

ABSTRAK

Peningkatan kebutuhan energi serta menurunnya ketersediaan sumber energi fosil mendorong pengembangan energi terbarukan, salah satunya energi angin. Turbin angin sumbu vertikal (Vertical Axis Wind Turbine/VAWT) tipe Darrieus-H memiliki konstruksi yang sederhana, mampu beroperasi pada berbagai arah angin, serta berpotensi dikembangkan di Indonesia. Penelitian ini bertujuan untuk menganalisis pengaruh variasi kecepatan angin dan jenis material terhadap ketahanan struktural sudu turbin angin vertikal Darrieus tipe-H dalam kondisi interaksi fluida-struktur (*Fluid-Structure Interaction/FSI*). Penelitian dilakukan menggunakan perangkat lunak ANSYS Workbench dengan mengintegrasikan metode Computational Fluid Dynamics (CFD) dan Finite Element Analysis (FEA). Variasi kecepatan angin yang digunakan adalah 5 m/s, 10 m/s, 15 m/s, dan 20 m/s. Material yang dianalisis meliputi Aluminium Alloy 6061-T6, Rigid Polyvinyl Chloride (uPVC), S-Glass/Epoxy Composite, dan Carbon Fiber Reinforced Polymer (CFRP). Parameter yang dianalisis meliputi total deformation, equivalent stress, dan equivalent strain. Hasil simulasi menunjukkan bahwa peningkatan kecepatan angin menyebabkan kenaikan nilai total deformation, equivalent stress, dan equivalent strain akibat meningkatnya beban aerodinamis yang bekerja pada struktur sudu. Material Rigid PVC (uPVC) menghasilkan nilai deformasi dan regangan terbesar sehingga memiliki kekakuan struktur yang paling rendah. Sebaliknya, Carbon Fiber Reinforced Polymer (CFRP) menunjukkan nilai deformasi dan regangan terkecil, sehingga memiliki kemampuan terbaik dalam mempertahankan kestabilan dan integritas struktur sudu turbin. Berdasarkan hasil simulasi secara keseluruhan, material CFRP merupakan material yang paling optimal untuk diaplikasikan pada sudu turbin angin Darrieus tipe-H.

Kata kunci: Turbin angin Darrieus-H, *Fluid-Structure Interaction*, CFD, FEA, Ketahanan Struktural.

ABSTRACT

Increasing energy demand and the depletion of fossil energy resources have encouraged the development of renewable energy sources, particularly wind energy. The Darrieus-H Vertical Axis Wind Turbine (VAWT) offers a simple structure, the ability to operate under various wind directions, and significant potential for implementation in Indonesia. This study aims to investigate the effects of wind speed variations and material types on the structural durability of Darrieus-H wind turbine blades under Fluid-Structure Interaction (FSI) conditions. The study was conducted using ANSYS Workbench by integrating Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA). Wind speed variations of 5 m/s, 10 m/s, 15 m/s, and 20 m/s were applied. The materials investigated were Aluminum Alloy 6061-T6, Rigid Polyvinyl Chloride (uPVC), S-Glass/Epoxy Composite, and Carbon Fiber Reinforced Polymer (CFRP). The evaluated parameters included total deformation, equivalent stress, and equivalent strain. The simulation results showed that increasing wind speed led to higher values of total deformation, equivalent stress, and equivalent strain due to increased aerodynamic loading on the blade structure. Rigid PVC (uPVC) exhibited the highest deformation and strain values, indicating the lowest structural stiffness. In contrast, Carbon Fiber Reinforced Polymer (CFRP) produced the lowest deformation and strain values, demonstrating superior capability in maintaining blade stability and structural integrity. Overall, CFRP was identified as the most suitable material for Darrieus-H wind turbine blade applications. The findings of this study are expected to provide a reference for the development of more efficient, reliable, and structurally durable wind turbine designs under dynamic operating conditions.

Keywords: *Darrieus-H wind turbine, Fluid-Structure Interaction, CFD, FEA, Structural Durability*