Thomas Böllinghaus
Horst Herold

Hot Cracking Phenomena in Welds
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With 322 figures and 46 tables

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Dr.-Ing. Thomas Böllinghaus  
Vizepräsident und Prof. der BAM  
Bundesanstalt für Materialforschung und -prüfung  
Unter den Eichen 87  
12205 Berlin  
Germany  
Thomas.Boellinghaus@bam.de

Prof. Dr.-Ing. habil. Dr. E.h. Horst Herold  
Institut für Füge- und Strahltechnik  
Fakultät für Maschinenbau  
Otto-von-Guericke-Universität  
Universitätsplatz 2  
39106 Magdeburg  
Germany  
Horst.Herold@mb.uni-magdeburg.de

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Preface

During modern fabrication welding of welded components the avoidance of hot cracking still represents a major topic, sometimes also under new aspects. Austenitic stainless steels, for instance, widely used in industry and known to be crack-free joinable by arc welding might turn their primary solidification mode from ferrite to austenite and thus, might become increasingly susceptible to hot cracking during increasingly applied modern laser and hybrid processes.

Additionally, the phenomena of hot cracking in welds have not completely been understood up to the present. Hydrogen added to the shielding gas in arc welding processes, for instance, might enhance solidification cracking by an increasing the heat input, but has been also tentatively considered to contribute to ductility dip cracking by embrittlement. Quite numerous technological hot cracking test procedures have been developed all over the world to rank the hot cracking resistance of base and filler materials ahead of fabrication welding. Standardization of such tests appears as very challenging, because the different results are difficult to compare and to transfer to real component welds.

In order to provide a forum to define the present state of knowledge, to exchange recent research results, to discuss different viewpoints and to contribute to the ongoing standardization work on hot cracking phenomena in welds an international workshop has been organized in March 2004.

The present book contains the 20 individual contributions from experts all over the world covering four major subjects.

By seven contributions the first chapter provides a complete overview of the different hot cracking phenomena. Different mechanisms of solidification cracking proposed in the past decades are summarized and new insight is particularly given into the mechanism of ductility dip cracking.

In the second chapter, metallurgy and materials, the effect of different alloying elements on the hot cracking resistance of various materials are shown. The initiation of stress corrosion cracking at hot cracks has additionally been included in one contribution as a special metallurgical effect.

Since numerical analyses and other simulation techniques represent very helpful tools to explain cracking phenomena, three individual contributions show in the third chapter how modelling of hot cracking can be performed and how such results might support the explanation of mechanisms.
In the final chapter, the various hot cracking tests are presented in seven individual contributions with a special emphasis on the ongoing process of standardization. As a final contribution the necessary linking between testing and practise is outlined on the basis of actual extraordinary cases.

In total, the extensive contributions from eight different countries do not only provide the latest insight and define the international state of knowledge on hot cracking phenomena in welds. As a particular item, the authors included numerous future research perspectives, fairly enough to excite also the next generation of scientists. By touching all three types of hot cracking, namely solidification cracking, liquation cracking and ductility dip cracking and also by explanations of their differences various articles represent also a very helpful tool for metallurgical and mechanical engineering students of the higher semesters. Furthermore, the text contains helpful individual advices, particularly for international welding engineers confronted with hot cracking in practise.

The editors convey their sincere gratitude to the authors and to all the participants of the workshop for their individual contributions and their eager discussions and, in particular, for pushing the scientific knowledge about hot cracking phenomena in welds a huge step forward.

We especially thank Karen Stelling for her tremendous work in formatting the individual articles and to prepare this book for printing, Margit Bauer for her very helpful translation assistance and, in particular, Thomas Kannengiesser as well as BAM Division V.5 Joining Technology for the organization and their support during the workshop.

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I Phenomena and Mechanisms