

## ABSTRACT

*UAVs (Unmanned Aerial Vehicles) have experienced rapid development in various sectors such as the military, public, and civil, becoming a primary focus in aviation technology. One critical aspect of UAV design is the propulsion system, which includes the unique toroidal propeller. Toroidal propellers offer significant potential for energy savings and vibration reduction. Recent research from the Massachusetts Institute of Technology (MIT) compared toroidal propellers to conventional ones, revealing the potential for sensitive noise reduction without adding additional weight and the ability to achieve thrust levels equivalent to multirotor propellers. However, further research is required to determine the optimal blade pitch angle for toroidal propellers.*

*The research process began with the creation of toroidal propeller designs featuring three blade pitch angle variations: 15°, 30°, and 45°. The research then continued with an aerodynamic performance analysis using computer-aided engineering (CAE) methods, aided by Ansys Fluent software. The propeller was simulated to rotate at varying speeds (RPM) ranging from 5000, 20000 and 40000.*

*The analysis results from the study indicate that the most efficient toroidal propeller is found at a 15° blade pitch angle, with an average efficiency of 0.003341693. Furthermore, the blade pitch angle has a significant impact on the values of thrust, torque, and efficiency. As the blade pitch angle increases, both thrust and torque values increase, while the efficiency values decrease.*

**Keywords:** *CFD, Propeller, Toroidal, UAV*

## INTISARI

UAV (*Unmanned Aerial Vehicle*), mengalami perkembangan pesat di berbagai sektor seperti militer, publik, dan sipil, menjadi fokus utama dalam teknologi penerbangan. Salah satu elemen penting dalam desain UAV adalah sistem propulsi, termasuk toroidal *propeller* karena memiliki desain unik. Toroidal *propeller* menawarkan potensi penghematan energi dan pengurangan getaran yang signifikan. Penelitian terbaru dari Massachusetts Institute of Technology (MIT) membandingkan toroidal *propeller* dengan *propeller* konvensional, menunjukkan potensi pengurangan tingkat kebisingan yang sensitif bagi manusia tanpa menambah berat tambahan, dan kemampuan untuk mencapai *thrust* yang setara dengan *propeller* multirotor. Namun, penelitian lebih lanjut diperlukan untuk menentukan *blade pitch angle* yang optimal untuk toroidal *propeller*.

Proses penelitian dimulai dari pembuatan *design* toroidal *propeller* dengan tiga variasi *blade pitch angle* yaitu 15°, 30°, dan 45°. Proses penelitian dilanjutkan dengan analisis performa aerodinamika menggunakan metode *computer aided-engineering* (CAE) dengan bantuan *software* Ansys *Fluent* dan kemudian *propeller* disimulasikan berputar dalam (RPM) dimulai dari 5000, 20000, dan 40000 RPM.

Hasil analisis dari penelitian menunjukkan bahwa toroidal *propeller* yang paling efisien berada pada *blade pitch angle* 15° dengan rata-rata efisiensi sebesar 0.003341693. Selain itu, *blade pitch angle* berpengaruh terhadap nilai *thrust*, *torque*, dan *efficiency*. Nilai *thrust* dan *torque* meningkat seiring dengan kenaikan angka *blade pitch angle*. Nilai *efficiency* menurun seiring dengan kenaikan angka *blade pitch angle*.

**Kata Kunci:** CFD, *Propeller*, Toroidal, UAV