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Generative Design Method for Cooled Additively Manufactured Gas Turbine Parts

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Abstract : The improvement of gas turbine efficiency is one of the main drivers of research and development in the gas turbine market. This has led to elevated gas turbine inlet temperatures beyond the melting point of the utilized materials. The turbine parts need to be actively cooled in order to withstand these harsh environments. However, the usage of compressor air as coolant decreases the overall gas turbine efficiency. Thus, coolant consumption needs to be minimized in order to gain the maximum advantage from higher turbine inlet temperatures. Therefore, sophisticated cooling designs for gas turbine parts aim to minimize coolant mass flow. New design space is accessible as additive manufacturing is maturing to industrial usage for the creation of hot gas flow path parts. By making use of this technology more efficient cooling schemes can be manufacture. In order to find such cooling schemes a generative design method is being developed. It generates cooling schemes randomly which adhere to a set of rules. These assure the sanity of the design. A huge amount of different cooling schemes are generated and implemented in a simulation environment where it is validated. Criteria for the fitness of the cooling schemes are coolant mass flow, maximum temperature and temperature gradients. This way the whole design space is sampled and a Pareto optimum front can be identified. This approach is applied to a flat plate, which resembles a simplified section of a hot gas flow path part. Realistic boundary conditions are applied and thermal barrier coating is accounted for in the simulation environment. The resulting cooling schemes are presented and compared to representative conventional cooling schemes. Further development of this method can give access to cooling schemes with an even better performance having higher complexity, which makes use of the available design space.

Keywords : additive manufacturing, cooling, gas turbine, heat transfer, heat transfer design, optimization
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