Research Interest May 2017

Prof. Dr. Mehmet Ali GÜLER

My research is concerned with the general area of mechanics of materials. My previous contributions illustrate my methodology: I find it important to balance my work between theoretical basic research, where the quest for understanding dominates, and the development of practical tools. My PhD work on contact mechanics focused on understanding and modeling graded material properties and effect of this material property grading on the contact stresses. My research has primarily focused on the following topics:

Contact Mechanics of FGMs: Graded materials or functionally graded materials (FGMs) are multiphase composites with continuously varying volume fractions and, consequently, thermo-mechanical properties. Many of the present and potential applications of FGMs involve contact problems which are mostly load transfer problems in the presence of friction. Such structural components as bearings, gears, machine tools, cams and abradable seals in gas turbines may be mentioned as some examples. An important problem in the design of load transfer components is the preparation of surfaces to reduce the likelihood of cracking. Several different contact conditions such as sliding, rolling, receeding contact have been considered. This research activity was sponsored by TUBITAK (Scientific and Research Council of Turkey)

Crashworthiness Assessment: I studied this topic while I was working as a chief engineer in a bus builder company (TEMSA). The main topic was the rollover strength which has become an important issue for bus and coach manufacturers imposed by the European regulation ECE-R66 to prevent catastrophic consequences of such rollover accidents, thereby ensuring the safety of bus and coach passengers. According to the said regulation the certification can be gained either by full-scale vehicle testing, or by analysis techniques based on advanced numerical methods (i.e., nonlinear explicit dynamic finite element analysis). The quantity of interest at the end is the bending deformation enabling engineers to investigate whether there is any intrusion in the passenger survival space along the entire vehicle. explicit dynamic ECE-R66 rollover crash analyses of a stainless-steel bus under development were performed and the strength of the vehicle is assessed with respect to the requirements of the official regulation. This research activity was sponsored by Ministry of Science, Technology and Industry of Turkey.

Springback Prediction in Metal Forming Operations: Today, there is a high tendency to use light weight but high strength materials in automotive industry. Using high strength steels to lighten the vehicle weight, leads to a major problem which is known as springback and high yield stress of these materials cause an increase in the level of springback. The springback phenomenon, which is an undesired elastic deformation, results in geometrical inaccuracies in the assembly line. Therefore, it should be predicted accurately in order to avoid mismatches of the components in the assembly processes. For an accurate prediction and die compensation, it should be known a priori, how the parameters such as temperature, blank holder force, blank thickness and friction affect springback behavior. In this study, springback behavior of DP600 steel was examined. An analytical model based on Hills 48 yield criterion for anisotropic materials was used to validate a finite element model for prediction of springback after a stretch bending process. This research activity was sponsored by TUBITAK (Scientific and Research Council of Turkey)

Drop Test Simulation: In the appliance manufacturing industry, the mechanical structure of a prototype is commonly assessed through physical tests such as the static loading, vibration, and drop tests. The freefall/drop test is one such test and is widely used for electronic products. Based on the test results, engineers modify the mechanical structure or packaging module while relying on their experience. This type of design methodology needs many tests to be conducted and is very expensive and time-consuming. In order to overcome these problems, finite element (FE) simulations need to be performed in the design stage. The drop of a dishwasher can be analyzed by using simulations to understand the physics of the impact. In addition, FE simulations allow for direct modifications to the design structure. This research activity was sponsored by TUBITAK (Scientific and Research Council of Turkey) and a dishwasher manufacturer company ARCELIK.

Peridynamics: In classical continuum mechanics (CCM) modeling of crack initiation and propagation is not possible without modifications to its original formulation. The difficulty of crack modeling in CCM comes from its governing equations which require spatial derivatives. Spatial derivatives are not defined at crack tips by definition. As a remedy, Silling (2000) proposed a nonlocal theory of continuum mechanics called Peridynamics (PD). PD employs integrodifferential equations which remains valid at discontinuities. Thus, a special treatment at the crack tip is not necessary and crack initiation and crack growth can be analyzed without requiring an external criteria. In this study a peridynamic model for orthotropic plates, using the homogenized approach, was proposed and applied to static and dynamic analyses of progressive damage taking into account the bending stiffness. This research activity was sponsored by TUBITAK (Scientific and Research Council of Turkey)