Journal of Mechanical Design

Guest Editorial

Top Gear

The *Journal of Mechanical Design* has long been established as one of the favorite venues for designers and researchers in gearing keen to disseminate their findings to a large international audience. Considering the various sections or research areas covered by JMD as defined in the scope of the Journal, "*Power Transmission and Gearing*" explicitly refers to a technological component which, beyond the words themselves, certainly illustrates the historical significance and symbolic weight of gearing and gears in Mechanical Engineering. Gear is indeed "old" since, according to etymological dictionaries, this word was already in use in the XIVth century in England after being very likely imported from Scandinavia (Old Norse). The sense at that time was that of generic equipment with no reference to power transmission between rotating parts. Its present multiplicity of meanings is indicative of widespread usage; of very solid roots in everyday life. Search engines on the Internet, for instance, produce a surprisingly varied list of results when it comes to the term "gear." In 2009, the *ASME Mechanical Engineering Magazine* conducted a survey to determine the icon that was perceived as being most representative of Mechanical Engineering. Interestingly, the winner by a substantial margin was the humble gear followed by engines, robots, etc.! Gears constantly show up in newspapers, television, logos, etc., in a more or less symbolic form with, at times, no obvious link to actual gears (and rather strange tooth shapes). One obvious drawback of this long standing presence and iconic quality is a definite sense of déjà vu and the temptation to construe that, from a research perspective, gear behavior is perfectly understood and no longer worthy of research work and funding.

With this editorial in mind, a number of leading experts and researchers in the world were contacted. One unanimously expressed concern was the lack of "modernity" associated with the concept (gear as part of "Old Mechanics," so to speak) which, in particular, deters younger colleagues from seeking careers in this area. At the same time, everyone agreed on the fact that although gears have been used for centuries, they will undoubtedly survive long into the 21st century in all kinds of machinery and vehicles because of their advantages over other available methods of transmitting power and matching the speeds and torques of one machine to another. Gear transmissions have high power-to-weight ratios, can be made very compact and present the major advantage of high efficiency. In terms of versatility, all industrial sectors are concerned and gears range in size from micro-mechanisms with diameters of less than 1 mm up to the very large units of several meters in diameter found in mining and cement mills, for example. However, deviations as minor as 10–20 microns (on profile or lead modifications for instance) can make the difference between a safe mechanism and a potentially serious problem! Similarly, rotational speeds can vary from a couple of rpm up to ultra-high speeds above 50,000 rpm. In this context, it is clear that several research specialities are involved and gears are at the intersection of a number of subjects such as dynamics, tribology, material sciences, structural mechanics, thermal analysis … and a serious dose of geometry! This specificity is at odds with the way that modern research is conducted, i.e., extreme specialization, but this is also a real opportunity to tackle a variety of problems and keep a reasonably open mental horizon over the years. This broad range spectrum is also a difficulty in the training of qualified engineers, and the need for more gear courses at advanced levels was highlighted by the panel of experts.

Competitive pressure, the increasing power of prime-movers, the demand for higher speeds and environmental concerns combine to force the pace of development of all types of gears. While no technological breakthroughs in the coming years are readily obvious, there will be a continuous push toward more efficient, more compact, more silent, less costly units, mostly as a result of improvements in manufacturing techniques and material strength combined with the increasing capacity of computer-based numerical simulations. The drive toward better design will continue to necessitate greater insight into the underlying mathematical and physical issues in order to generate more accurate, versatile predictive models and optimization tools. Concerns about climate change and sustainable development will probably provide an impetus for original research in gearing. Wind turbines, new generation aircraft engines, hybrid car transmissions are just some of the fields of application where we can reasonably anticipate new challenges for gear designers and researchers. In these examples, gears are certainly not considered to be at the core of these cutting-edge products but, like supporting actors in a movie, a poor performance will put lay to any hopes of an Oscar. Whatever the application, one predominant trend is to favor multidisciplinary approaches with more effort toward integration into CAD/CAM packages and consider global systems as opposed to individual mechanical components. The example of power loss reduction is particularly telling in this respect since, depending on the speed/power range, tooth friction usually considered as the major source of dissipation may indeed be rather secondary and other mechanisms related to the circulation and compression of an air–oil mixture within a casing can become the dominant factor. Gear dynamics and noise is another example which illustrates the need for multi-scale studies from non-linear time-varying tooth contact analysis to the global problem of airborne noise radiated by the housing via shafts and bearings. Reliability is another challenge which depends on the mastery of manufacturing/finishing techniques, material sciences, heat and surface treatments but also on the capacity to predict load and stress distributions in the actual thermal and mechanical environment. It is therefore clear that the potential for interesting research in this area is still enormous and that the pressure from industry is as strong as ever (probably greater). In this context, a journal devoted to mechanical design such as JMD appears as a natural and efficient forum for multi-

disciplinary, transversal research work on gearing and power transmission which undoubtedly contributes to the necessary dialog between specialists in various fields of engineering.

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