INTISARI

Pertumbuhan kebutuhan energi fosil yang pesat menimbulkan berbagai dampak lingkungan, sementara akses energi di wilayah 3T masih terbatas. Pemanfaatan energi terbarukan, khususnya energi angin, menjadi solusi potensial. Karena kecepatan angin di wilayah tersebut tergolong rendah, dibutuhkan desain turbin angin kecepatan rendah dengan material bilah yang tepat agar mampu beroperasi optimal.

Dalam penelitian ini, bilah turbin dirancang menggunakan QBlade dengan *tip speed ratio* (TSR) 6 dan divariasikan pada kecepatan angin 3,8; 4,5; 5,2; 6,0; dan 7,3 m/s berdasarkan data karakteristik angin Pantai Baru, Yogyakarta. Analisis kinerja dilakukan melalui simulasi numerik berbasis ANSYS dengan pendekatan *Fluid-Structure Interaction* (FSI) untuk mengevaluasi aspek aerodinamika dan respons struktural dari berbagai material bilah.

Hasil penelitian menunjukkan adanya perbedaan daya yang dihasilkan, di mana QBlade memberikan rentang 36,73 hingga 431,79 W, sedangkan CFD ANSYS menghasilkan 21,86 hingga 251,22 W, namun keduanya menunjukkan tren kenaikan seiring meningkatnya kecepatan angin. Analisis FSI mengungkapkan bahwa epoxy carbon fiber UD 395 GPa merupakan material paling optimal dengan deformasi minimum dan daya keluaran tertinggi, sedangkan aluminium alloy mengalami deformasi signifikan dan epoxy S-glass menunjukkan kinerja menengah. Oleh karena itu, epoxy carbon fiber UD 395 GPa direkomendasikan sebagai material bilah turbin angin kecepatan rendah.

Kata Kunci : Ramah Lingkungan, Energi Angin, Turbin Angin Kecepatan Rendah, QBlade, ANSYS, *Fluid-Structure Interaction* (FSI).

ABSTRACT

The rapid growth in fossil energy demand has led to various environmental impacts, while energy access in remote, frontier, and underdeveloped (3T) regions remains limited. The utilization of renewable energy, particularly wind energy, offers a potential solution. However, since wind speeds in these regions are generally low, it is necessary to design low-speed wind turbines with appropriate blade materials to ensure optimal operation.

In this study, the turbine blade was designed using QBlade with a tip speed ratio (TSR) of 6 and tested under wind speed variations of 3.8, 4.5, 5.2, 6.0, and 7.3 m/s, based on wind characteristic data from Pantai Baru, Yogyakarta. Performance analysis was carried out through numerical simulations using ANSYS with the Fluid-Structure Interaction (FSI) approach to evaluate both aerodynamic performance and structural responses of different blade materials.

The results indicate differences in power output, where QBlade produced values ranging from 36.73 to 431.79 W, while CFD ANSYS generated 21.86 to 251.22 W. Despite the differences, both showed consistent upward trends with increasing wind speed. FSI analysis revealed that epoxy carbon fiber UD 395 GPa provided the most optimal performance with minimum deformation and the highest power output, whereas aluminum alloy exhibited significant deformation and epoxy S-glass demonstrated moderate performance. Therefore, epoxy carbon fiber UD 395 GPa is recommended as the most suitable material for low-speed wind turbine blades.

Keywords : Environmentally Friendly, Wind Energy, Low-Speed Wind Turbine, QBlade, ANSYS, Fluid-Structure Interaction (FSI).