ON THE SCALE SIMILARITY IN LARGE EDDY SIMULATION.

F. Gallerano, G. Cannata e E. Pasero

Dipartimento di Ingegneria Idraulica, Trasporti e Strade, Università degli Studi di Roma "La Sapienza

Email: *e.pasero@tin.it*

Among the most common LES models present in literature there are Eddy Viscosity-type models.
In these models the subgrid scale (SGS) stress tensor is related to the resolved strain rate tensor through a scalar eddy viscosity coefficient.
These models are affected by two fundamental drawbacks: they are purely dissipative, i.e. they cannot account for back scatter; they assume that the principal axes of the resolved strain rate tensor and SGS stress tensor are aligned.
Several authors, by means of both numerical and experimental tests, have proved that backscatter occurs and is significant, even in equilibrium flows, and there is no alignment between the strain rate tensor and the SGS stress tensor.
Scale similarity models (SSM) were created to overcome the drawbacks of eddy viscosity-type models. The SSM models, such as that of Bardina et al. and that of Liu et al., assume that scales adjacent in wave number space present similar hydrodynamic features.
This similarity allows to effectively relate the unresolved scales, represented by the Modified Cross tensor and the Modified Reynolds tensor, to smallest resolved scales represented by the modified Leonard tensor (Bardina et al.) or by a term obtained through multiple filtering operations at different scales (Liu et al.).
The SSM models unlike the eddy viscosity-type models, assume neither the local alignment of the resolved strain rate tensor to the SGS stress tensor nor the local balance between production and dissipation of SGS kinetic energy.
The models of Bardina et al. and Liu et al. are affected, however, by a fundamental drawback: they are not dissipative enough, i.e. they are not able to assure a sufficient energy drain from resolved scales of the motion to unresolved ones.
In this paper it is shown that such drawback is due to the fact that such models do not take into account the smallest unresolved scales where the most dissipation of turbulent SGS energy takes place.
Indeed in the Bardina Model. the principle of material Frame indifference imposes that the SGS stress tensor should be represented only by the modified Leonard tensor.
Thus the modified Cross tensor an modified Reynolds tensor are not taken into account and thus neither are the unresolved scales, where the most viscous dissipation occurs.
The Liu et al. model assumes that the SGS stress tensor is equal to the product of a scalar and a resolved stress tensor obtained performing a double filtering operation on the grid scale and on the test scale. Such scalar is computed by means of a Germano identity operated on a grid scale and on a test scale whose dimensions are four times as big.
Consequently the Liu et al. model represents the SGS stress tensor only through terms that are associated to a limited range of small resolved scales, lying between the SGS

kinetic energy production scales range and the SGS kinetic energy dissipation scales range.
In this paper a scale similarity LES model that is able to grant an adequate drain of energy from resolved scales to unresolved ones.
The SGS stress tensor is aligned with the modified Leonard tensor.
The coefficient of proportionality is expressed in terms of the trace of the modified Leonard tensor and in terms of the SGS kinetic energy (computed by solving its balance equation).
The validity of the proposed model was tested through channel flow simulations with friction-velocity-based Reynolds numbers ranging from 180 to 2340.