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Perspective

Multistage Gearbox Design Using Advanced Optimization Techniques

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DESCRIPTION

Energy conservation is the buzz phrase in the current era with an emphasis on high carbon emission reduction in sectors such as the automotive, aerospace and manufacturing industries. Such a reduction is envisaged to reduce the impact on the environment and paving way for a sustainable future. To achieve this, engineering design and optimization methods must evolve to include sustainability. Gears are key mechanical elements that enable the transmission of motion and power with an average energy loss of 10-20% depending on the type of gear applied. Characteristically, gears in machinery link prime movers to driven loads and their ability to vary the rotational speed, torque and power output renders them suitable for a variety of applications. Gear systems are therefore widely applied for torque and motion control in agricultural, automotive, manufacturing, power generation, aerospace, and marine industries to enable mechanization and automation leading to higher productivity. However, objective importance varies depending on product performance parameters and application. For example, electric vehicle efficiency or driving range can be greatly enhanced by weight and volume reduction. Although, wind and thermal power generation units are keener on reliability weight and volume remain important. The volume or weight of a gearbox is related to cost.

Traditional gear design standards, procedures and analytical methods are iterative and resource expensive thereby rendering them unattractive. Furthermore, the likelihood of a naive or imperfect solution is higher. Application of such methods maybe as a result of a lack of knowledge of a better method or a belief that this is an esoteric technique. In engineering design, the optimization of gear systems is an important area of study as evidenced by the numerous research studies available in the literature. Methods such as Genetic Algorithm (GA), Firefly Algorithm (FA), Grey Wolf Optimization (GWO), Simulated Annealing (SA), Teaching Learning-Based Optimization (TLBO), Particle Swarm Optimization (PSO), etc. exist in gear literature. There are numerous types of gears *viz*. spur, helical, worm, straight and spiral bevel gears which have been investigated in the literature.

Gear systems, in some cases, can be both multi-speed and multi-stage. An interesting research trend based on an Optimal Weight Design (OWD) problem has been observed in the literature. The OWD problem was first introduced by Yokota. While focusing on a single-stage spur gear and applying an improved genetic algorithm method. Sets of five variables and five constraints were introduced to investigate the weight objective for solution improvement.

CONCLUSION

In the OWD study, two optimization algorithms *viz* Simulated Annealing (SA) and Particle Swarm Optimization (PSO) were applied to solve the design problem. Two design cases as reported by previous authors were investigated using the teaching earning-based optimization while comparing against other algorithms. The parameter-less feature of the TLBO algorithm resulted in the improvement of the solution. Gear systems may have single or multiple stages depending on application, power, torque and speed ratio requirements. Employing to optimize load carrying capacity and volume simultaneously. A three-stage spur gear arrangement. While applying an interactive physical programming method. Module and tooth number were considered in place of the diametral pitch. Two-stage spur gear systems have been considered with design variables *via* module, tooth number for both stages and overall transmission ratio and applied decision-making methods to the Pareto frontier.

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