Application of an evolutionary algorithm to LES modelling of turbulent transport in pre-mixed flames.

Summary: Recently the concept of gene expression programming (GEP) has been introduced with very encouraging results for the purpose of modelling the unclosed tensors in the context of RANS (Reynolds averaged Navier-Stokes) turbulence modelling. This paper extends the previous framework to modelling subgrid stresses (SGS) in the context of large eddy simulation (LES). In order to achieve this goal the GEP algorithm was coupled with an external multiprocessor postprocessing tool that evaluates a cost function based on a-priori analysis of explicitly filtered DNS data of turbulent premixed planar flames. Although LES of combustion systems is becoming increasingly popular, the closures for sub-grid scale (SGS) stresses have mostly been derived assuming constant density flows. However, it has been shown recently that depending on the relative strength of heat release and turbulence, counter-gradient transport can occur for the stress tensor if the isotropic part is not properly accounted for. The focus of this work is not to put forward a particular new model but to demonstrate that evolutionary algorithms can successfully be used in the framework of LES modelling. To achieve this purpose the GEP software is used for modelling the deviatoric stress, the trace of the SGS tensor and the stress tensor itself. Although the functional form of the model was not imposed, the evolutionary algorithm did find a well known model from the literature with even the model constants comparable to values reported in the literature.

MSC:

76F65 Direct numerical and large eddy simulation of turbulence
76V05 Reaction effects in flows
68T05 Learning and adaptive systems in artificial intelligence

Keywords:
evolutionary algorithm; gene expression programming; large eddy simulation; turbulent premixed flame; subgrid scale stress tensor

Full Text: DOI

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