
# UNIVERSITY OF DIPONEGORO

## DETERMINISTIC CONTACT ANALYSIS OF ROUGH SURFACE USING FINITE ELEMENT METHOD

**BACHELOR THESIS**

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**UNIVERSITY OF DIPONEGORO**

**SEMARANG**

**MARCH 2012**

# BACHELOR THESIS

Given to:

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| Name | : | Fanni Fattah |
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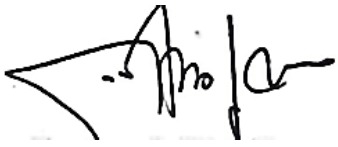
| Thesis Advisor | : | Dr. Jamari, ST, MT |
| Time Required | : | 6 month |
| Title | : | **Deterministic Contact Analysis of Rough Surface Using Finite Element Method.** |
| Substantive Material | : | |

1. Generating three dimensional models of rough surfaces in commercial finite element software.
2. Comparing generated surface with normal surface on ABAQUS.
3. Applying generated surface in static case of elastic and elastic-plastic contact.
4. Comparing finite element model with experimental result.

Thesis Advisor,



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## DECLARATION LETTER OF ORIGINALITY

**I hereby declare that I made this thesis by myself**

**Every reference both cited and refered is definitely correct**

Name : Fanni Fattah

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Signature : 

Date : 13 Maret 2012

# APPROVAL SHEET

University of Diponegoro

Department of Mechanical Engineering

This is to certify that we have examined this copy of a bachelor's thesis by

Fanni Fattah

and have found that it is complete and satisfactory in all respects and that any and all revisions required by the final examining committee have been made.

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| Title | : Deterministic Contact Analysis of Rough Surface Using Finite Element Method |

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## PROVERB AND ACKNOWLEDGMENT

***”Rise and rise again until lambs become lions”***

*When I type this page, suddenly I am wondering what my parents has done to make me as fine and healthy as today in condition to able finish my bachelor thesis. Even thousand of this work will never equal compared with all of their love and bless. Also my little brother who fought lot with me, even we never made any phone call during my time in university. I know that we are apparently close each other, as you are a person I spent most of my playing time with. This thesis is dedicated to all of you, MY FAMILY.*

***PS: Since department of mechanical engineering was established in June 1983, this is the first ever bachelor thesis written in English.***

## ABSTRACT

A surface geometry of many components and systems is not always known and not always be measured. This condition make study of real surface was hard to accomplish. Numerical contact simulations of rough surfaces are common but most models contain extensive assumptions and idealizations about asperity shape and size. This thesis presents a new method for generating deterministic of rough surface in ABAQUS with pre-treatment in SolidWorks. Validation by comparing simple geometry which generated by this method and generated directly in ABAQUS shows a good agreement. Random geometry of a real rough surface and a deformable smooth ball is then taken for simulating real rough surface contact using finite element analysis. The result is covering on contact area, contact pressure, von Misses stress contour distribution and plot of surface topography. Random rough and sinusoidal solid surface were used in contact simulation. In the end, an experimental result is taken then generated to form finite element surface. The simulation results compared with the experimental result show identical contact area and surface topography at y-axis in x = 288 μm. These techniques, combined with the ability to model real surfaces in ABAQUS, can be used to help researchers in material science, mechanical engineering, and beyond to better understand micro scale surface contact mechanics.



**Key words:** Rough surface, FEM, contact mechanics, asperity

## PREFACE

Praise be to Allah SWT who has bestowed his mercy and grace to the author, so I can get through the study and completed the bachelor thesis which is the final stage of the process to obtain *Sarjana Teknik* of Mechanical Engineering at the University of Diponegoro

Success in completing the bachelor thesis of author is not separated from the people who help me with their guidance and support, both moral and material. Therefore, the authors wish to thank

1. Dr. Jamari, ST, MT, as a thesis advisor of my thesis and as head of Engineering Design and Tribology Laboratory who has fully guide me to completed my work and encourage me to use english in this work.
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6. All people who not mentioned yet help a lot on my work.

Author realize that in preparing this thesis there are mistakes and failures, therefore, criticism and suggestions that are built to perfection and progress in the future are encouraged. In the end, author hope that this work can be useful for all readers.

Semarang, March 2012

Author

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## NOMENCLATURE

| Symbol | Description | Unit |
|---|---|---|
| $a$ | Radius contact area | [mm] |
| $A$ | Contact area | [$mm^2$] |
| $A_{c\text{-}KE}$ | Contact area on critical KE model | [$mm^2$] |
| $A_e$ | Contact area elastic | [$mm^2$] |
| $A_{ep}$ | Contact area elastic-plastic | [$mm^2$] |
| $A_p$ | Contact area fully plastic | [$mm^2$] |
| $E$ | Modulus elastisity | [MPa] |
| $E^*$ | Effectie modulus elastisity | [MPa] |
| $E_1$ | Modulus elastisity material 1 | [MPa] |
| $E_2$ | Modulus elastisity material 2 | [MPa] |
| $E^*$ | Modulus efective contact | [MPa] |
| $H$ | Hardness of material | [MPa] |
| $h$ | Distance between two point which is contacting each other | [mm] |
| $p$ | Average contact pressure | [MPa] |
| $p_e$ | Average contact pressure elastic | [MPa] |
| $p_{ep}$ | Average contact pressure elastic-plastic | [MPa] |
| $p_p$ | Average contact pressure fully plastic | [MPa] |
| $P$ | Contact force | [N] |
| $P_e$ | Contact force elastic | [N] |
| $P_{ep}$ | Contact force elastic-plastic | [N] |
| $P_p$ | Contact force fully plastic | [N] |
| $P_c$ | Contact force during initial yield | [N] |
| $R_e$ | Effective radius curvature | [mm] |
| $R_1$ | Radius 1 | [mm] |
| $R_2$ | Radius 2 | [mm] |
| $R_x$ | Effective radius principal x direction | [mm] |
| $R_y$ | Effective radius principal y direction | [mm] |
| $Y$ | Yield modulus | [MPa] |

| | | |
|---|---|---|
| $\delta$ | Deflection | [mm] |
| $\upsilon$ | Poisson's ratio | [-] |
| $\omega_{P1}$ | Plastic deformation material 1 | [mm] |
| $\omega_{P2}$ | Plastic deformation material 2 | [mm] |
| $\omega_{PL}$ | Plastic deformation during loading | [mm] |
| $\omega_{PU}$ | Plastic deformation during unloading | [mm] |
| $e$ | Elastic spring back | [mm] |
| $\omega$ | Interference | [mm] |
| $\omega_1$ | Interference initial yield | [mm] |
| $\omega_2$ | Interference fully plastic | [mm] |
| $\omega_{1\text{-}CEB}$ | Interference initial yield CEB model | [mm] |
| $\omega_{1\text{-}KE}$ | Interference initial yield KE model | [mm] |
| $\omega_{1\text{-}ZMC}$ | Interference initial yield ZMC model | [mm] |
| $\omega_{2\text{-}KE}$ | Interference fully plastic KE model | [mm] |
| $\omega_{2\text{-}ZMC}$ | Interference fully plastic ZMC model | [mm] |