Design of Universal Joint Mechanism for Flapping and Feathering Wing Application

**Chapter 1: Introduction and Motivation**

The evolution of flight from the Wright brothers’ pioneering efforts to modern unmanned aerial vehicles (UAVs) highlights significant advancements in aerodynamics and control. However, UAVs face persistent challenges in hovering and maneuverability. Micro Air Vehicles (MAVs), particularly Flapping Wing MAVs (FWMAVs), address these issues by drawing biological inspiration from insects. This approach focuses on replicating their natural flight dynamics to achieve superior aerodynamic efficiency and precise maneuvering capabilities. The objective of this thesis is to design and optimize a flapping and feathering mechanism for FWMAVs through kinematic analysis and experimental validation.

**Chapter 2: Kinematic Analysis of Mechanism**

This chapter presents the design and analysis of a universal joint mechanism tailored for flapping and feathering motions, inspired by the biomechanics of beetle insects. Key parameters such as angular velocity ratios, RPM calculations, and torque considerations are analyzed to achieve biomimetic flight dynamics. Detailed diagrams and mathematical formulations illustrate the operational constraints and performance parameters essential for optimization. The findings underscore the potential of the universal joint mechanism in enhancing the efficiency and maneuverability of aerial vehicles, emphasizing its alignment with beetle-inspired flight dynamics.

**Chapter 3: Selection of Motor Based on Required Specifications**

Motor selection is crucial for the effective functioning of the flapping mechanism. This chapter explores criteria such as required RPM, torque, step angle, number of phases, rated voltage, and weight to identify the most suitable motor. Two options are evaluated: the BLDC 2020 motor and the RMCS 1023 stepper motor. Each motor’s specifications and operational characteristics are assessed through experimental setups. The results provide a comparative analysis, guiding the selection of a motor that balances performance and compatibility with the designed mechanism.

**Chapter 4: CAD Modeling**

The detailed design and 3D modeling of the flapping and feathering mechanism are presented in this chapter. Autodesk Inventor PRO 2023 is employed for the CAD modeling process, complemented by simulations conducted in SolidWorks. These simulations validate the mechanism’s functionality and ensure compatibility with the desired kinematics. Component configurations, including the universal joint, motors, dynamic sensors, and wing holder, are described in detail. Material considerations, assembly methods, and maintenance strategies are discussed to optimize performance and durability. This chapter demonstrates the integration of engineering principles and advanced software tools in achieving a robust and efficient design.

**Conclusion**

The research offers a comprehensive approach to designing and optimizing flapping wing mechanisms for MAVs, drawing inspiration from nature to overcome existing challenges in UAV technology. The integration of kinematic analysis, motor selection, and advanced CAD modeling lays a strong foundation for further innovations in biomimetic aerial vehicles.