OPTIMASI TOPOLOGI DAN PROSES CAM PADA DESAIN *BELL CRANK* DENGAN PENDEKATAN SIMULASI

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ABSTRAK

Bell crank merupakan komponen mekanis penting dalam sistem transmisi gaya yang memerlukan optimasi desain untuk meningkatkan efisiensi struktural. Penelitian ini bertujuan menganalisis pengaruh optimasi topologi terhadap distribusi tegangan, *displacement*, dan faktor keamanan pada desain *bell crank* menggunakan simulasi berbasis Finite Element Method (FEM) dengan software Autodesk Fusion 360. Variasi *mass retain* yang diteliti meliputi 90%, 80%, 70%, dan 60% pada tiga jenis material: Aluminium 6061, Baja Karbon, dan Baja Paduan. Hasil penelitian menunjukkan bahwa penurunan *mass retain* dari 90% ke 60% meningkatkan tegangan *von Mises*. Tegangan tertinggi terjadi pada mass retain 60% dengan nilai 166,398 MPa (Aluminium 6061), namun masih di bawah *yield strength* material. *Displacement* juga meningkat seiring pengurangan massa, dengan Aluminium 6061 menunjukkan peningkatan dari 0,786 mm menjadi 1,198 mm. Meskipun faktor keamanan menurun, nilai terendah tetap di atas batas kritis (SF > 1.5), membuktikan desain tetap aman. Proses *generate G-code* berhasil dilakukan menggunakan simulasi CAM, menghasilkan program NC dengan 72.295 baris kode dan waktu pemesinan 23 menit 2 detik. Optimasi topologi terbukti efektif mengurangi massa hingga 40% dengan mempertahankan kekuatan struktural *bell crank*.

Kata Kunci: *Bell crank*, optimasi topologi, simulasi CAM

TOPOLOGY OPTIMIZATION AND CAM PROCESS OF BELL CRANK DESIGN USING SIMULATION BASED APPROACH

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ABSTRACT

Bell crank is an important mechanical component in force transmission systems that requires design optimization to improve structural efficiency. This research aims to analyze the effect of topology optimization on stress distribution, displacement, and safety factor in bell crank design using Finite Element Method (FEM) simulation with Autodesk Fusion 360 software. The mass retain variations studied include 90%, 80%, 70%, and 60% on three material types: Aluminum 6061, Carbon Steel, and Alloy Steel. The research results show that mass retain reduction from 90% to 60% significantly increases von Mises stress. The highest stress occurs at 60% mass retain with a value of 166.398 MPa (Aluminum 6061), but remains below the material's yield strength. displacement also increases with mass reduction, with Aluminum 6061 showing an increase from 0.786 mm to 1.198 mm. Although the safety factor decreases, the lowest value remains above the critical limit (SF > 1.5), proving the design remains safe. The G-code generation process was successfully performed using CAM simulation, producing an NC program with 72,295 lines of code and a machining time of 23 minutes 2 seconds. Topology optimization proves effective in reducing mass up to 40% while maintaining the structural integrity of the bell crank.

Keywords: *Bell crank, CAM simulation, topology optimization*