CALIFORNIA STATE UNIVERSITY, NORTHRIDGE
Department of Mechanical Engineering

BRAKE ASSEMBLY DESIGN: MATERIALS, MANUFACTURING, AND COST ANALYSIS

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ABSTRACT

High-performance automotive braking systems operate under extreme mechanical loads and severe thermal conditions, requiring careful integration of geometry, material properties, manufacturing feasibility, and economic constraints. As vehicle speeds, power output, and mass continue to increase, braking systems must safely dissipate large amounts of kinetic energy while maintaining consistent frictional performance and structural reliability. The design of such systems therefore represents a multidisciplinary engineering challenge involving solid mechanics, heat transfer, manufacturing science, and cost optimization.

The focus of this project is on design choices, material selection, manufacturing process selection and cost analysis of a high-performance automotive braking system. Modern braking systems must undergo high mechanical and thermal stresses while providing responsiveness, reliability, and durability. The objective of this project is to design and develop a braking assembly that is capable of withstanding the operating and service conditions of a high-performance automotive.

To accomplish this objective, the braking system was evaluated as an integrated mechanical and thermal energy conversion device. Design considerations included the transfer of hydraulic pressure into clamping force, the transformation of kinetic energy into heat at the rotor–pad interface, and the subsequent dissipation of that heat through conduction and convection. These operating principles guided all design, material, and manufacturing decisions.

The scope of the components considered in this project includes the rotor, brake pads, calipers, pistons and other relevant supporting components of the assembly. Each component was analyzed based on their functionality, anticipated mechanical and thermal loads, and geometry. CAD modeling, calculations, and other general engineering analysis aided us in the reasoning behind each design decision.

Each component was evaluated using fundamental engineering principles including stress analysis, heat transfer behavior, and manufacturability considerations. Tradeoffs between performance and cost were assessed by comparing conventional production materials and methods with higher-performance alternatives typically used in motorsports and premium automotive applications.

The report is broken into four chapters. Chapter 1 is the introduction. Chapter 2 focuses on design choices, such as geometry, assembly design, and cooling features. Chapter 3 discusses material selection. This includes an analysis of each material's mechanical and thermal properties, performance, manufacturability, and cost . Chapter 4 presents the manufacturing techniques and processes selection, with a focus on feasibility, scalability, and product efficiency. Chapter 5 is our final cost analysis estimations based on how each design process selection affected the system c

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