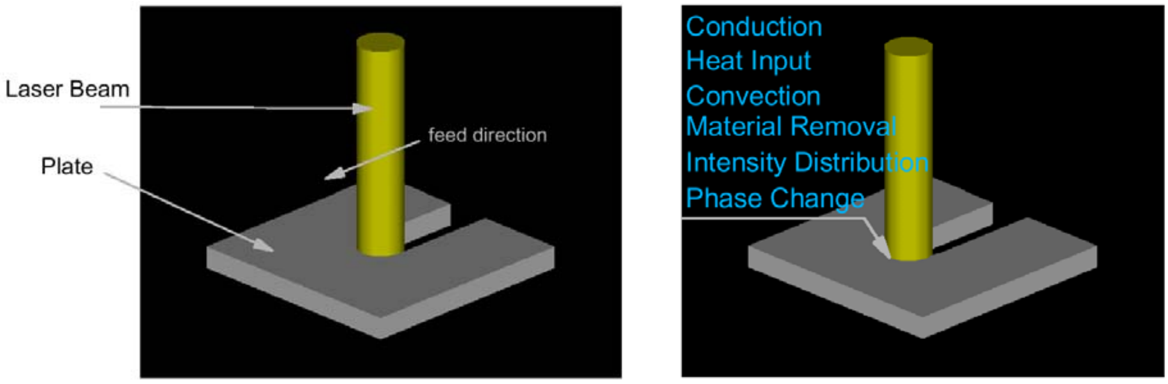
Modeling of Laser Cutting and Related Processes

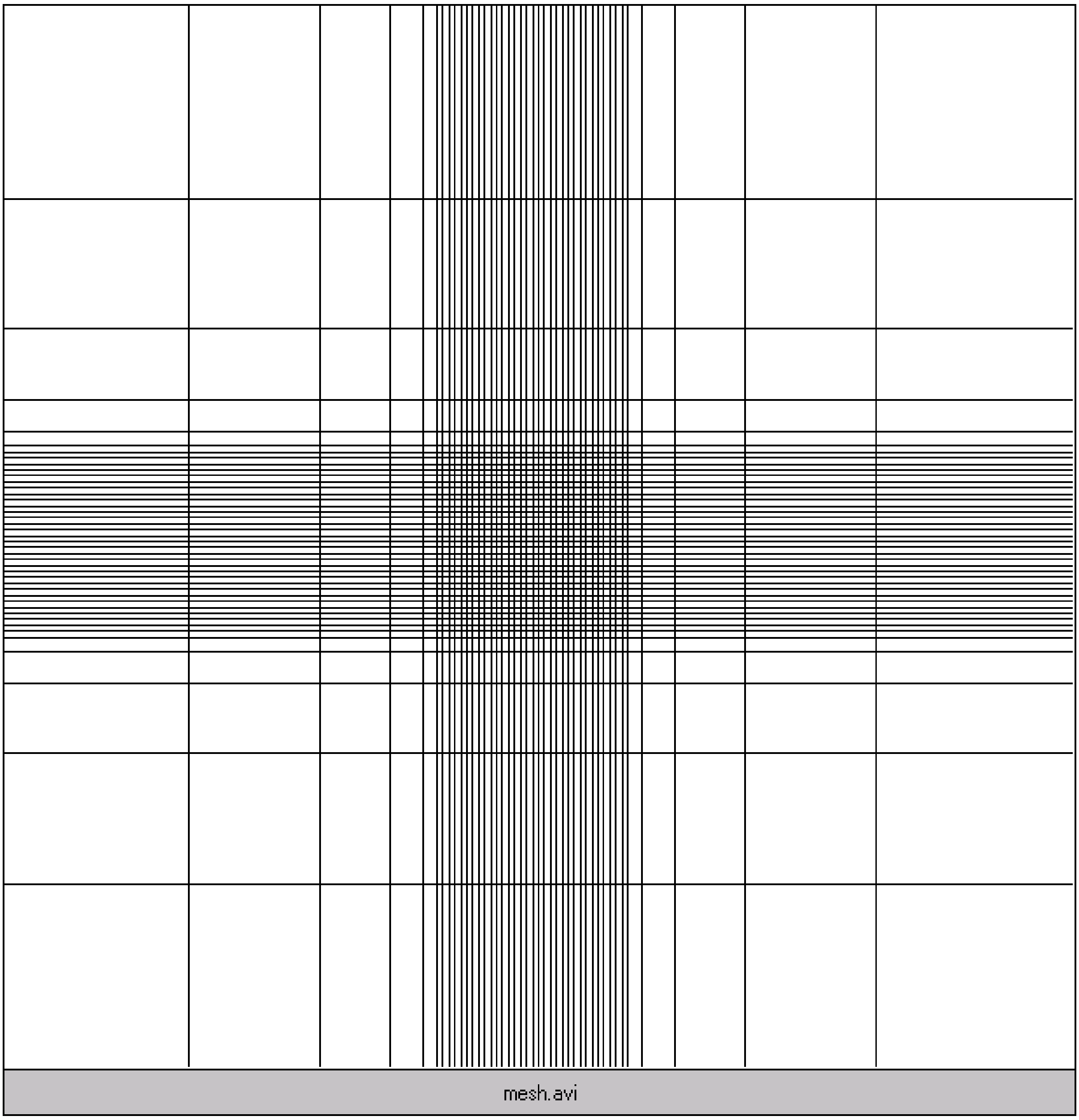
A considerable proportion of laser processing modeling work in the academic literature has been directed at understanding the physics of the interactions between the various processes involved. Such modeling, based on first principles, is a necessary long-term contribution to the field, and has clearly provided stimulating challenges to a large number of scientists.

However, only some of this work has been taken to a point, where the results can be usefully extracted by those whose aims are towards the development and control of industrial processes, which is our declared goal. In common with many sophisticated modeling activities in other fields, provision of useful modeling tools for the industry is far more frequently cited as an objective than practiced in reality.



Modeling laser cutting and its features

Recent modeling work has concentrated on the implementation and numerical evaluation of a transient three-dimensional computer simulation of the CO_2 laser cutting process. By using Crank-Nicolsen-Finite-Difference equations for the solution of the Fourier heat transfer equation with Newtonian convection, the temperature distribution is predicted. For high accuracy the mesh is of non-equidistant nature, following a Weibull distribution for the grid spacing.

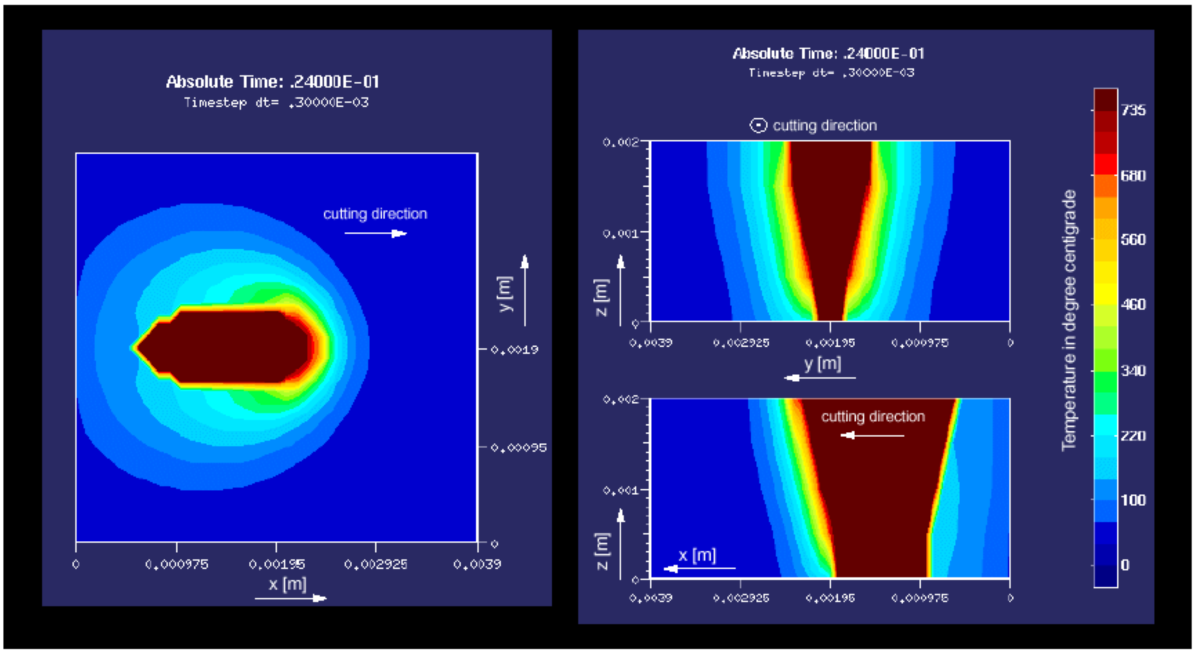


Non-equidistant adaptive mesh

A parallel computation solver is used, based on Divide-and-Conquer Gaussian elimination for banded matrices (ScaLAPACK), to calculate the nodal temperatures using a mini-cluster of two of our HP J5000 workstations.

Included in the solution is the behavior of the material during phase change, whilst the open structure of the developed software allows incorporation of effects such as surface oxidation, radiation and limited convective flow.

The main area of interest is the cutting capability with respect to varying material thickness (e.g., tailored blanks), cutting speed, power of the laser, laser mode, focal spot diameter and material properties, as well as the effect of these parameters on the quality of the cut.



Selected modeling results: Full-through cutting of 2 mm sheet metal

In this field of research we collaborate with Prof. R. L. Reuben, Mr. I. Black, and Mr. M. Gross from Heriot-Watt University in Edinburgh/U.K.