



APS Blasting 2

NEW DEVELOPMENT ON ENGINEERING BLASTING

**Editor in Chief
Prof. WANG Xuguang**



METALLURGICAL INDUSTRY PRESS



APS Blasting 2

NEW DEVELOPMENT ON ENGINEERING BLASTING

**Editor in Chief
Prof.WANG Xuguang**

江苏工业学院图书馆
藏书章

METALLURGICAL INDUSTRY PRESS

Copyright © 2009 by Metallurgical Industry Press, China

Published and distributed by
Metallurgical Industry Press
39 Songzhuyuan North Alley, Beiheyuan St
Beijing 100009, P. R. China

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of the copyright owner.

图书在版编目 (CIP) 数据

工程爆破新进展. 2: 英文 / 汪旭光主编. —北京: 冶金工业出版社, 2009.7
ISBN 978-7-5024-4982-7

I. 工… II. 汪… III. 爆破技术—文集—英文 IV. TB41-53

中国版本图书馆 CIP 数据核字 (2009) 第 098079 号

出 版 人 曹胜利

地 址 北京北河沿大街嵩祝院北巷 39 号, 邮编 100009

电 话 (010) 64027926 电子信箱 postmaster@cnmip.com.cn

责任编辑 程志宏 钱文涛 美术编辑 张媛媛 版式设计 张 青

责任校对 刘 倩 责任印制 牛晓波

ISBN 978-7-5024-4982-7

北京盛通印刷股份有限公司印刷; 冶金工业出版社发行; 各地新华书店经销

2009 年 7 月第 1 版, 2009 年 7 月第 1 次印刷

210mm×297mm; 40 印张; 1896 千字; 625 页; 1-510 册

冶金工业出版社发行部 电话: (010) 64044283 传真: (010) 64027893

冶金书店 地址: 北京东四西大街 46 号(100711) 电话: (010) 65289081

(本书如有印装质量问题, 本社发行部负责退换)

The Asian-Pacific Symposium on Blasting Techniques (2009)

ORGANIZED BY:

China Society of Engineering Blasting

CO-ORGANIZED BY:

Engineering Blasting Society of Liaoning Province, China

Dalian Kai-sheng Blasting Demolition Engineering Co., Ltd., China

CHAIRMAN:

Prof. WANG Xuguang

Academician of Chinese Academy of Engineering, China

VICE-CHAIRMAN:

President YANG Xusheng,

Shensi Design Institute of Engineering and Scientific Research, China

THE ORGANIZING COMMITTEE MEMBERS (in alphabetical order):

BHANDARI Sushil	(INDIA)	HUSTRULID William	(AMERICA)
CARLOS P. Orlandi	(CHILE)	KANEKO Katsahiko	(JAPAN)
Chang-Ha Ryu	(REPUBLIC of KOREA)	KUNIHISA Katsuyama	(JAPAN)
CHEN Peiling	(CHINA)	LI Chengjun	(CHINA)
CHIAPETTA Frank	(AMERICA)	LI Xiaojie	(CHINA)
Francisco Mardones B	(CHILE)	LI Zhanjun	(CHINA)
GAO Wenxue	(CHINA)	LIU Dianshu	(CHINA)
GU Yicheng	(CHINA)	LIU Honggang	(CHINA)
GUAN Zhiqiang	(CHINA)	LIU Qian	(CANADA)
		Mckenzie Keith Cameron	(AUSTRALIA)



MOHANTY Bibhu	(CANADA)	WU Chengqing	(SINGAPORE)
Qon Hoe Sing	(MALAYSIA)	XIE Xianqi	(CHINA)
QU Guangjian	(CHINA)	XIONG Daiyu	(CHINA)
RICHARDS Alan B	(AUSTRALIA)	XU Tianrui	(CHINA)
Sergei D. Victorov	(RUSSIA)	XUE Peixing	(CHINA)
SPATHIS Alex	(AUSTRALIA)	YANG Jun	(CHINA)
SUMIYAA Ganjargal	(MONGOLIA)	YANG Ruilin	(AMERICA)
SUN Junpeng	(CHINA)	YANG Xusheng	(CHINA)
Terushige Ogawa	(JAPAN)	YU Yalun	(CHINA)
WANG Hao	(CHINA)	ZHANG Yongzhe	(CHINA)
WANG Minglin	(CHINA)	ZHANG Zhengyu	(CHINA)
WANG Xuguang	(CHINA)	ZHANG Zhengzhong	(CHINA)
WANG Yaohua	(CHINA)	ZHENG Bingxu	(CHINA)
WANG Zhongqian	(CHINA)	ZHOU Jiahan	(CHINA)

EDITORIAL BOARD

CHIEF EDITOR:

WANG Xuguang

EDITORIAL BOARD MEMBERS (in alphabetical order):

GAO Yintong	(CHINA)	WU Chunping	(CHINA)
GAO Wenxue	(CHINA)	XIE Xianqi	(CHINA)
GU Yicheng	(CHINA)	XU Tianrui	(CHINA)
GUAN Zhiqiang	(CHINA)	XUE Peixing	(CHINA)
LI Zhanjun	(CHINA)	YANG Jun	(CHINA)
LIU Dianshu	(CHINA)	YU Yalun	(CHINA)
LIU Honggang	(CHINA)	ZHANG Jingjing	(CHINA)
LIU Qian	(CANADA)	ZHANG Yongzhe	(CHINA)
SONG Jinquan	(CHINA)	ZHANG Zhengzhong	(CHINA)
WANG Hao	(CHINA)	ZHANG Zhengyu	(CHINA)
WANG Ke	(CHINA)	ZHENG Bingxu	(CHINA)
WANG Xuguang	(CHINA)	ZHOU Jiahan	(CHINA)
WANG Zhongqian	(CHINA)		

SECRETARIAT:

CUI Mingying ZHU Mingxiu

PREFACE

The Asian-Pacific region and Russia are the most active regions globally in the field of blasting engineering. There is no exaggeration to say that the development of blasting technology in the Asian-Pacific region and Russia is of far-reaching influence over the world.

In order to further promote the development of blasting industry in the Asian-Pacific region, China Society of Engineering Blasting successfully held the first Asian-Pacific Symposium on Blasting Technology on May 8-12th, 2007 in Kunming, China. The organizing committee unanimously acknowledged the success of the symposium and approved the motion of making the "Asian-Pacific Symposium on Engineering Blasting" into serial conferences. The Symposium will be held every two years and the second Asian-Pacific Symposium will still be held in China. The International Conference on Physical Problems of Rock Destruction was successfully held five times in Russia. I, together with other Chinese experts, was warmly invited to attend the Conference for several times. It has been decided that the Sixth International Conference on Physical Problems of Rock Destruction will be hosted by China Society of Engineering Blasting in the city of Dalian, China.

The Asian-Pacific Symposium on Engineering Blasting and the International Conference on Physical Problems of Rock Destruction are intended to strengthen the academic exchange and technological cooperation among various countries in the Asian-Pacific region and Russia, to enhance interdisciplinary penetration, to explore the opportunities, challenges and counter-measures faced by blasting technology and physical problems of rock destruction in the new century and to forecast the application prospects of blasting technology in various fields in a bid to jointly promote the development of blasting technology and physical problems of rock destruction in the world. The two conferences will offer valuable opportunities for experts, professors and engineers from the Asian-Pacific region and Russia engaged in industrial explosives, engineering blasting, rock destruction and other relevant fields to enhance understanding and cooperation. I hope and believe these two series international conferences will go ahead smoothly and successfully.

These two conferences have attracted intensive and extensive attention and support from various countries in the Asian-Pacific region and Russia including Chinese engineering blasting industry. The organizing committee has received more than 150 papers and finally accepted 120 after review by experts from China Organizing Committee, of which 57 papers are from other countries than China. These accepted papers will be published as symposium proceedings, covering a wide range of subjects



and presenting the leading technological innovations and achievements in industrial explosives, detonating facilities, rock fragmentation theory, physical problems of rock destruction, blasting vibration effect, blasting numerical simulation, blasting excavation, blasting demolition, blasting safety & management and others. At present, the deepening and spreading international financial crisis has an increasingly evident impact on global real economy. It has become a severe and imminent challenge for international community to promote and recover the world economy in the face of global financial crisis. Under such a circumstance, we believe these two conferences will further the development of industrial explosives and blasting technology not only in the Asian-Pacific region and Russia but also in the whole world, and also make new contribution towards a brighter future for human beings.

The two conferences are well prepared thanks to the great effort and effective work of the organizing committee composed of experts from various countries. Here I'd like to express my truly gratitude in particular to Dr. Liu Qian in Canada for his active support and assistance. Also I'd like to take this opportunity to convey my cordial appreciation to all the other experts both at home and abroad for their great effort and contribution.

Prof. Wang Xuguang

Chairman of the Organizing Committee of the 2nd Asian-Pacific Symposium on Blasting Technology

President of China Society of Engineering Blasting

Academician, China Academy of Engineering

May 18, 2009

Contents

1 General Review

Blasting Technology Scenerio in the Next Decade	
<i>Sushil Bhandari, Sourabh Sahay (India)</i>	3
An Overview of Instrumentation for Rock Blasting	
<i>LIU Qian (Canada)</i>	8
Scientific and Technological Advance of Rock Breaking by Blast in Russia	
<i>K.N. Trubetskoy, S.D. Viktorov, V.M. Zakalinsky (Russia)</i>	16
A Review of Current International Standards, Guidelines and Criteria for the Control of Airblast Overpressure from Blasting	
<i>Alan B. Richards, Adrian J. Moore (Australia)</i>	19
Danger Removal Technology by Blasting after Earthquake	
<i>SHI Fuqiang, CHAI Jian, WANG Jian, LIANG Zhenyu, ZHU Yong (China)</i>	23
Production of Emulsion Explosives in Russia	
<i>E.V. Kolganov, V.A. Sosnin (Russia)</i>	29
State of Production and Application of Current Explosives and Devices for Their Initiation in Serbia and World	
<i>Ivan Krsmanović, Slobodan Trajković, Dragan Jovanović (Serbia)</i>	33

2 Blasting Theory Research

Characteristics of Stress-wave Induced Fractures in Controlled Laboratory-scale Blasting Experiments	
<i>B. Mohanty and M. M. Dehghan Banadaki (Canada)</i>	43
Blasting Operations Information Management System	
<i>Sushil Bhandari, Akshat Bhandari (India)</i>	50
Rock Microstructure Disintegration in Case of Breakage by Blast	
<i>S.D. Viktorov, A.N. Kochanov (Russia)</i>	56
Study to Damage Effect of In-situ Stress Dynamic Unloading during Drilling and Blasting Excavation	
<i>YAN Peng, LI Xianchen, LU Wenbo, TANG Xiaojun, CHEN Ming, SHU Daqiang (China)</i>	60
Dynamic Caustics Analysis of Oblique Crack Propagation under Blast Loading	
<i>YANG Renshu, YUE Zhongwen, YANG Liyun, XIAO Tongshe, DONG Jucai (China)</i>	67
PPV Management and Frequency Shifting in Soft Ground Near Highwalls to Reduce Blast Damage	
<i>Ruilin Yang, Tamara Whitaker, Shawn Kirkpatrick (USA)</i>	72
Methods for Determination of Basic Characteristics of Explosives and Properties of Rocks for Development of Rational Parameters of Drilling and Blasting Operations	
<i>Kotlyashev A.A., Matorin A.S., Shemenyov V.G., Sinitzyn V.A. (Russia)</i>	84
Fine Particles in Experiments on Destruction of Rocks by Repeated Explosions	
<i>Adushkin V.V., Dubovskoi A.N., Pernik L.M., Popel S.I. (Russia)</i>	87
Failure Analysis and Its Numerical Simulation on Impact-damage Rock	
<i>GAO Fuqiang, YANG Jun, ZHANG Hua (China)</i>	90
Experimental Study on Rock Damage in Slope Cut by Presplit Blasting	
<i>YANG Nianhua (China)</i>	94
Failure Mechanism of Lignocellulosic Material under Explosive Load	



<i>DOU Jinlong, LIU Jinhui, WANG Xuguang (China)</i>	99
Advanced Profiling Technology	
<i>Robert McClure (USA)</i>	104
Deformation and Failure of Rocks within Limit and Beyond-limit Ranges	
<i>V.M. Zhigalkin, V.N. Semyonov, O.M. Usoltseva, P.A. Tsoi A.I., Chanyshv, I.L. Abdulin (Russia)</i>	110
Estimating and Forecasting the Parameters of Technogenic Faulting Zones Around Mine Workings	
<i>V.D. Baryshnikov, L.N. Gakhova (Russia)</i>	114
Meteorology & Airblast - Effects & Prediction	
<i>Alan B. Richards, Adrian J. Moore (Australia)</i>	118
Pressure on Wall of Hole and Destruction of Rock after Blasting of Water-decouple Charge	
<i>ZONG Qi (China)</i>	122
Effect of Explosion Waves on Wood Chips Stacked in a Closed Vessel	
<i>LIU Yunchuan, DOU Jinlong, LIU Liansheng, Wu Chunping, WANG Xuguang (China)</i>	126
The Pressure of Non-ideal Detonation Wave	
<i>L.G. Bolkhovitinov, S.D. Viktorov (Russia)</i>	133
Preliminary Analysis on the Broken Rock Zone of a Deep Mine Tunnel under the Influence of Moving Load Created by Blasting	
<i>XU Ying, SUN Yong, FU Jugen, ZONG Qi (China)</i>	138
Explosion Vessel for Simulating Exploding in Deep Water of Small Charge	
<i>ZHANG Li, YAN Shilong, SUN Yueguang, ZHANG Mingxiao (China)</i>	142
Stress Wave Energy Distribution in Solid Rock During Shothole Blasting	
<i>N.N. Kazakov, A.V. Shlyapin (Russia)</i>	147
Effect of Blast Shock on Luminescence of Diamonds	
<i>V.P. Mironov, I.F. Bondarenko (Russia)</i>	151
Experimental Research on the Mechanism of Reinforcing Soft Clay Ground by Blasting	
<i>ZHANG Zhiyi, MENG Haili, YANG Nianhua, XUE Li (China)</i>	155
<hr/>	
3 Physical Problems of Rock Destruction	
Resource Saving Strategy in the Process of Rock Disintegration	
<i>Goncharov S. A. (Russia)</i>	163
Dilatancy Mechanical Model for Strain and Failure of Rocks under Creep Conditions	
<i>Kovrizhnykh A.M. (Russia)</i>	167
Basic Types of Rock Destruction and Productivity of It	
<i>G.V. Sekisov, V.M. Zakalinsky, N.V. Zykov, A.A. Yakimov (Russia)</i>	170
Loss of Pit-wall Stability and Rock Failure around Mine Workings under Creep Conditions	
<i>Baryshnikov V.D., Kovrizhnykh A. M. (Russia)</i>	175
Research into the Strength and Deformation of Rocks in Conditions of Triaxial Inequicomponent Compression	
<i>Yu.V. Gorlov, S.E. Chirkov (Russia)</i>	178
Intensification of Minerals Disintegration in Autogenous Mills	
<i>Bortnikov A.V., Vaisberg L.A., Samukov A.D. (Russia)</i>	181
Rock Breaking and Main Aspects of Its Scale Application	
<i>G.V. Sekisov, S.D. Viktorov, Y. N. Reznik (Russia)</i>	188
Main Methods of Increasing Minerals Liberation Selectivity In Processes of Ore Preparation for Beneficiation	
<i>Vaisberg L.A., Bilenko L. F. (Russia)</i>	191
Dynamics Analysis on Sizing Crushing and Industrial Application of Sizing Crusher	
<i>PAN Yongtai (China)</i>	195
Influence of Ball Mill Operating Parameters on Grinding Effect	
<i>WEI Dezhou, LIU Wengang, CUI Baoyu, HAN Cong, YANG Hailong (China)</i>	200



Research on the Effects of Microwave Radiation to the Strength of Ore <i>LIU Quanjun, CHEN Huaqun (China)</i>	205
Ferruginous Quartzite Destruction under High Explosion and Magnetic Effect <i>V.N. Anisimov, V.N. Morozov (Russia)</i>	209
Analysis of Processes of Rock Disintegration and Man-made Seismic Activity Development. Methods of Control of Geodynamic Situation on Ore Mines of Talnashsky Copper-nickel Deposit <i>Tsirel S. V., Shabarov A. N., Mulev S. N., Zvezdkin V. A. (Russia)</i>	213
Criterion of Destruction Nanopores in A Coal Material Saturated by Sorbed Gas <i>Bobin V.A. (Russia)</i>	218
Combined Method of Coal Seam Softening <i>A.V. Dzhygrin, Yu.V. Gorlov, V.M. Buchatsky (Russia)</i>	223
Mechanisms of Coal Fracture Due to Sorbed Methane <i>Odintsev V.N. (Russia)</i>	227
Pre-split Blasting in Lead Zinc Mine to Maintain Stable Slopes <i>P. K. Singh, M. P. Roy (India)</i>	231
Theory of Multi-boundary Rock Blasting and Its Application <i>GAO Wenxue, LIU Yuntong (China)</i>	239
Research on High Bench Castblasting Techniques in Open-pit Mines <i>GAO Yintong, YANG Yungu, WU Chunping (China)</i>	243
Prediction of Damage Zone by Smooth Blasting in Jointed Mudstone Slope <i>LIU Fengzhou, XIE Xiongyao (China)</i>	248
Research of Controlling Rate of Fine Ores in a Big Quarry of Daily Output of 35000 m ³ of Specification Stones <i>XING Guangwu, ZHENG Bingxu (China)</i>	253
The General Pattern of Explosive Destruction of Rocks in Their Loosening in the Quarries <i>G.M. Kryukov, S.N. Zhavoronko (Russia)</i>	257
Peculiarities of Hole Blasting Applied in Induced Sublevel Caving <i>S.A.Kozyrev, A.V.Sokolov, K.N.Konstantinov, S.S.Pugachyov (Russia)</i>	260
Blasting Operations in Combined Geotechnologies <i>A.E. Frantov, Yu.P. Zhelunitsyn (Russia)</i>	265
The Increasing of the Fractured Explosion Effect on Rocks <i>E. Yefremov, V. Nikiphorova (Ukraine)</i>	268
Technological Problems of Iron Ore Mining in Siberia <i>A. Eremenko, D. V. Eremenko, S. Viktorov, V. Konyakhin, Ya. Baiborodov, V.Filippov, A. Pesterev (Russia)</i> ...	270
Explosion-thrown Dams in the Former Soviet Union <i>V.V.Adushkin (Russia)</i>	274
Key Technique of Precision Demolition Blasting of Water Retaining Rock-step in Hydroelectric Station Enlargement Project <i>XU Chengguang (China)</i>	279
Excavation Techniques for the Left Bank Spandrel Trough at Jinshajiang River Xiluodu Hydro Power Station (XHPS) <i>ZHAO Lin, GE Wenhui (China)</i>	284
Controlled Blasting Technology of Liner Demolition and Expanding Excavation for Shallowly Buried Tunnel Being Changed from Single-track to Double-track Railway Line under Complex Conditions <i>HU Guowei, HAO Siwang, CHENG Wenbing, ZHANG Junbing (China)</i>	290
An Applied Analysis of the Boulder Frequency Control in the Chamber Blasting of Hard Rockmass <i>XIAO Chun, ZHANG Jinbang, XIAO Bei, HUANG Hai, SONG Zhenguo, ZHANG Jinhua (China)</i>	296

4 Blasting Demolition

To Simulate the Demolition Blasting Collapse Process of Large-size Structures by Using SIm-dem



<i>XIE Xianqi, JIA Yongsheng, LIU Changbang, LIU Jun, LUO Qijun (China)</i>	303
Blasting Demolition and Numerical Simulation of Reinforced Concrete Tour Tower	
<i>XIE Chunming, YANG Jun, ZHANG Guangxiong (China)</i>	308
The Case Study of Explosives Demolition at Chung-Ang Department in Daejeon City	
<i>Hyung-Dong Min, Jong-Ho Park, Young-Suk Song, Hoon Park (South Korea)</i>	314
Study on the Key Technology for Cofferdam Demolition Blasting of Diversion Tunnel for Instant Flow	
<i>ZHAO Gen (China)</i>	329
The Demolition of High Hydraulic Structures by Non-destructive Directional Blasting	
<i>Qin Jianfei, Qin Ruxia (China)</i>	335
Technique Analysis of Controlled Blasting Demolition of Tianzhuangtai the Liaohe River Highway	
Big Bridge	
<i>SHI Fuqiang, YANG Xusheng, LI Wenquan, XUE Peixing, CHAI Jian, WANG Jian, LIANG Zhenyu (China)</i> ...	339
Study on the Collapse Mechanism and Parameters of Blasting Cuts of Directional Blasting Demolition	
of Cylindrical Buildings	
<i>YANG Xusheng, LING Qiuxiang, YAN Junwei, DONG Dekun (China)</i>	345
<hr/>	
5 Explosives and Initiation Technology	
Study on Optimum Powder Factor and Quality of Explosives in Surface Mines	
<i>Nabiullah, B.M.P. Pingua, Jagdish, K.L. Patel, A. Sinha (India)</i>	351
“Field of Dreams” A Testing Tool for Electronic Detonator Blasting System	
<i>G.Teowee (USA)</i>	358
A Fundamental Study on the Prevention of Occurrence of Channel Effect	
<i>Fumihiko Sumiya, Yoshikazu Hiroaki, Yukio Kato, Yuji Wada, Yuji Ogata, Kuniyama Katsuyama (Japan)</i>	363
The Key Technique of Highly Precise and Safe Delay Detonator without Primary Explosive	
<i>SHEN Zhaowu, MA Honghao (China)</i>	368
Production and Application of New Explosives at the Mining Enterprises of Kazakstan	
<i>B.R.Rakishhev, A.K. Bakhtin (Kazakhstan)</i>	374
Relationship between Pressure Desensitization and Sensitization Bubbles Content of Emulsion	
Explosives	
<i>WANG Yinjun, WANG Xuguang, YAN Shiliu (China)</i>	379
Study of the Effect of Particle Size Distribution on the Detonation Velocity of Modified ANFO	
<i>LIU Liansheng, WU Chunping, WANG Xuguang (China)</i>	384
Specific Features of Emulsion Explosives (EE) during the Development of Diamondiferous Deposits	
of Western Yakutia	
<i>I.F. Bondarenko, V.I. Khon (Russia)</i>	390
About Modern Systems of Blasting	
<i>V.V.Andreev, A.G.Ignatenko (Russia)</i>	396
Study about Effect of Particle Size and Gradation of Modified AN on the Sensitivity of Modified AN	
<i>LIU Liansheng, WANG Xuguang, WU Chunping (China)</i>	399
Study on Method of Explosive Power Test for Industrial Explosives	
<i>WANG Zhaozhong, WANG Xuguang, XIA Bin (China)</i>	403
Research on the Thermal Decomposition Kinetics of Powdery Emulsion Explosive	
<i>MA Ping, LI Guozhong (China)</i>	407
Principles and Methods for the Assessment of Hollow Charge Efficiency in Well Perforating Systems	
<i>Derzhavets A.S., Kutvin N.G., Dmitriev Yu.M, Lipchenko Yu.N. (Russia)</i>	411
Methods of Failure Diameter of Detonation Measurement	
<i>Kozak G.D., Raikova V.M., Aleshkina E.I. (Russia)</i>	414
Use of Nano-and Microtechnologies for the Improvement of Safety and Efficiency of Production and	
Application of Commercial Explosives	
<i>N.N. Efremovtsev, P.N. Efremovtsev (Russia)</i>	420



Research and Application on Composite Powder for Combustible & Expendable Charge Tube in Oil and Gas Wells	
<i>LI Senmao (China)</i>	425
The Application of Non-Electric Detonator Network Technology in Chamber Blast	
<i>HOU Yu (China)</i>	430
The Application of Electron Detonator during Blasting Demolition of Dockyard Cofferdam	
<i>WANG Zongguo, ZHANG Zhengzhong, SONG Zhiwei, CHEN Feiquan (China)</i>	435
Application Research on Conflagration Caused by Blast of High Explosive and the Technique of Stopping Conflagration Via Explosion Suppression	
<i>XUE Yongpeng, XUE Shaowei, JIN Guojie, ZHANG Wei (China)</i>	439

6 Special Blasting and Underwater Blasting

Preliminary Cutting Trials of Steel Cables and Rods Using Bulk Explosive Charges	
<i>Li Yumin, Ettore Contestabile, Don Wilson (Canada)</i>	449
Analysis of Microstructure of Explosive Welding of Ni-Ti Shape Memory Alloy	
<i>TONG Zheng, LIN Yulong, LI Jinfu, TONG Shujie (China)</i>	454
Explosive Cladding Weld of Titanium Clad Steel Plate	
<i>HOU Fachen, ZHANG Chao, REN Jiangyi (China)</i>	459
The Effects of Different Explosive Features on Titanium/Steel Clad Plate Interfacial Appearance	
<i>GUAN Shangzhe, LIU Runsheng, FAN Jiangfeng, CHE Longquan, FU Guanghui, WANG Xiaobing, JIANG Cheng (China)</i>	463
Explosion Synthesis for Nanometer Zinc Oxide	
<i>XIE Xinghua, ZHOU Huisheng, ZHU Jing, YAN Shilong (China)</i>	468
Application of Relieving Welding Residual Stresses by Means of Explosive Technique in Large Construction Projects	
<i>TAN Shengyu, LIU Guiqing (China)</i>	472
Blasting Technology for the Clay Layer within Steel Boxed Cofferdam under 20m Deep Water for Pier of Huaihe River Bridge	
<i>LIANG Renqun, FU Jugen, ZONG Qi (China)</i>	476

7 Blasting Vibration and Measuring

Discussion on the Calculation Equations of Collapse Vibration Velocity Caused from Blasting Demolition	
<i>ZHOU Jiahao (China)</i>	483
Characteristics of Ground Vibration Induced by Explosive Demolition and Its Effects on the Structural Response	
<i>Chang-Ha Ryu, Byung-Hee Choi, Ju-Hwan Jeong (South Korea)</i>	488
Blasting Vibration Test and Its Analysis in Demolition Blasting of Liaoning Provincial Gymnasium	
<i>LI Guichen, WANG Minglin, YANG Xusheng (China)</i>	494
Research on Vibration Characteristics of Precision Initiation in Longhole Bench Blasting	
<i>ZHAO Gen (China)</i>	500
Analysis of Control Blast-induced Vibration & Practice	
<i>WEI Xiaolin, ZHENG Bingxu (China)</i>	506
Blasting Vibration Signal Comparative Analysis Based on Wavelet and Wavelet Packet Technology	
<i>XIE Quanmin, LONG Yuan, ZHONG Mingshou, LI Xinghua (China)</i>	513
Study to the Blasting-induced Vibration Monitored in High In-situ Stress Area by Wavelet Analysis	
<i>YAN Peng, LU Wenbo, CHEN Ming, SHU Daqiang (China)</i>	520
Time-frequency Characteristics Extracting and Analysis of Blasting Seismic Wave Based on the Wavelet Packet Transform	
<i>YAN Junwei, YANG Xusheng, LIANG Qiuxiang, DU Fugui (China)</i>	528



Numerical Modeling of Seismic Effects on Underground Structures	
<i>Kovalsky E. (Russia)</i>	534
A Study on Cumulative Effect of Production Blast Vibration on Slope Failure in Xiaolongtan Coal Mine	
<i>YANG Yi, WANG Guohua, ZHANG Zhiyu, WANG Shiwen, LI Xianglong (China)</i>	538
Application Study on Vibration Monitoring and Control Technique of Deep-hole Blasting nearby Buildings	
<i>ZONG Qi, WANG Haibo, LIANG Renqun (China)</i>	542
Research on Blasting Vibration Regionalization and Blasting Seismic Wave Propagation Characteristics	
<i>CHEN Shihai, WEI Haixia, ZHANG Zihua, BI Weiguo (China)</i>	547
The Monitoring of Vibration Effects Caused by Blasting Demolition of the Boiler Room under Complex Environment	
<i>CHANG Rui, XU Ying, ZONG Qi (China)</i>	551
Shallow Hole Blasting Vibration Spectral Analysis	
<i>CHEN Chao, YAN Guobin, ZHANG Yabin (China)</i>	556
Numerical Analysis of Collapse Vibration In Building Blasting Demolition	
<i>LIU Wei, LIU Feng (China)</i>	560
Research of the Relationship between Hypersonic Changing and Rule of Blasting Vibration Velocity Decayed	
<i>FEI Honglu, ZHAO Xinpu (China)</i>	564
Analyzing the Slumping Process of the Cooling Tower by Analyzing Blasting Vibration Wave in Actual Measurement	
<i>LIU Yi, FU Jianqiu, WEI Xiaolin (China)</i>	568
Experimental Study on the Stability of the Computer's Hard Drive under Blasting Vibration	
<i>TIAN Yunsheng, XIE Wenli (China)</i>	574

8 Blasting Safety

Standardization of Blast Vibration Damage Threshold for the Safety of Residential Structures in Mining Area	
<i>P. K. Singh, M. P. Roy, A. Sinha (India)</i>	581
Blasting Technologies for Special Operations Aimed at the Prevention and Mitigation of Emergencies	
<i>A.I. Goncharov, A.S. Derzhavets, V.I. Kulikov, A.A. Filchakov (Russia)</i>	590
Study to Technology of Rock-burst Prevention and Treatment Based on Controlled Blasting	
<i>YAN Peng, LI Tianbin, LU Wenbo, CHEN Ming, SHU Daqiang (China)</i>	596
Safety Analysis of Large Section Roadway Heading Blasting and Improve of Blasting Network	
<i>LI Lingchun (China)</i>	603
Determination of Gas Hazard from Modern Industrial Explosives	
<i>Kozyrev S.A., Vlasova E.A., Sokolov A.V. (Russia)</i>	607
Numerical Analysis of Explosion Growth from Hot Spot in Liquid Explosive	
<i>A.V. Dubovik (Russia)</i>	611
Mechanism Analysis of Detonating Electric Detonator and Exciting Shoch-conducting Tube by Human Body Electrostatic Discharge and Its Preventive Measures	
<i>DONG Wengeng, CHE Wencai, XIE Zenglin (China)</i>	614
Ammonium Nitrate Safety	
<i>E.V. Kolganov, V.A. Sosnin (Russia)</i>	619

General Review

Blasting Technology Scenerio in the Next Decade

Sushil Bhandari¹, Sourabh Sahay²

(1. Earth Resource Technology Consultants, Jodhpur, India; 2. Deepak Fertilisers and Petrochemicals Corporation Limited, Pune India)

ABSTRACT: There have been several developments in blasting technology during the recent past. Many of these are in beginning stages of experimentation and improvement, which would be applied in increasing number of operations during the next decade. Drills have been developed to obtain information about geotechnical and rock quality characterization and this information would be used in improving design of drilling pattern, charging with explosives and sequencing of blast holes would become more common. Increasing blast result assessment techniques would be applied and which would then lead to increasing mine to mill integration. There would be greater awareness of safety & environmental norms and increasing prediction and controlling tools would need to be applied. Security of explosives would become an important issue and responsibility on all those involved in storage and usage would increase.

KEYWORDS: blasting;drilling information;blast design;result analysis;security

1 INTRODUCTION

The essential elements of hard rock mining technology have not changed much during the 20th century. Rock blasting is, and in the next decade it will still be, the principal method for breaking strong rock. However, blasting is an imprecise tool. Blasting makes it difficult to control the sizes of the rock fragments, it produces damage to the walls of the excavation, it causes difficulties in mining accurately to a given boundary, it imposes several environmental concerns (fumes, dust, noise, and vibration), and it is hazardous. Mines have also to ensure that they comply with strict regulatory regime and face increasing public outcry against damage to the environment. During the next decade it is expected that many of these problems would be overcome and there would be greater control on blasting operations and their results by better designs using computer simulations, improved executions of blasts, explosive placement, security and environmental controls. Blasting operations would be of bigger sizes and with emphasis on safety aspects. Increased integration with information technology will also improve blast optimization capabilities through in-field measurement, reporting of muck loading information and blast results such as particle size, heave, and distribution. Also there would be greater need for security of explosives—storage, transportation and usage.

2 IMPROVED BLAST DESIGN

Several rock blasting models of exist today^[1]. These models predict factors such as the rock fragmentation (i.e.

the size distribution of the broken rock), the throw of the broken rock (i.e. the shape of the muckpile), the extent of damage to the excavation walls, and the magnitude of ground vibrations.

However, blasting models find limited use in current mining operations for two reasons. One, because they need to be calibrated for specific sites and two, because, at best they provide only a rough guide to blast design and to the blasting outcomes. The problem is that the models need accurate information on the behavior of the explosive charges, the sequential timing of these charges, and the properties of the rock mass. Detailed information is available on the first two of these required input parameters. Unfortunately, the information on the rock properties is incredibly poor. This is a difficult problem because in mines often the rock mass properties change significantly not just between adjacent benches (or adjacent stopes) but between adjacent holes.

Clearly a solution to this problem will require the measurement of rock properties in each blasthole. It is believed that in the coming decade these measurements will be made as a routine part of the drilling process. Already today manufacturers are marketing drills that monitor data such as: drilling rate, torque, and thrust. Software is starting to be developed to interpret rock property information from these data. This is a significant step forward from the common position today where almost no information is gathered from blastholes (other than assaying of drill cuttings). This is extremely wasteful. Production drilling is an important and expensive operation in many mines. For a relatively small increase in cost the data gathered during