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Sommario/riassunto	This thematic issue on advanced simulation tools applied to materials development and design predictions gathers selected extended papers related to power generation systems, presented at the XIX International Colloquium on Mechanical Fatigue of Metals (ICMFM XIX), organized at University of Porto, Portugal, in 2018. In this issue, the limits of the current generation of materials are explored, which are continuously being reached according to the frontier of hostile environments, whether in the aerospace, nuclear, or petrochemistry industry, or in the design of gas turbines where efficiency of energy production and transformation demands increased temperatures and pressures. Thus, advanced methods and applications for theoretical, numerical, and experimental contributions that address these issues on failure mechanism modeling and simulation of materials are covered. As the Guest Editors, we would like to thank all the authors who submitted papers to this Special Issue. All the papers published were peer-reviewed by experts in the field whose comments helped to improve the quality of the edition. We also would like to thank the Editorial Board of Materials for their assistance in managing this Special Issue.