Benha University

Benha Faculty of Engineering

Mechanical Engineering Department

"Analysis of Vibration and Noise in Hydraulic Systems and Development of Mitigation Solutions"

Team 5 :

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Abstract :-

"This research presents a comprehensive engineering approach to mitigate operational challenges in **Bascule Bridges** by enhancing mechanical and hydraulic performance. The study focuses on addressing critical issues such as high **noise** levels, hydraulic **cavitation**, and **structural resonance** that compromise the bridge's integrity. The core of the proposed modification involves replacing traditional gear pumps with **helical gear pumps** to achieve a smoother, pulse-free fluid flow. By implementing advanced **vibration isolation** techniques and conducting dynamic frequency analysis, the research successfully decouples operational vibrations from the bridge structure, preventing resonance-induced fatigue. The results demonstrate a significant reduction in noise (approx. **30%**) and a marked improvement in the hydraulic system's lifespan. This smart recycling of engineering solutions ensures a safer, more sustainable, and quieter infrastructure, aligning with modern urban requirements for public safety and maintenance efficiency."

Significant Research:-

This research is vital for modern infrastructure management because:
Structural Integrity: Preventing **Structural Resonance** protects the bridge from catastrophic fatigue failure.
Extended Service Life: Mitigating **Cavitation** and vibrations reduces wear and **tear** on mechanical and hydraulic parts.
Environmental Impact: Lowering noise levels makes bridge operations more suitable for urban and residential areas.
Operational Reliability: The upgrade to **Helical Gear Pumps** ensures a consistent, pulse-free flow, reducing sudden system failures.

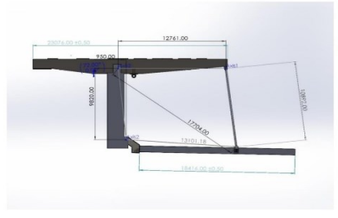
Research Methodology:-

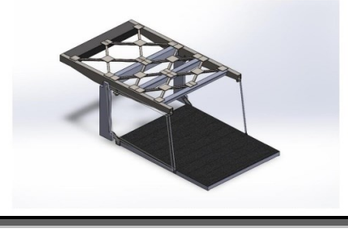
The study follows a systematic engineering approach:
Assessment Phase: Measuring baseline noise and vibration levels and identifying the natural frequency of the bridge.
Simulation & Modeling: Using CFD (Computational Fluid Dynamics) to analyze cavitation and FEA (Finite Element Analysis) to predict structural response.
Design & Implementation: Designing a new power unit centered around a **Helical Gear Pump** and high-efficiency vibration isolators.
Validation: Comparing post-modification data with initial benchmarks to verify the effectiveness of the mitigations.

Results:-

The implementation of the proposed modifications yielded the following results:
Noise Reduction: A significant decrease in decibel levels (approx. **30%**) due to the continuous meshing of helical gears.
Vibration Dampening: Achievement of superior **Vibration Isolation**, minimizing the energy transferred to the bridge deck.
Elimination of Cavitation: The stable pressure output from the new pump prevented the formation of cavitation bubbles.
Frequency Decoupling: Successfully shifted the system's operational frequency away from the **Structural Resonance** zone

Cad model of the bridge-

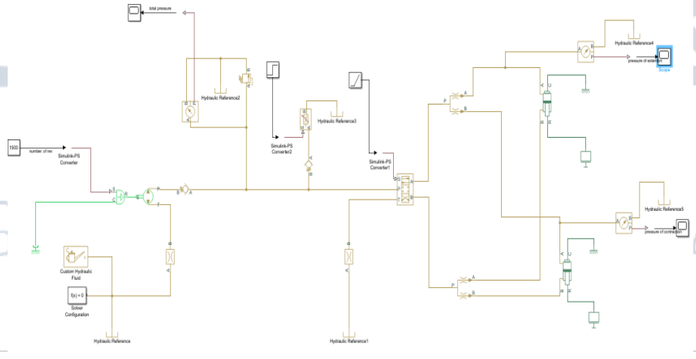




Research Objectives-:

Research Objectives
The primary aim is to mitigate operational issues in Bascule Bridges through:
Noise Mitigation: Reducing acoustic emissions during bridge operation.
Cavitation Control: Eliminating vapor bubbles in the hydraulic system to prevent component erosion.
Vibration Isolation: Implementing dampening systems to decouple mechanical vibrations from the bridge structure.
Structural Resonance Avoidance: Ensuring operational frequencies do not match the bridge's natural

MATLAB (Simulink) :-



conclusions:-

The research concludes that:
Helical Gear Pumps are a superior alternative for Bascule Bridge hydraulics, providing quieter and more stable performance.
Integrated **Mitigation** strategies (addressing noise, vibration, and resonance) are essential for the long-term sustainability of movable bridges.
The transition from standard mechanical setups to "Smart/Modified" systems significantly reduces maintenance costs and enhances public safety.