UNDERGRADUATE THESIS

ANALYSIS OF THE EFFECTS OF TAPERED BLADE RATIO VARIATIONS AND TIP SPEED RATIO (TSR) ON SAVONIUS WIND TURBINE PERFORMANCE USING COMPUTATIONAL FLUID DYNAMICS (CFD)

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JAWA TIMUR

2026

UNDERGRADUATE THESIS
APPROVAL SHEET

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Telah mengerjakan revisi / tidak ada revisi *) ~~PRA-RENCANA (DESAIN)~~ / ~~SEMINAR PROPOSAL~~ / SKRIPSI /~~TUGAS AKHIR~~ Ujian Lisan Periode IV, TA . 2026/2027.
Dengan judul : ANALISIS PENGARUH VARIASI RASIO *TAPERED BLADE* DAN *TIP SPEED RATIO* (TSR) TERHADAP KINERJA TURBIN ANGIN SAVONIUS DENGAN METODE *COMPUTATIONAL FLUID DYNAMICS* (CFD)

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PREFACE

Praise and gratitude are expressed to Allah SWT for His blessings, mercy, and guidance, which have enabled the author to complete this undergraduate thesis entitled: "Analysis of the Effects of Tapered Blade Ratio Variations and Tip Speed Ratio (TSR) on the Performance of a Savonius Wind Turbine Using Computational Fluid Dynamics (CFD)." This thesis is submitted as one of the requirements for obtaining the Bachelor of Engineering degree in the Mechanical Engineering Study Program, Faculty of Engineering, Universitas Pembangunan Nasional "Veteran" Jawa Timur.

The completion of this thesis would not have been possible without the assistance, support, and guidance of many individuals. Therefore, on this occasion, the author would like to express sincere gratitude and appreciation to the following parties::

1. **Prof. Dr. Dra. Jariyah, M.P**., Dean of the Faculty of Engineering and Science , Universitas Pembangunan Nasional "Veteran" Jawa Timur.
2. **Dr. T. Ir. Luluk Edahwati, M.T**., Head of the Mechanical Engineering Study Program.
3. **Tria Puspa Sari, S.T., M.S**., and **Anisah Nurul Izzah, S.T., M.T**., for their invaluable guidance, direction, and constructive feedback throughout the process of completing this thesis.
4. **Dr. Musyaroh, S.T.P., M. T** and **Fatkhurrohman, S.T., M.Eng**., who have provided invaluable guidance, direction, and input during the process of compiling this thesis.
5. **The author's beloved parents and family**, for their endless prayers, love, moral support, and financial assistance during the completion of this thesis.
6. **Syawalia Maghfira Yahya**, which, in this process of thesis preparation, serves as a source of motivation and a place to share. Thank you for all forms of support, prayers, attention, patience, and consistently provided trust. One of the challenges that writers face in overcoming many obstacles up to this point is motivation and presence that never wavers.
7. **Naufal Alifio, Saka Palwaguna**, and **M. Fauzi**, for their unwavering support and collaboration as teammates in the Savonius wind turbine project.
8. **Antonius Angel Wijaya, Reinand Ari Pratama, Izza Muhammad Hanif Surya Alam, Daniel Ebenezer Budiharto, Aditya Thoriq, Farryzki Noor Thoriq, Muhammad Zaky Fahlevy**, **A Aldy Gymnastyar** for the close friendship that has always provided support from high school until now.

9. **The Mechanical Engineering Class of 2022**, for their support, companionship, and motivation throughout this academic journey.
10. **Myself**, for choosing not to give up despite the challenges encountered during the completion of this thesis and for always believing in Luffy's words: "If the path seems too easy, perhaps I am on the wrong path."

The author acknowledges that this thesis is not without limitations and may still require further improvement. Nevertheless, it is hoped that this work will be beneficial to readers and serve as a valuable reference for future studies in the field of Mechanical Engineering.

Surabaya, 26 June 2026

Author
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ABSTRAK

Kebutuhan energi listrik yang terus meningkat serta tingginya emisi karbon akibat penggunaan bahan bakar fosil mendorong pengembangan energi terbarukan, salah satunya energi angin. Turbin angin Savonius dipilih karena mampu bekerja pada kecepatan angin rendah yang sesuai dengan kondisi angin di Indonesia, namun masih memiliki kelemahan berupa nilai *coefficient of power* (*CoP*) yang relatif rendah. Penelitian ini bertujuan untuk menganalisis pengaruh variasi rasio *tapered blade* dan *tip speed ratio* (*TSR*) terhadap kinerja turbin angin Savonius menggunakan metode *Computational Fluid Dynamics* (*CFD*). Simulasi dilakukan secara tiga dimensi (3D) menggunakan ANSYS Fluent 2021 R2 dengan model turbulensi *realizable k-ε* dan metode *sliding mesh*. Variasi rasio *taper* yang digunakan yaitu 0,7; 0,6; dan 0,5 dengan variasi *TSR* sebesar 0,2 hingga 1,2. Parameter yang dianalisis meliputi *coefficient of power* (*CoP*), *coefficient of moment* (*CoM*), dan *coefficient of static torque* (*CTs*). Hasil penelitian menunjukkan bahwa variasi rasio *taper* berpengaruh terhadap performa turbin Savonius. Variasi *taper* 0,7 menghasilkan performa terbaik dengan nilai *CoP* maksimum sebesar 0,478 pada *TSR* 1,0, sedangkan *taper* 0,5 menghasilkan performa terendah dengan nilai *CoP* maksimum sebesar 0,314 pada *TSR* 0,6. Hasil analisis kontur aliran menunjukkan bahwa geometri *tapered blade* mampu mengurangi *flow separation* dan meningkatkan gaya *drag* pada *advancing blade* sehingga meningkatkan efisiensi turbin pada kondisi angin rendah.

Kata kunci: Turbin Savonius, *tapered blade*, *tip speed ratio*, *CFD*, *coefficient of power*.

ABSTRACT

The increasing demand for electrical energy and the high carbon emissions caused by fossil fuel consumption have encouraged the development of renewable energy, particularly wind energy. The Savonius wind turbine was selected because it can operate effectively at low wind speeds commonly found in Indonesia; however, it still has the drawback of a relatively low coefficient of power (CoP). This study aims to analyze the effect of tapered blade ratio and tip speed ratio (TSR) variations on the performance of a Savonius wind turbine using the Computational Fluid Dynamics (CFD) method. Three-dimensional (3D) simulations were conducted using ANSYS Fluent 2021 R2 with the realizable k-ε turbulence model and sliding mesh method. The taper ratios investigated were 0.7, 0.6, and 0.5, with TSR variations ranging from 0.2 to 1.2. The analyzed parameters included coefficient of power (CoP), coefficient of moment (CoM), and coefficient of static torque (CTs). The results showed that the taper ratio significantly affected the turbine performance. The 0.7 taper ratio produced the best performance with a maximum CoP value of 0.478 at TSR 1.0, while the 0.5 taper ratio resulted in the lowest performance with a maximum CoP value of 0.314 at TSR 0.6. Flow contour analysis indicated that the tapered blade geometry reduced flow separation and increased the drag force on the advancing blade, thereby improving turbine efficiency under low wind speed conditions.

***Keywords*:** *Savonius turbine, tapered blade, tip speed ratio, CFD, coefficient of power.*

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