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Book review

Spray simulation: modelling and numerical simulation of sprayforming metals, Fritsching U., 2004, 271 pp. Cambridge University Press. £60 hb. ISBN 0 521 82098 7

The subject of modelling and numerical simulation of sprayforming metals is a relatively new one. As mentioned by the author, the basic concept of metal spray forming was established in the late 1960s. Since that time this area has been developing rapidly, and much contribution came from the research group of Professor Fritsching.

In this book a successful attempt has been made to document the current status of this area of research. Although the emphasis is given to spray forming processes, much attention of the book is focused on the description of common analysis tools and explanation of the general principles that the readers may then apply to other spray modelling strategies. This is expected to widen considerably the readership of this book from researchers in sprayforming metals to researchers involved in modelling and numerical simulation of various sprays not directly related to molten metals. The understandable brief discussion of some topics is supplemented by an extensive reference list.

After a short introduction, describing the scope and main aims of the book, the author describes the spray forming of metals and the general strategy for modelling the processes. After that, the author describes modelling within chemical and process technologies. This part of the book is very brief and rather general, providing an overview of the methods used in computational fluid dynamics codes. It is probably aimed at researchers working on sprayforming metals, but not familiar with computational fluid dynamics methods. This is followed by the three main chapters of the book. These address fluid disintegration, spray dynamics and compaction.

The analysis of fluid disintegration starts with a description of melt flow in tundish and nozzle and a general review of the modelling of this process. Both subsonic and supersonic flows are considered. The emphasis is not just on describing the models, but on comparing the results of modelling and available experimental data. The analysis is restricted mainly to the two-dimensional case, which seems to be applicable for the geometry under consideration. However, some results of three dimensional simulation are also presented. Jet disintegration processes is analysed using the conventional approach based on the solution of the dispersion equation. The general dispersion equation is studied in two limiting cases: large-wavelength area and small-wavelength area. A qualitative jet disintegration model is described. The secondary atomisation process is described in terms of droplets break-up. These break-up processes are related to the development of normal and tangential stresses at the surface of the droplets (bag and stripping break-up). In these cases analogues of Rayleigh–Taylor and Kelvin–Helmholtz types of instabilty are expected

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to develop. Interestingly, this approach has a much wider range of applications including modelling of fuel droplet break-up in diesel engines.

The modelling of spray dynamics, described in the following chapter, is based on Eulerian/Lagrangian and Eulerian/Eulerian approaches. Firstly, droplet movement and cooling are discussed. The interaction of droplets with gas and the turbulent dispersion of droplets in the spray are taken into account. In modelling the convective and radiative heating of droplets the effects of temperature gradient inside droplets and possible droplet semitransparency were ignored. This is probably justified in the case of molten metal droplets ($Bi \ll 1$) when the time scales are not too short. Particular attention is paid to the modelling of solidification of droplets. The modelling of the internal spray flow field, spray-chamber flow and droplet/particle collisions are reviewed.

The last major part of the book is focused on modelling droplet impact and compaction. The models discussed include those of droplet solidification and secondary atomization during impact, and form filling spray process. Also, much attention is focused on modelling of billet cooling. The concluding short chapter is focused on an integral modelling approach.

In conclusion I found this a very scholarly and well produced volume. The book produces a good balance between mathematical analysis and experimental data referring to sprayforming metals. It is easy to read, and can be recommended to postgraduate students and researchers working on modelling and numerical simulation of sprayforming metals, and a wider group of researchers working on mathematical modelling of various sprays.

Sergei Sazhin
School of Engineering
University of Brighton
Brighton BN2 4GJ, UK
Tel.: +44(0)1273-642677; fax: +44(0)1273-642301
E-mail address: s.sazhin@bton.ac.uk