

FINAL PROJECT

**THE EFFECT OF REACTANT COMPOSITIONS ON THE
MICROSTRUCTURE OF CERAMIC MATERIALS FORMED
BY COMBUSTION SYNTHESIS**



RAMZUL IRHAM RIZA
D 200102010

**MECHANICAL ENGINEERING DEPARTMENT
INTERNATIONAL PROGRAM
IN AUTOMOTIVE/MOTORCYCLE ENGINEERING
MUHAMMADIYAH UNIVERSITY OF SURAKARTA
2014**

DECLARATION OF RESEARCH AUTHENTICITY

I assert verily that the research entitles:

**THE EFFECT OF REACTANT COMPOSITIONS ON THE MICROSTRUCTURE
OF CERAMIC MATERIALS FORMED BY COMBUSTION SYNTHESIS**

That made to fulfill some of requirement to get Bachelor Degree of Engineering in
Automotive Department of Muhammadiyah University Surakarta, as far as I know
it is not a plagiarism of research that has been published, except the information
source which used to solve the problem.

Surakarta, December 2014

Researcher,



Ramzul Irham Riza

APPROVAL

The final project entitles "THE EFFECT OF REACTANT COMPOSITIONS ON THE MICROSTRUCTURE OF CERAMIC MATERIALS FORMED BY COMBUSTION SYNTHESIS", has been approved by supervisor and authorized by Director of International Program as partial fulfillment of the requirements for getting the Bachelor Degree of Engineering in Automotive Department of Muhammadiyah University of Surakarta.

Written by:

Name : Ramzul Irham Riza

NIM : D 200102010

Has Approved and legalized on:

Day : Saturday

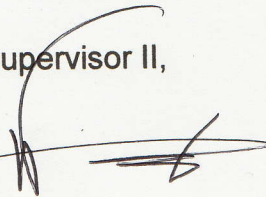
Date : 27 December 2014

Supervisor I,



(Dr. Tri Widodo Besar Riyadi)

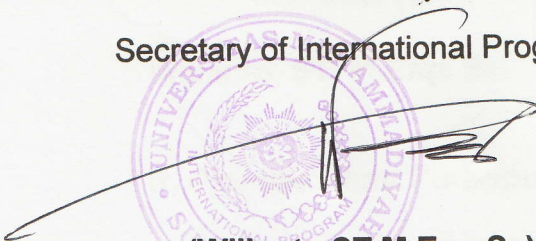
Supervisor II,



(Wijianto, ST, M.Eng.Sc)

Admitted by,

Secretary of International Program



(Wijianto, ST, M.Eng.Sc)

VALIDATION

The Final Project entitled "THE EFFECT OF REACTANT COMPOSITIONS ON THE MICROSTRUCTURE OF CERAMIC MATERIALS FORMED BY COMBUSTION SYNTHESIS", has been defended in front of examiners team and approved as a partial fulfillment of the requirements for getting the Bachelor degree of Engineering in Automotive Department of Muhammadiyah University of Surakarta.

Written by:

Name : Ramzul Irham Riza

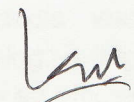
NIM : D 200102010

Has Approved and legalized on:

Day : Saturday

Date : 27 December 2014

Team of Examiners :

Chair Person : Dr. Tri Widodo Besar Riyadi ()

Member 1 : Wijianto, ST. M.Eng. Sc. ()

Member 2 : Ir. Pramuko Ilmu Purboputro, MT ()

Dean of
Engineering Faculty,

(Ir. Sri Sunarjono, MT, Ph.d.)

Head of
Mechanical Engineering Department,

(Dr. Tri Widodo Besar Riyadi)

THE EFFECT OF REACTANT COMPOSITIONS ON THE MICROSTRUCTURE OF CERAMIC MATERIALS FORMED BY COMBUSTION SYNTHESIS

Ramzul Irham Riza

Mechanical Engineering Department

Universitas Muhammadiyah Surakarta

Jl. Ahmad Yani Tromol Pos I Pabelan Kartasura Surakarta 57102

Email: ioriza@yahoo.com

ABSTRACT

Ceramics have been attractive as advance materials for high temperature applications due to their advantages such as high modulus, high hardness, high melting temperature, and high corrosion resistance. Of a broad range of ceramics, titanium carbide and aluminide have developed into one of the most interesting ceramics since they have high strength and good wear resistance at elevated ceramic materials. Producing TiC-Al₂O₃ from economical material (TiO₂) is less expensive than that from their elemental powders. The combustion synthesis (CS) process offers significant advantages to fabricate TiC-Al₂O₃ since it produces high exothermic reaction and takes a short processing time. The objective of this study was to explore the combustion synthesis of TiC-Al₂O₃ and investigate the effect of reactant compositions on the combustion process and microstructure of synthesized products. The combustion synthesis was carried out in a combustion chamber with an atmospheric condition. The ignition technique to initiate the CS was performed using an arc flame. The microstructure and mechanical properties of synthesized products were observed. The result of this research would benefit for producing a high performance ceramic material obtained from economical material with an efficient process.

Keywords: Ceramics, TiC-Al₂O₃, TiO₂, Combustion synthesis, Arc flame, Microstructure

MOTTO

Imaging my word, I read the meaning, I tied in paragraph, I frame in chapter a number of five, and it become a masterpiece, I received a bachelor's degree, parents, fiancée and future in-laws were happy.

I came, guidance, examination, revision, and I won.

I am thankful to all those who said NO to me, It is because of them I did it myself.

(Albert Einstein)

Real friend is one who grabbed your hand and touches your heart. (Heather Pryor)

We pray when troubles and in need of something, we should also pray in great excitement and abundant sustenance. (Khalil Gibran)

I can accept failure, everyone fails at something but I cannot accept not trying (Michael Jordan)

The lack of confidence that make people afraid to face the challenges, and I believe in myself. (Muhammad Ali)

Work like do not need money. Love like never hurt. Dance like no one watching. (Mark Twain)

DEDICATION

This Research Paper is dedicated to

Allah SWT,

Thanks for the best everything You have given for me and thanks for your love that make me never give up to do the best. I believe that you will always give me the best for everything.

My Beloved Dad and Mom,

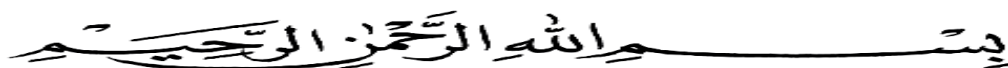
Dr. Irwandi,M.Pd and Dra. Ratna Eliza

Thanks for your pray, love, support, and affection. You always give me happiness but I often made you disappointed. I am sorry and I promise to give you the best in the future.

All of my classmates (Automotive 2010),

Thanks to all of you for giving me valuable experience for along 4 years.

ACKNOWLEDGEMENT



Assalamu'alaikum Warohmatullahi Wabarokatuh

Alhamdulillahirobbil'alamin. Praise and gratitude to Allah SWT, The Lord of The Universe, because of His blessing and guidance the Research paper can be done. The Final Project entitles "THE EFFECT OF REACTANT COMPOSITIONS ON THE MICROSTRUCTURE OF CERAMIC MATERIALS FORMED BY COMBUSTION SYNTHESIS" can be done because of a lot of support from other people. Therefore, writer sincerely would like to say thanks and appreciate to:

1. Ir. Sri Sunarjono, MT, Ph.D., as the Dean of Engineering Faculty of Muhammadiyah University Surakarta.
2. Dr. Tri Widodo Besar Riyadi., as the Head of Mechanical Engineering of Muhammadiyah University Surakarta.
3. Wijianto, ST.M.Eng.Sc., as the Secretary of International Program of Muhammadiyah University Surakarta.
4. Dr. Tri Widodo Besar Riyadi as the First Supervisor who has given researcher inspiration, spirit, advices, suggestions, and corrections to the paper completion.
5. Wijianto, ST.M.Eng.Sc., as the Second Supervisor who has given researcher guidance, suggestions, and correction wisely.
6. Ir. Pramuko, MT as the examiners team members
7. All lecturers of Automotive Engineering Department for the guidance during the study in the university.

8. My beloved Mother and Father who always give enormous pray, biggest support, care, affection, and great attention.
9. My Classmates Automotive Engineering 2010, thanks for you laugh and funny moment for along these 4 years.
10. Those who cannot be mentioned one by one, writer want to say thanks and appreciation to all of them.

The writer realize that this research is far from being perfect, so the writer sincerely welcome any constructive comment, critics, and suggestion from anyone.

Wassalamu'alaikum Warohmatullahi Wabarokatuh

Surakarta, December 2014

Writer

Ramzul Irham Riza

LIST OF FIGURES

Figure 2. 1 a) SHS Illustrations b) VCS Illustrations	5
Figure 2. 2. ECAS Ilustrasion.....	7
Figure 2. 3 Density effect on compaction pressure	10
Figure 2. 4 SEM Micrograph of HDH CP-Ti powder	12
Figure 2. 5 The Incoming Beam.....	14
Figure 2. 6 SEM Scheme.....	16
Figure 3. 1 Titanium Dioxide powder	17
Figure 3. 2 Alumunium Powder.....	18
Figure 3. 3 Carbon powder.....	18
Figure 3. 4 Ohaus adventurer balance	20
Figure 3. 5 Watch Glass	22
Figure 3. 6 Mortar and pestle	24
Figure 3. 7 Compaction process ilustrations.....	25
Figure 3. 8 Torque wrench	25
Figure 3. 9 Arch Welding inverter	27
Figure 3. 10 Argon gases tube.....	28
Figure 3. 11 Experimental procedure	29
Figure 4. 1 Pure material synthesized product	30
Figure 4. 2 Synthesized product with 20% excess of TiO_2 and C top side	31
Figure 4. 3 Syntesized product with 20% excess of TiO_2 and C bottom side	32

Figure 4. 4 Syntesized product with 40% excess of TiO_2 and C top side	33
Figure 4. 5 Synthesized product with 40% excess of TiO_2 and C bottom side	33
Figure 4. 6 Syntesized product with 60% excess of TiO_2 and C top side	34
Figure 4. 7 Syntesized product with 60% excess of TiO_2 and C bottom side	35
Figure 4. 8 Syntesized product with 80% excess of TiO_2 and C top side	36
Figure 4. 9 Syntesized product with 80% of TiO_2 and C bottom side	36
Figure 4. 10 Syntesized product with 100% excess of TiO_2 and C top side	37
Figure 4. 11 Syntesized product with 100% excess of TiO_2 and C bottom side...	37
Figure 4. 12 XRD Pattern	39
Figure 4. 13 XRD pattern with 20% excess of TiO_2 and C	40
Figure 4. 14 XRD pattern with 40% of TiO_2 and C	41
Figure 4. 15 SEM result on pure material	42
Figure 4. 16 SEM results with 20 % excess of TiO_2 and C.....	43
Figure 4. 17 SEM result with 40 % excess of TiO_2 and C	44

LIST OF TABLES

Table 2. 1 Adiabatic and measured combustion temperatures for various reaction system.....	9
Table 2. 2 Particle Size Distribution.....	11
Table 3. 1 Material sources	19
Table 3. 2 Arch Welding inverter specifications.....	21
Table 3. 3 Mass Compositions in grams	23
Table 3. 4 Arch Welding Specifications.....	27
Table 4. 1 Synthesized product compositions	42
Table 4. 2 Syntesized product compositions	44
Table 4. 3 Synthesized product compositions	45

Contents

ABSTRACT	iv
LIST OF FIGURES.....	ix
LIST OF TABLES	xi
CHAPTER I Introduction	1
1.1 Backround.....	1
1.2 Problem Statement.....	2
1.3 Objective of Study.....	2
1.4 Problem Limitations	2
1.5 Outcomes	3
CHAPTER II Literature Review	4
2.1 Ceramics.....	4
2.2 Combustion Synthesis.....	4
2.3 Ignition Techniques.....	5
2.4 Parameter of Combustion Synthesis.....	7
2.5 Microstructure.....	13
CHAPTER III Research Procedures.....	17
3.1 Preparation of Starting Material.....	17
3.2. Sample Compositions.....	19
3.3. Powder mixing.....	19
3.4. Powder compaction	24
3.5. Reaction chamber.....	26
3.6. Ignition techniques.....	26
CHAPTER IV Results and Discussion.....	30

4.1 Combustion Products	30
4.2 XRD Results	38
4.3 Microstructures	41
CHAPTER 5 Cnclusions and Suggestions.....	46
5.1 Conclusions	46
5.2 Suggestions.....	46
References.....	47
APPENDIX	50