HEAT TREATMENT SHANGHAI '83

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Proceedings of the Third International Congress on Heat Treatment of Materials, 7 - 11 November 1983, Shanghai, organised by the Heat Treatment Institution of the Chinese Mechanical Engineering Society and the International Federation for the Heat Treatment of Materials

EDITED BY PROFESSOR T BELL

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Edited Proceedings of the Third International Congress on Heat Treatment of Materials held on 7 - 11 November 1983 in Shanghai, People's Republic of China.

Organised by the Heat Treatment Institution of the Chinese Mechanical Engineering Society (HTICMES) in co-operation with the IFHT, the Congress was attended by some 500 delegates from China and 24 other countries. More than 60 firms from all parts of the world displayed their latest equipment and products in the concurrent exhibition.

Nearly 70 technical papers were presented, plus a further 50 in poster sessions. Subject areas of the nine sessions: physical metallurgy; ferritic and austenitic thermochemical treatments; quality control and equipment; controlled atmospheres; coatings; and the topical subjects of energy management and high energy heating techniques.

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FOREWORD

China, as an old civilised country, has a rich cultural heritage and a 5000-year old history in which heat treatment has played an important role. Nearly 3000 years ago metal tools for agriculture and daily utensils were made of white cast iron. Metallography on some of the unearthed tools clearly indicates that attempts had been made to soften the metal by annealing. Later, to improve the hardness, the quenching of steel weapons such as swords, spears and arrowheads took place. Different quenching media were also tried. Other evidence shows that pack carburising treatments were being carried out during the Han Dynasty (206 BC - 220 AD). The analysis of swords revealed that the carbon content in the core was 0.15 - 0.4% and the carbon content on the surface was over 0.6%. Later, in the Ming and Qing Dynasties, a nitriding agent was included in the process to give a form of carbonitriding treatment.

Although heat treatment in China has been practised over many centuries, it is only since the founding of the People's Republic of China (PRC) that significant development has taken place towards self-sufficiency in machine construction. As a result of the growing needs of the Chinese engineering industry, better links with the industrialised countries have been generated in terms of technical information exchange as well as in trade in equipment and manufactured goods. It was in this context that the International Federation for the Heat Treatment of Materials (IFHT) took a significant step forward to consolidate its world-wide role when it held its Third Congress in the PRC.

Approval for the holding of the Third International Congress for the Heat Treatment of Materials in Shanghai in November 1983 had been granted by the State Council of the People's Republic of China and the Shanghai Municipal Government. It was the first event of its kind to be held in China and was most efficiently organised by the Heat Treatment Institution of the Chinese Mechanical Engineering Society, which had become a member of the IFHT in 1981.

The present volume is a permanent record of the technical papers which were presented in Shanghai, this being the first time that an IFHT Congress has been published in this form for world-wide circulation. This edited version of the Shanghai Congress is arranged in six Chapters:

1 *Ferritic and Austenitic Thermochemical Treatments*
2 *Application of High Energy Heating in Heat Treatment*
3 *Surface Coatings*
4 *Energy Management, Controlled Atmospheres and Quality Control in Heat Treatment*
5 *Physical Metallurgy Aspects of Heat Treatment*
6 *Abstracts of Additional Papers and Poster Contributions*

Chapters 1 to 5 are based on original scientific papers which were fully presented at Shanghai and were available to the Editor in an English language form by 31st January 1984. Many of these papers, including some not originally in English, have been extensively revised by the Editor; in the time scale available the authors have not had an opportunity to see the modified text as now printed.

Several papers which were either entirely commercial in character, or which did not include substantial amounts of new material, or for which an English language version was not available to the Editor, have been presented as a series of abstracts in alphabetical order in Chapter 6, in which abstracts of the majority of the poster papers available in Shanghai have also been included.

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Ferritic thermochemical treatments

T BELL

The author is Hanson Professor of Metallurgy and Director of the Wolfson Institute for Surface Engineering, Department of Metallurgy and Materials, University of Birmingham.

SYNOPSIS

The factors influencing the hardening response of gas and plasma nitrided low alloy steels are reviewed. The fatigue properties resulting from the nitriding process are outlined with special emphasis being placed on the characteristics of bright nitrided low alloy steels. In particular, it is shown that bright nitriding leads to a loss in optimum hardening, case depth and endurance limit. Nitrocarburising treatments are considered in some detail, especially recent work concerning treatments in methanol/ammonia mixtures. Experimental studies on the influence of monophased and dual phased compound layers on adhesive wear properties of nitrocarburised mild steel are briefly described. Finally, attention is focussed on recent patented developments in this field of surface engineering, which involve combined nitrocarburising and oxidising treatments, and which are finding application in the automotive industry.

INTRODUCTION

Ferritic thermochemical treatments involve the diffusional addition of the non-metallic elements into the surfaces of ferrous engineering components at temperatures below the eutectoid temperature. The components are subsequently quenched, or cooled in the processing medium. Unlike the austenitic thermochemical treatments they do not undergo any martensitic phase transformation and as such the ferritic treatments possess very good dimensional stability with minimum shape distortion.

In the present paper only the current status of the two principal groups of ferritic treatments, namely, nitriding and nitrocarburising are considered in detail and emphasis will be placed not on the processing variables but on the properties that result from the treatments. In particular, the metallurgical factors influencing the tribological, fatigue and corrosion resistance of ferrous material treated by the ferritic treatments will be discussed.

NITRIDING

Traditionally, nitriding which involves the introduction of atomic nitrogen into the ferrite phase at temperatures below 590°C the eutectoid temperature of the Fe-N system, has been undertaken using partially dissociated ammonia as the mass transfer medium. However, more recently a nitrogenous plasma has become widely accepted as the means of transferring nitrogen to the surface of steel components.

Surface Hardening Phenomena

In order to substantially harden the surface of ferrous components by nitriding it is necessary to use alloy steels containing small quantities of nitride forming elements, such as aluminium, chromium, molybdenum and vanadium and a typical series of hardness profiles generated for a 3%Cr Mo steel after various plasma nitriding treatment times is shown in Fig.1(1). A scientific appreciation of the hardening mechanisms taking place during ferritic nitriding treatments has lagged considerably behind the industrial acceptance of the nitriding process but there are now reasonably well established explanations of the observed phenomena on the basis of fundamental studies which have been reviewed by K.H. Jack(2).

When nitride forming elements are present in steel the hardness achieved and rate of nitrogen penetration during nitriding are a function not only of the nitriding temperature and concentration of the alloying elements, but also of the strength of the interaction between the alloying elements and nitrogen. The strong nitride formers, aluminium and titanium, have a pronounced effect on the hardness even at small concentrations. Molybdenum and vanadium, on the other hand, have an intermediate effect as does chromium at low concentrations. As the concentration of chromium increases, so too does its hardening capacity. Increasing the concentration results in a decrease in the effective case depth and for the strong alloying elements this is quite dramatic. Hence, the selection of a steel with optimum nitridability relies critically on the balance between the nature of the alloying elements selected and the amount incorporated in the alloy. In practice, steels which contain several alloying elements exhibit higher hard-