPB as fuel binder, Al as fuel and ACCS as catalyst. AP composition was taking uniform 70%, in all propellants samples. The average particle size of all materials sample were 400 mesh. The total propellant mass was 250 grams, Length (L propelan) : 200 mm, diameter (D propelan) : 20 mm, diameter hollow(D Hollow) : 10 mm. (as shown Figure 1 and Figure 2).

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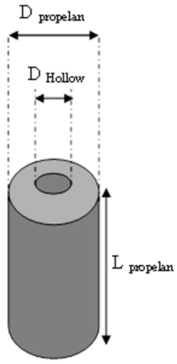

Figure 1. Size of solid propellant

Figure 2. Solid propellant sample

2.3. Instrumentals

Before measurement, the particles of propellants were characterized with scanning electron microscope(SEM) and energy dispersive X-ray spectroscopy (EDX). After this section the static thrust testing for measuring thrust rocket, burn time, total impulse propellants combustion. (as shown figure 3 and figure 4).

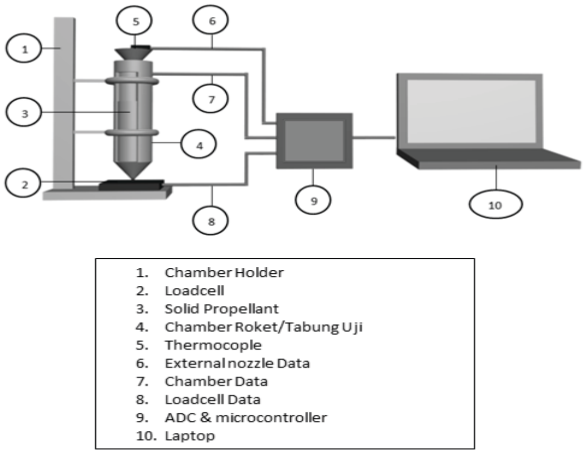

Figure 3. Experimental setup of thrust testing

Konstanta Chamber and Nozzle Rocket Dimension as shown the figure 4

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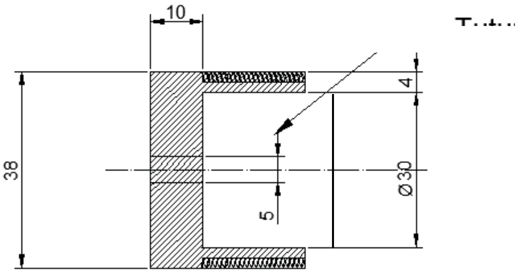
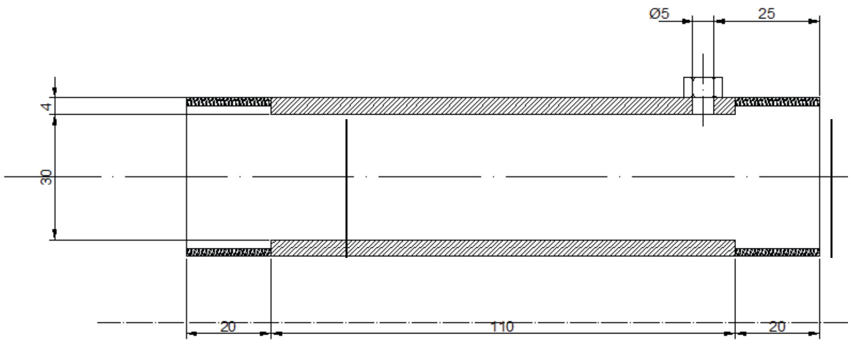
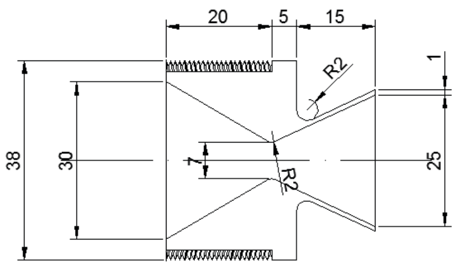


(a)



(b)



(c)

Figure 4. (a) & (b) chamber and (c) Nozzle

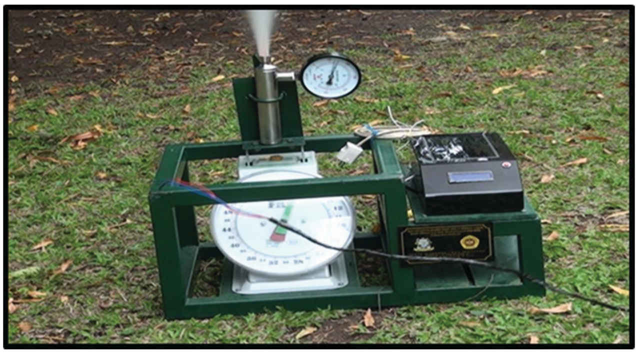


Figure 5. Thrust test tool

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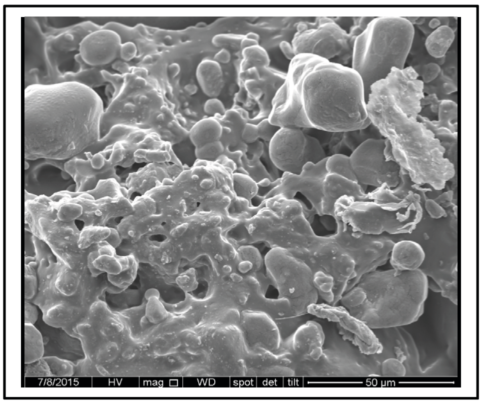
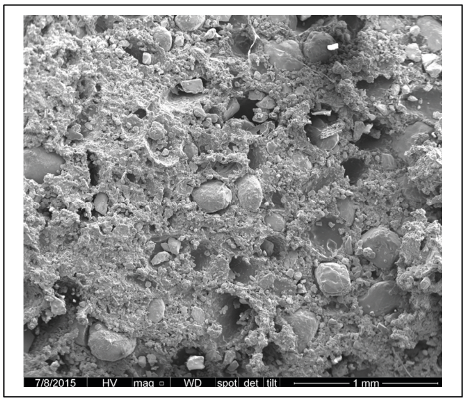
3. RESULT AND DISCUSSION

SEM of Composite Solid propellants (CSP) as shown figure 6.



(a)



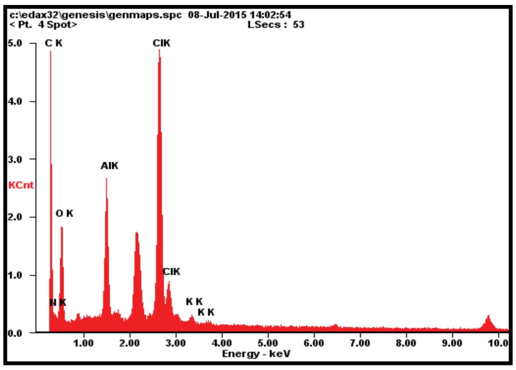
(b)

Element	*Wt%*
CK	52.55
NK	08.00
OK	21.32
AlK	03.68
ClK	14.35
Matrix	Correction

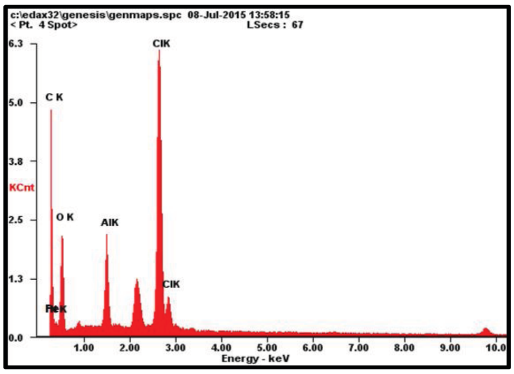
(c)

Element	*Wt%*
CK	57.85
NK	08.00
OK	20.35
AlK	07.08
ClK	14.30
KK	00.16
Matrix	Correction

(d)



(e)



(f)

Figure 6. (a)&(d) SEM of CSP without catalyst and CSP with catalyst
(b)&(c)&(e)&(f) Graph and EDAX of CSP without cata and Solid Propellant

SEM image of CSP without catalyst (as shown Figure 5) showed more solid than CSP with a catalyst. This character causes it was flammable and the buning time was shorter. However, the content of CSP elements with catalyst contains more fuel (such as C, Al, Cl,K). It can be observed that the CSP element with catalyst ratio have increase the burning time, thrust and total impulse.

3.2. Thrust test

Result of thrust test were thrust value, burn time and total impulse such as graph of thrust and parameters value (as shown figure 5). Comparison all compositions yield C3 were the best materials of CSP with catalyst. Effect of ACCS particles as a catalayst were canbe increase total impulse and burn time. (As shown Figure 7 and Figure 8 thrust graph, average thrust, burn time and total impulse)

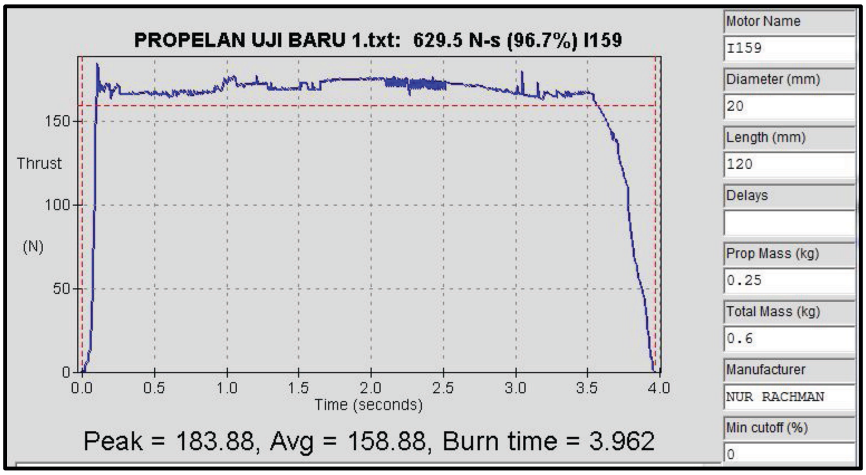


Figure 6. Thrust curve of CSP without catalist

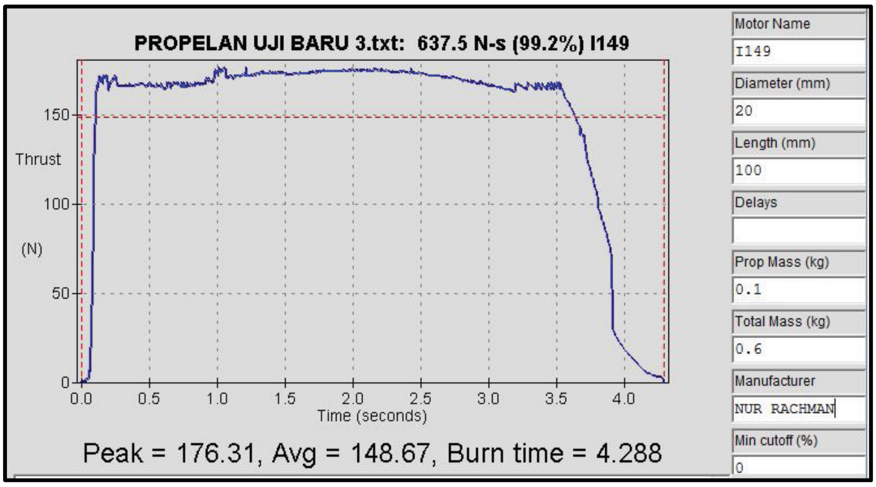


Figure 7. Thrust curve of CSP with catalist (C3)

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From The Figure 6 and The Figure 7 can be comparasion that CSP without catalyst better its thrust values than CSP with catalyst(C3), but better its burn time and the thrust impulse. Thus, C3(AP70%, HTPB15%, Al 10%, ACCS 5%) was the best composition of CSP.

4. CONCLUSIONS

The following conclusions can be drawn from the present investigations on the combustion characteristics of composite solid propellants (AP-HTPB-Al) with and without activated carbon from coconut shell as catalyst.

Addition of activated carbon from coconut shell(ACCS) as catalyst has been found to increase the burning time. Although the CSP without catalyst better its thrust, but total impulse value is lower.

The best CSP of all sample were C3 (AP70%, HTPB15%, Al 10%, ACCS 5%).

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