Synopsis Seminar

Seminar Title	: Tribology and Rotordynamics of Locomotive Turbochargers with Textured Bearing System
Speaker	: Hara Prakash Mishra (Rollno : 519me1001)
Supervisor	: Suraj Kumar Behera
Venue	: Mechanical Seminar Room (ME-001)
Date and Time	: 09 Jun 2025 (11:00 AM)

Abstract : The turbocharger (TC) was invented by Swiss engineer Dr. Alfred Büchi with the objective of increasing the fuel efficiency and overall power output of a naturally aspirated internal combustion (IC) engine. Over time, TC has evolved to serve a wide range of applications, including locomotives, automobiles, marine propulsion systems, power generation units, and industrial machinery. Researchers are continuously evolving their performance by modifying their components, such as rotors, turbines, compressors, bearings, etc. In the present study, an effort is made to improve the performance of TC by modifying its bearing system. This is achieved by introducing surface texturing with various patterns on the bearing surfaces to enhance load-carrying capacity, minimize power losses, reduce the coefficient of friction and side leakage, and improve rotordynamic stability. For this, the study specifically investigates the rotor-bearing system of a Holset® diesel locomotive turbocharger, which operates at speeds up to 1,00,000 rpm, making it suitable for analyzing high-speed bearing performance enhancements.

Conventionally, the turbocharger rotor is supported by a pair of floating ring bearings (FRBs) and a taper land thrust bearing (TLTB) to carry the radial and axial load, respectively. However, these bearings are prone to issues such as sub-synchronous vibration (oil whirl and oil whip), insufficient damping at high speeds, and oil starvation due to tight bearing clearances. To address these challenges, surface texturing on both the bearing surface is proposed. The textured bearing configurations proposed in the current research are: (i) Herringbone Textured Floating Ring Bearing (HTFRB), (ii) Spiral-Grooved Thrust Bearing (SGTB), and (iii) Herringbone-Grooved Thrust Bearing (HGTB). Tl herringbone texture pattern is inspired by the flight feathers of birds, leveraging bio-inspiration to reduce viscous drag and enhance lubrication.

The textured floating ring bearing and thrust bearings are modeled numerically using the Reynolds equation to evaluate their static characteristics, including load-carrying capacity, power loss, side leakage, and coefficient of friction. The dynamic characteristics of the textured FRB are derived by solving the zeroth- and first-order perturbed Reynolds equations. A sensitivity analysis is carried out to assess the impact of texture geometry on performance metrics. Furthermore, an artificial intelligence-based optimization framework is developed using artificial neural networks and adaptive neuro-fuzzy inference systems to determine optimal groove parameters. After designing textured bearings, the rotordynamic analysis of the turbocharger rotor with the proposed bearing is conducted. This confirms the dynamic stability and effectiveness of the designed bearing.

Following the design and optimization phase, the textured bearings are fabricated using precision manufacturing techniques. Surface profilometry is employed to validate the accuracy of the fabricated groove depths. The textured bearings are then assembled into a turbocharger rotor system that is dynamically balanced using an industrial balancing machine. The Experiment is conducted using a Holset® locomotive turbocharger test rig, equipped with accelerometers, proximity probes, and a data acquisition system. Vibration data&mdashincluding time-domain signals, frequency spectra, rotor orbit plots, and unbalance responses&mdashare collected and analyzed to assess the rotor's dynamic behavior. The experimental results confirm that the textured bearings significantly improve the dynamic stability and reduce vibration amplitudes compared to conventional bearing configurations.

This comprehensive study, from design and optimization to fabrication and experimental validation, demonstrates that textured bearings are a viable, high-performance alternative to traditional bearing systems for high-speed turbocharger applications. The findings offer a promising pathway for future advancements in turbocharger bearing technology, particularly in critical locomotive applications.