Designing Fitness Equipment to Withstand the Workout

Life Fitness

Sports and Leisure

U.S.A.

www.lifefitness.com

ANSYS® Mechanical™

Overview

Life Fitness is a world leader in developing and manufacturing advanced fitness equipment for the home market and industry-tailored solutions for fitness facilities and training centers. Commercial product lines include Life Fitness Cardio, Life Fitness Strength and Hammer Strength equipment, which professional and college athletes use to train. Life Fitness consumer cardio and strength equipment is aimed at home exercise programs. The extensive list of products from the company includes more than 50 U.S. patents and performance features that have led the way in the fitness industry. Life Fitness products are intended to facilitate the muscular effort and exercise required to develop strength, speed, agility, range of motion and endurance in athletes and people everywhere.

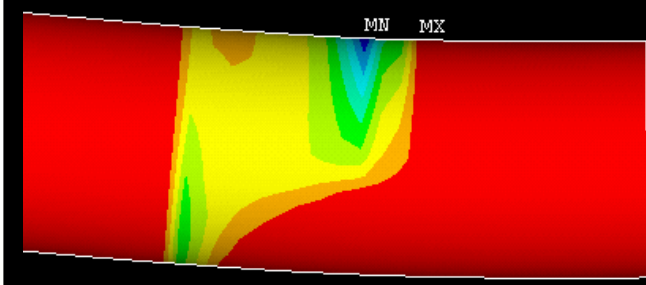
Equipment consists of electromechanical assemblies coupled with software control systems engineered for innovation, safety, reliability, quality and cost. In developing these products, engineers at Life Fitness use ANSYS Mechanical software to analyze parts and simulate the performance of fully assembled equipment to optimize designs, ensure safety and maintain some of the highest standards of quality in the fitness industry.

Testimonial

"Since bushing wear rate is proportional to contact pressure, integrating these ANSYS values for non-uniform pressure distribution in the shaft/bearing contact provides a more accurate calculation of wear rate. By clearly showing the effect of misalignment loading on the wear rate of the bushing, ANSYS analysis helped guide design decisions in selection of bushing and shaft materials and surface finishes for a new model of fitness equipment. In this way, the predictive capabilities of advanced solutions such as ANSYS play a critical role in enabling Life Fitness to develop some of the most innovative and reliable equipment in the industry."

Patrick Tibbits
Staff Engineer
Life Fitness

Bushings get a real workout in equipment such as this Life Fitness Cable Motion series of strength training machines. Twenty adjustments per column on the equipment's dual adjustable pulley system create a variety of exercises. The mechanism allows for higher speed movements for sport-specific training.



Plot shows non-uniform contact pressure distribution between shaft and bushing, enabling engineers to accurately calculate bushing wear rates and thus guide decisions on selection of component materials and surface finishes to maintain overall reliability of the fitness equipment.

Challenge

In cardiovascular and strength equipment, cylindrical bushings and plain bearings are used extensively in transmitting high radial loads from a rotating shaft to a support structure. To meet reliability goals for the equipment, contact pressures between the bushing and shaft must be accurately determined to ensure that bushing wear rates are within acceptable limits. Bushing catalogs often report wear rates as a function of average surface pressure, whereas Hertzian formulas generally are used to predict maximum pressure along a line of contact between the bushing and shaft. Neither of these methods accounts for axial misalignment between the shaft and bushing, however, which develops extremely high non-uniform pressure distributions difficult to determine from these traditional methods.

Solution

With conventional FEA codes, users must manually define which surfaces are touching and line up nodes of contacting part meshes. In contrast, ANSYS surface-to-surface contact element technology automatically detects regions where parts touch; it also uses higher-order elements that do not require nodes of contacting parts to line up. In this way, ANSYS contact element technology readily handles solutions of such numerically difficult contact problems and saves considerable time and effort. TARGE170 and CONTA174 elements were used to simulate three-dimensional contact between the shaft and bushing, which get modeled with second-order solid elements with mid-side nodes. Extensive facilities for setting real constants and KEYOPTS for the contact elements greatly improve the detection of initial contact.

Benefits

The model of the bushing/shaft/housing assembly required no artificial constraints to prevent rigid-body motion. Surface-to-surface contact element technology enabled engineers to quickly and accurately determine the contact pressure due to axial misalignment between the shaft and bushing. Maximum pressure revealed by ANSYS software exceeded the Hertzian line-contact pressure of 1,700 psi by 35percent; this was nearly 10 times greater than the average pressure of 250 psi computed by traditional formulas. Moreover, simulation showed how the distribution of non-uniform pressure varied from one point to another over the entire surface, providing valuable insight into potential bushing wear patterns and material behavior. In this respect, ANSYS is a microscope to examine pressure variations in the bushing/shaft contact.

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