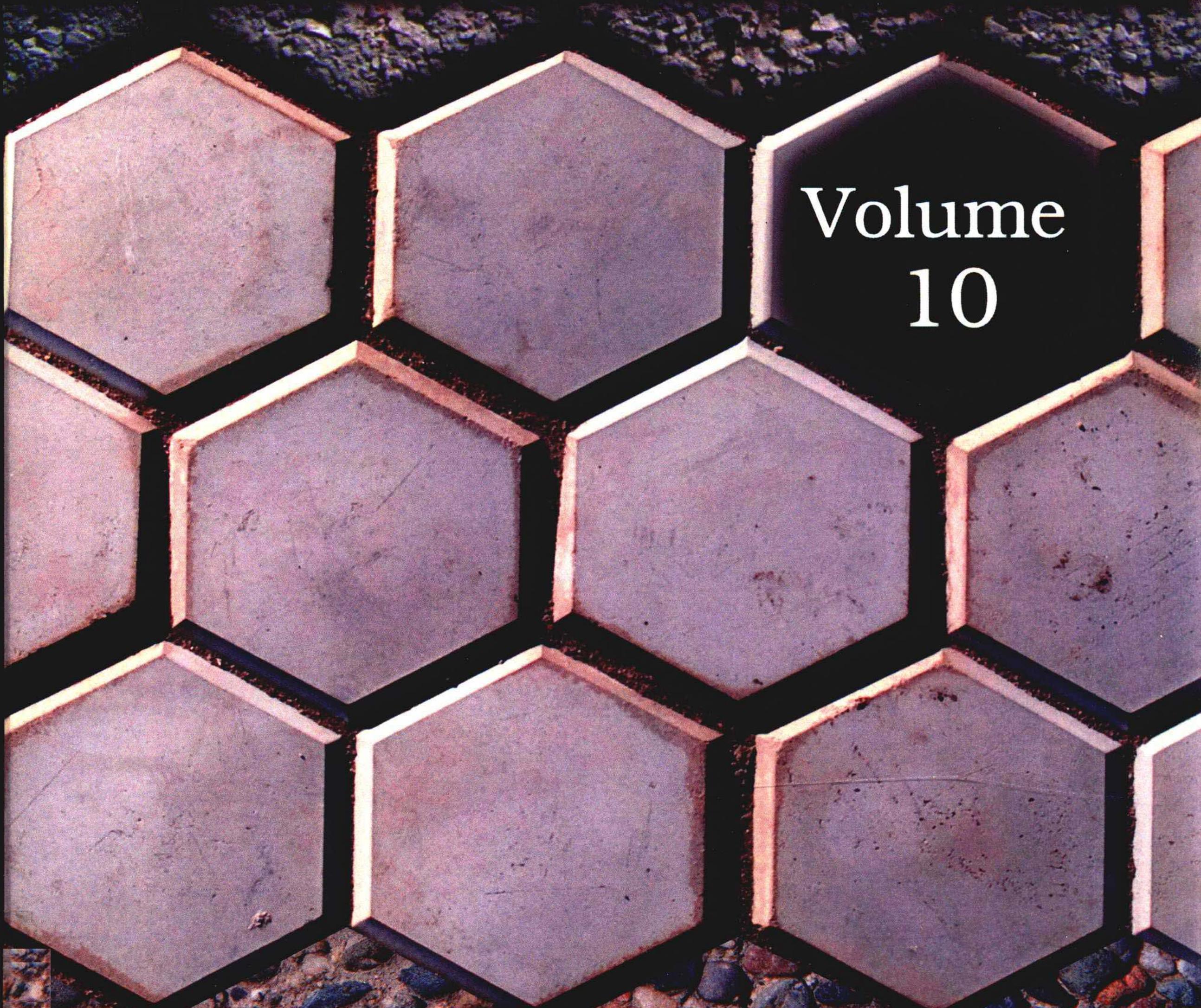
Advances in Materials Science Research



Volume 10

Maryann C. Wythers
Editor

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ADVANCES IN MATERIALS SCIENCE RESEARCH

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VOLUME 10

MARYANN C. WYTHERS
EDITOR

NOVA

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ADVANCES IN MATERIALS SCIENCE RESEARCH

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PREFACE

Materials science encompasses four classes of materials, the study of each of which may be considered a separate field: metals, ceramics, polymers and composites. This volume gathers important research from around the globe in this dynamic field including research on the structure and properties of polypropylene foams; sensitization in TIG welding of austenitic stainless steel, tribotesting of polymers in line contact; the synthesis and crystal growth of nonlinear optical materials and their application in telecommunications; poly (vinyl alcohol) hydrogels in drug delivery devices; developments in processing technologies of functionally graded materials and the indentation size effects in polymers.

Chapter 1 – This work covers the studies on the phenomena and mechanisms of cavitation damages during the last two decades, and it mainly focuses on the mechanical, electrochemical, thermal, and especially the synergistic effects on the damages on metal surfaces. On mechanical effect, the role of the microjet and the shock wave in the mechanical damage is discussed first, and then different damages styles on the metal surfaces are classified with metallurgical analysis. The analytical models of cavitation erosion, which has been rarely discussed in other reviews, are presented here. On thermal effect, new techniques on the temperature measurement at the moment of bubble collapse are reviewed, and the corresponding results are provided. Based on the experiment results, the possibility of the direct heating by the hot bubbles on the metal surface is discussed. On corrosion effect, the passivation film behavior is considered as the most important reason affecting the cavitation corrosion rate, and the studies on the rupture of the passivation film in different corrosive environments are mostly concerned. Besides the separated mechanisms, current advances in the studies on synergistic effect are emphasized here, as they extend the traditional cavitation erosion-corrosion model to a broader range of interactions of mechanical, chemical and thermal effects. The relevant experimental methods and mechanisms are introduced as a unique section, and a new technique of erosion-corrosion map, which is developed to give a visual representation of material performance under cavitation erosion-corrosion, is also included. To make the review more systematically, some of the classic theories and experiment results are also briefly presented in this work.

Chapter 2 – The complexity of the brain and the membranous blood-brain barrier (BBB) has proved to be a significant limitation to the systemic delivery of pharmaceuticals to the brain rendering them sub-therapeutic and ineffective in the treatment of neurological diseases. Apart from this, lack of innovation in product development to counteract the problem is also a major contributing factor to a poor therapeutic outcome. Various innovative strategies show potential in treating some of the neurological disorders; however drug delivery remains the most popular. To attain therapeutic drug levels in the central nervous system (CNS), large, intolerable systemic doses are generally administered. The success of maintenance therapy in many neurological diseases depends on a number of variables, including the constant release of neurotherapeutics, a reduction in the dosing frequency, a greater antipsychotic drug bioavailability and ultimately improved patient compliance, many of which is not achievable by conventional oral or parenteral formulations. This article reviews the therapeutic implantable polymeric and transdermal devices employed in an attempt to effectively achieve therapeutic quantities of drug across the BBB over a prolonged period, to improve patient disease prognosis.

Chapter 3 – It is well known the relevance given to the study of heat transfer in polymer foams, as one of the main applications is as lightweight thermal insulating elements. Alongside some of the possible strategies for improving the thermal insulating characteristics of polymer foams, there is also a tremendous interest in further extending the applications of these materials, mainly focusing on improving their poor mechanical properties.

Although there is a great deal of interest in preparing and studying polypropylene foams, largely due to their good balance of properties and reduced cost, there is still lack of information regarding their mechanical and thermal conduction characterizations. With that in mind, this chapter considers the preparation, structure and properties of different polypropylene and polypropylene-based nanocomposite foams, focusing on the importance of the foam's cellular structure and microstructure characteristics and/or filler's orientation and dispersion in the mechanical and mainly thermal conduction properties, with the main objective of developing new multifunctional thermal insulating lightweight materials for diverse applications.

A great deal of importance is given to some of the different strategies used towards the development of rigid polypropylene-based foams to be used as structural elements with improved thermal insulation characteristics. Particularly, the focus is on reducing the value of thermal conductivity via cellular structure control, as it is known to strongly depend on cellular structure characteristics such as cell size, cell density and cell anisotropy. First of all the importance of the foaming process and foaming parameters in establishing a certain cellular structure is addressed and secondly, in the possibilities of adding high aspect ratio nano-sized fillers, that act as cell nucleating sites, promoting the formation of finer closed-cell foams.

Chapter 4 – Austenitic stainless steel (316L) is a corrosion resistance material used extensively in oil production, chemical, power generation industries for transportation and reservoir of corrosive products. In spite of its corrosion resistance property there exist severe problems of sensitization. In the present work an effort has been made to investigate the effect of sensitization in TIG welding of Austenitic stainless steel (316L). Three welding procedures (namely conventional, back step, skip welding) have been adopted to study the effect of sensitization on mechanical properties (such as tensile strength, yield strength, percentage elongation, hardness). The results of study suggested that the better mechanical properties were attained by Skip welding procedure and recommended welding parameters are 90Amp current and 10L/min of gas flow rate. Experiment results have been counter verified with Scanning Electron Microscopy (SEM) analysis.

Chapter 5 – The friction and wear properties of polymers are difficult to predict theoretically, due to the many parameters that influence the tribological behaviour.

Knowledge about the tribological properties of self-lubricating properties of polymers is therefore mainly gathered from experimental testing, which is often closely related to the final application conditions. In contrast to traditional pin-on-disc test set-ups, the analysis of a contraformal cylinder-on-plate contact with initial line contact providing high contact pressures and promoting polymer transfer to the counter-face at running-in is presented. Especially, different types of polyimide cylinders are tested because of their good thermal and mechanical properties and resistance against high initial contact pressures. The statistical variation in test results is discussed in relation to variations in the sample geometry. There is a statistical variation of about 7 to 9% on dynamic coefficients of friction, about 10 to 12% on static coefficients of friction, about 8 to 9% on wear rates from weight loss and about 12 to 15% from wear rates from dimensional measurements. The on-line and off-line wear measurements can be combined to distinguish between real material loss, visco-elastic deformation, plastic deforma-tion and thermal expansion of the polymer samples. The transition between running-in and steady-state sliding conditions are further detailed, in relation to the visco-elastic deformation and variations in macroscopic contact situation into a more conformal contact during sliding. Finally, an analytical expression for calculating the maximum polymer surface temperature T* has been developed for the present sliding configuration.

Chapter 6 – Extensive studies have been made on the synthesis and crystal growth of nonlinear optical (NLO) materials over the past decades because of their potential application in the field of telecommunication, optical signal processing and optical switching. Organic materials have been of particular interest because the NLO responses in this broad class of materials is microscopic in origin, offering an opportunity to use theoretical modeling coupled with synthetic flexibility to design and produce novel materials [1,2]. By converting the IR laser radiation into useful UV-Visible wavelength and in particular with the generation of the blue-violet via second order nonlinear optical (SONLO) material, several applications such as high density data storage, laser printing, displays, inflorescence, photolithography, remote sensing, chemical and biological species detection, high resolution spectroscopy, medical diagnosis, underwater monitoring and communication can be realized [3]. Considerable theoretical and experimental investigations have been done in order to understand the microscopic origin of nonlinear behavior of organic NLO materials [4, 5]. Organic molecules with significant nonlinear optical activity generally consist of a pi electron conjugated moiety substituted by an electron donor group on one end of the conjugated structure and an electron acceptor group on the other end, forming a ‘push-pull’ conjugated structure. The conjugated pi-electron moiety offers a number of opportunities in applications as nonlinear optical materials. For efficient second harmonic generation (SHG), one requires highly polarisable molecular system having asymmetric charge distribution in the molecule, ie, donor and acceptor groups at the end of the molecule with noncentrosymmetric crystal structure [6].

The compounds 1, 2, 4-triazole derivatives show antibacterial, antifungal, antitubercular, anticancer, antitumor, anticonvulsant, anti-inflammatory, and analgesic properties. 1, 2, 4-triazoles also find applications in the preparation of photographic plates, polymers, and as analytical agents. Similarly Schiff base derivatives of 1, 2, 4-triazol-5-ones have been found to possess antitumor activity. 3-amino-1,2,4 triazole is used as an herbicide, especially in vineyards and orchards, an intermediate for the synthesis of dyes, lubricants, anticorrosion products and active ingredients for pharmaceuticals. Quantitative measurements of second harmonic generation of powdered 4-amino-1, 2, 4-triazol-1-ium hydrogen oxalate confirms its NLO property [7]. The hydrazones have found wide applications in various chemical processes like nonlinear optics, sensors, medicine etc. Experiments revealed consistently that the hydrazone derivatives show large nonlinear optical effects and are thus very interesting for electro-optic applications. To explore its nonlinear optical properties, the compound 4-amino-5-mercapto-3-[1-(4-isobutylphenyl) ethyl]-1,2, 4-triazole (AMIT) has been synthesized and single crystals were grown by slow evaporation of the solvent at room temperature. Many donor-acceptor complexes exhibiting high second order nonlinearity have been reported. Hence the compound N'-[(Z)-(4-Methylphenyl) Methylidene]-4-Nitrobenzohydrazide (NMPMN) was synthesized and single crystals were grown from ethanol by slow evaporation of the solvent at room temperature.

Chapter 7 – Anionic polyacrylamide (PAM) is a linear, water soluble anionic polymer. The formulation used in this study has a molecular weight of 12 to 15 Mg mole^{-1} and is widely used for erosion control and water quality protection. There has been an issue whether this formulation could possibly have negative effects on soil microbial diversity by altering microbial binding to soil particles or to one another and thus restricting their mobility and role in C and nutrient cycling To explore this possibility, an eight year study annually was conducted, applying ultra high rates (more than two orders of magnitude higher than recommended application rates) of PAM to soil and then monitored impacts on soil eubacterial diversity. In July and August, the authors measured active soil bacterial and fungal biomass and microbial diversity in soils receiving 0 (control), 2691 and 5382 kg active ingredient (ai) PAM ha^{-1}. Active microbial biomass in soil was 27-48% greater in the untreated control than soil treated with 2691 or 5382 kg ai PAM ha $^{-1}$. Active bacterial biomass in soil was 20-30 % greater in the control treatment than in soil treated with 2691 or 5382 kg ai PAM ha $^{-1}$ in August, but not July. Active fungal biomass in soils was 30-50% greater in the control treatment than soil treated with 2691 or 5382 kg ai PAM ha $^{-1}$ in July, but not August. Amplicon length heterogeneity polymerase chain reaction (LH-PCR) DNA profiling was used to access the eubacterial diversity, richness, and evenness in an agricultural soil that received 0 (control), 2691 and 5382 kg active ingredient (ai) PAM ha^{-1}. LH-PCR profiles showed no discernible change in the soil microbial diversity, richness, and evenness due to either of the PAM treatments at any sampling time. This chapter explains that although soil receiving these massive PAM application rates and prolonged exposure may reduce active bacterial and fungal biomass, those reductions were not consistent, varying with sampling date. Furthermore these massive application rates did not substantially or consistently affect eubacterial structural diversity, richness or evenness in this agricultural soil.

Chapter 8 – Poly (vinyl alcohol) (PVA) hydrogels have a number of interesting properties whose make it an excellent candidate for several applications. One of the well known uses of these materials is like drug delivery device for their high hydrophilicity and water uptake capability.

Hydrogels of PVA were obtained by two different routes: chemical method (by using a crosslinking agent, such as glutaraldehyde (GA)) and by physical method (carried out by freezing/thawing (F/T), resulting in cryogels). The main advantages of F/T are its easiness that does require neither high temperatures nor toxic agents as waste that can be harmful to the human body. It is possible, for biomedical applications, that un-reacted residue from the crosslinking agent may eluted slowly over time resulting in the release of toxic agents; being this toxicity undesirable for pharmaceutical applications because the activity of the drug or agent being released could be destroyed.

The properties of PVA hydrogels depend mainly on their density or degree of crosslinking and crystallinity. Nevertheless, it is still unclear what role of processing variables play on the significant properties of the material. These properties can be driven by the numbers of F/T cycles, the cycle extent, the freezing temperature, the rate of thawing, the polymer concentration and its molecular weight (Mw).

The aim of this chapter was to analyze the effect of some processing variables on the characteristic and properties of PVA hydrogels and to look at the delivery system behavior in aspirin and ibuprofen drugs. For this purpose, cryogels with different: numbers of F/T cycles (1 to 4), cycles extent (1, 12 and 24 h), Mw (18000; 40500, 93500 and 155000 g/mol) and polymer concentration (5 to 15 wt.%) were synthesized and analyzed by means of thermogravimetric analysis (TGA), differential scanning calorimetric (DSC), swelling studies, X-ray diffraction (XRD), rheological tests and mechanical properties. In addition, cryogels were compared with chemically based hydrogels by means of selected characterization techniques.

The results obtained in the present study suggest that it is possible to obtain cryogels with controlled properties and to be optimist about the future use of these kinds of hydrogels, avoiding the use of toxic crosslinking agent, for applications such as drug delivery.

Chapter 9 – Duplex stainless steels configure a family of metallic alloys that combined elevated mechanical properties with improved corrosion resistance when compared to standard austenitic grades. This excellent combination of properties leads to their use under many different applications, particularly in the fields of chemical, petrochemical, pulp and paper industries. Moreover, these applications usually involve cyclic loading, and consequently the study of fatigue properties has a great significance for reliable design and safe-operation.

This chapter is devoted to study and analyze the cyclic deformation response of duplex stainless steels under standard testing conditions. The first point studied is the fatigue behavior of a duplex stainless steel corresponding to the last generation or superduplex. The cyclic stress-strain curve (CSSC) was determined through a wide interval of plastic strain amplitudes by incremental fatigue tests. Afterwards, constant total strain amplitude fatigue tests were performed at four different total strain amplitude values, values that correspond to marked different positions within the CSSC. TEM analysis of the different substructures developed within both constituent phases, i.e. austenite and ferrite, was done for each plastic strain amplitude. Finally, results obtained for the superduplex steel are compared to those reported for other duplex with lower nitrogen content tested under similar experimental conditions.

Chapter 10 – Boron nitride has a great potential in Nanotechnology. It is not found in nature and is produced synthetically from raw materials like boric acids and boron trioxides. Boron Nitride Nano Tubes (BNNTs) were synthesized by various methods like hot filament chemical vapor deposition technique, laser ablation, ball milling, annealing method. Doping was also done of BNNTs using several compounds like F, Si, and Cu. These BNNTs offer many advantages like flexibility, non cytotoxicity. They work as excellent vectors in magnetic drug delivery. They were also used as imaging agents. Boron neutron capture therapy is used in targeting aggressive cancers. BNNTs are good desalinators. The permeability of various ions like Na, Cl into the cells was enhanced through BNNTs which help in regulating electrical properties in nervous system and also alters cell functioning under influence of hormones. Cell characteristics are studied by nano needles. BNNTs are also expelling out as nano imagers and they determine cell health.

Chapter 11 – Over Recent years advancement in nanoparticles drug delivery is widely expected to change the landscape of pharmaceutical and biotechnology industries for the foreseeable future. The pipelines of pharmaceutical companies are believed to be drying up in many cases, and a number of blockbuster drugs will come off patent in the near-term. Using nanoparticles, it may be possible to achieve improved delivery of poorly water-soluble drugs by delivering drug in small particle size increase the total surface area of the drugs allowing faster dissolution in blood stream.

Chapter 12 – The diagnosis and treatment of gene related will be greatly improved with the development of nanotechnoly that enable the delivery of gene and therapeutic agents into cells and cellular compartments with this application of nanotechnoly in diagnosis is referred as nanomedicine. Nucleic acid based next generation biopharmaceutics (i.e. pDNA, oligonucleotides, short interfering RNA) are potential pioneering materials to cope with various incurable gene related diseases. With development in nanotechnology, now offer numerous non-viral vectors (i.e. liposomes, lipoplexes, and nanoparticles), viral vectors (Retroviruses, Adenoviruses, Adeno-associated, and Herpes-simples) and nanodevices (i.e. Dendrimers, Chromallocytes, Nanoshells, and Gene gun) to relocate therapeutic DNA-based nanomedicine into the target cell. Biological macromolecules including DNA, RNA, and proteins, have intrinsic features that make them potential building blocks for the bottom-up fabrication of nanodevices for gene therapy. Gene therapy work by carrying gene on chromosomes thereby replacing abnormal disease causing gene, an abnormal gene could be swapped for a normal gene, the abnormal gene could be repaired through selective reverse mutation. This review article deals with nanodevices which are successfully used for gene therapy.

Chapter 13 – A large number of components in engineering and structural services demand location specific performance. The functionally graded materials (FGM) are class of smart materials in which location specific properties are achieved. It can be by changing the chemical composition or the structure of the material at that desired location. Such components will be more performance efficient and economical. Synthesis of such materials or smart components is technologically challenging and has great relevance for the coming years. In the last two decades efforts have been made in developing functionally graded materials for variety of engineering applications. Basically two approaches are available for Processing FGM. In the constructive approach, the functionally graded layers are built through processes like solid state powder metallurgy method, liquid phase sintering, infiltration and reactive powder sintering. In the transport aided approach the transportation of the second phase is achieved through natural phenomenon like diffusion, gravity or thermal and or mechanical or chemical aided forces. The chapter describes the state of art knowledge available on the processing of FGMs with specific examples of the industrial components. The authors have classified the processing methods broadly based on the physical state of the process as solid state processes, liquid state processes and gaseous aided / deposition process.

In solid state processes, the constituents of FGMCC, both the matrix and the reinforcements, are usually in the solid state during their processing. The powder metallurgy and diffusion bonding are the important solid state processes. In liquid state processes, the matrix is either fully or partially molten during the formation of FGMCC. The important methods are infiltration, controlled gravity aided settling, centrifugal casting etc. In deposition processes, the graded and the outer layers are deposited on a prefabricated bulk component. These processes are very attractive and find wide applications due to the formation of functionally graded layers between a bulk component and the outer coating which protects the components from the harsh conditions such as temperature, corrosion or erosion.

Realizing unlimited scope for the use of FGM for wide spectrum of applications in different areas such as aerospace, automotive, defense, electronics and communication, electrical, structural, biomedical and in general engineering, extensive development work is being carried out worldwide. The prime applications of FGM being considered are the area where the operating conditions are severe. For example, wear-resistant linings for handling heavy abrasive ore particles, rocket heat shields, heat exchanger tubes, thermoelectric generators, heat-engine components, plasma facings for fusion reactors, electrically insulating metal/ceramic joints etc. They are also ideal for minimizing thermal mismatch in metal-ceramic bonding, such as thermal barrier coatings (TBCs). The proposed chapter put emphasis on various processing techniques developed / used for the fabrication of functionally graded materials.

Chapter 14 – Austenitic-stainless steel is preferred over other stainless steels because of ease in both welding and deformation. However, negative metallurgic changes are also involved in the welding of steels. On the other hand, friction welding is known to eliminate these negative effects due to limited time and rapid cooling in working. Therefore, friction welding is more advantageous than other welding methods. Friction welding is widely used as a mass-production method in various industries. Friction welding involves generation of heat by the conversion of mechanical energy into thermal energy at the interface of the work pieces without using electrical energy or heat from other sources during rotation under pressure.

The aim of this study is to investigate experimentally the microstructural and mechanical properties of friction welded austenitic-stainless steels (AISI 304).

Chapter 15 – Similar to the size-dependent deformation observed in metals at length scale ranges from microns down to nanometers, many polymers exhibit size dependent deformation at these length scales. While for metals such size dependent deformation phenomena are commonly attributed to geometrically necessary dislocation densities, this notion can not be applied to polymers and a sound theory explaining these phenomena in polymers seems unavailable.

Such size dependent deformation can be studied with indentation experiments where such size dependent deformation manifests itself in the indentation size effect where increased hardness is observed at small indentation depths. Experimental investigations where the hardness of polymers at different indentation depths have been determined are reviewed in this article along with higher order gradient theories that can potentially model and explain the indentation size effects in polymers. A theory is presented in particular and discussed in detail which relates the indentation size effect to higher order gradient energies that have to be exerted at small indentation depths.

CONTENTS

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Chapter 1

SYNTHETICAL DAMAGES ON METAL SURFACE BY CAVITATION EROSION

Chen Haosheng[1*] and Li Jiang[2]

[1] State Key Laboratory of Tribology, Tsinghua University, Beijing, 100084, China
[2] Mechanical engineering school, University of Science and Technology Beijing, Beijing, 100083, China

Abstract

This work covers the studies on the phenomena and mechanisms of cavitation damages during the last two decades, and it mainly focuses on the mechanical, electrochemical, thermal, and especially the synergistic effects on the damages on metal surfaces. On mechanical effect, the role of the microjet and the shock wave in the mechanical damage is discussed first, and then different damages styles on the metal surfaces are classified with metallurgical analysis. The analytical models of cavitation erosion, which has been rarely discussed in other reviews, are presented here. On thermal effect, new techniques on the temperature measurement at the moment of bubble collapse are reviewed, and the corresponding results are provided. Based on the experiment results, the possibility of the direct heating by the hot bubbles on the metal surface is discussed. On corrosion effect, the passivation film behavior is considered as the most important reason affecting the cavitation corrosion rate, and the studies on the rupture of the passivation film in different corrosive environments are mostly concerned. Besides the separated mechanisms, current advances in the studies on synergistic effect are emphasized here, as they extend the traditional cavitation erosion-corrosion model to a broader range of interactions of mechanical, chemical and thermal effects. The relevant experimental methods and mechanisms are introduced as a unique section, and a new technique of erosion-corrosion map, which is developed to give a visual representation of material performance under cavitation erosion-corrosion, is also included. To make the review more systematically, some of the classic theories and experiment results are also briefly presented in this work.

Keywords: cavitation, cavitation erosion, erosion-corrosion, synergistic effect.

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* Email address: chenhs@mail.tsinghua.edu.cn

Nomenclature

A: exposed specimen area, cm^2.

C: mass loss by corrosion
C_p: specific heat of target

d_{grain}: diameter of grain
D: diffusion coefficient
D_p: particle density, kgm^{-3}

e: the coefficient of restitution
E: mass loss by erosion
E_e: elastic modulus of collision,
E_{er}: impact energy
E_{cor}: open circuit corrosion potential
Et: absorbed energy
Es: damage threshold energy
EW : the alloy equivalent weight which is the mass of metal in grams oxidized by the passage of one Faraday of electric charge

f_c: the proportion of particles impacting the surface cutting in an idealised manner,
f_i: Faraday's constant for i th element
F: Faraday's constant, $Cmol^{-1}$

h: thickness of the passive film
h_0: thickness of the passive film at passivation potential
H: pit depth
Hs : static hardness of target
H_v: hardness

i_A : average anodic current density over sample
i_{th}: threshold anodic current density to cause the chemo-mechanical effect
i_{corr}: corrosion current density, $\mu A/cm^2$.
i_{anet}: net anodic current density, $A\ cm^{-2}$
I_{corr}: total anodic current, μA

J: diffusion rate

k: constant
k_1: 3.27×10^{-3}, mmg/μA cm yr
k_2: 8.954×10^{-3}, $gcm^2/\mu A\ m^2\ d$
K_c: total rate of metal wastage due to corrosion
K_e: total rate of metal wastage due to erosion
K_{co}: corrosion rate in absence of erosion
K_{ec}: overall rate of metal wastage
K_{eo}: erosion rate in absence of corrosion

MR: g/m^3d

n': cyclic strain- hardening exponent
N: number of bubbles
n_i: number of electrons for i th element
n: number of electrons

p: pressure
p_∞: pressure at far field

R: bubble radius
R_0: Original bubble radius
R10%: the position where equals to 10% of the pit radius
Re: Reynolds number

S: mass loss by synergistic effect
Sc: Schmidt number
S_f: surface tension force
Sh: Sherwood number

T: Total mass loss
T_{em}: temperature
T_m: melting point of target
TS: the true ultimate tensile strength,

U_i: the erodent particle impact velocity

v: particle velocity,
V_D: activation volume of F-R source

W: Weight
W_d: deformation work
W_i: atomic weight of the *i* th element in the alloy

Y: Young modulus (N/mm^2)
YS: 0.2% proof stress

α: the particle impact angle.
γ: Ratio of distance between the boundary and the bubble centre to the bubble radius
τ_e: effective shear stress;
τ_a: applied shear stress;
ρ: density
σ_f': fatigue strength coefficient
σ: stress strength
η_{co}: collapse efficiency
υ: viscosity

ΔC: erosion enhanced corrosion
ΔE: corrosion enhanced erosion
ΔL: rupture length
ΔW: loss weight
ΔK_c: effect of erosion on corrosion
ΔK_e: effect of corrosion on erosion
$\dot{e}_0$:weight loss rate due to erosion without corrosion
$\dot{e}_c$: weight loss rate due to corrosion-enhanced erosion

Abbreviations:

AMCs: aluminium matrix composites
BCC: body centered cubic.
DSSs: duplex stainless steels
e.m.f.: electro-motive force
EDS: energy dispersive X-ray analysis
FCC: face centered cubic
FIB: focused ion beam
HCP: hexagonal closed packed
HV30: hardness.
HVOF: high Velocity Oxygen Fuel
HNSs: high nitrogen alloying stainless steels
LSF: laser shock forming
LSM: laser surface modification
MDPR: mean depth of penetration rate
SFE: stacking fault energy.
SEM: scanning electron microscopy
TEM: transmission electron microscopy
WDS: wavelength dispersive spectrometry