Australian Institute of High Energetic Materials
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High Energy Rate Technologies

Workshop for Intensive Professional Development of Engineers and Engineering Technologists

Workshop Guide

2009/2010

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Content

Workshop Outline

Workshop synopsis

This unit conveys the fundamentals of high energy rate technologies for forming, welding, hardening, cutting, compaction of powders, synthesis of new materials and structures, etc. The main relations for calculating technological parameters are given. Modern methods for generating shock waves in condensed matters and devices for conservation of shock-compressed substances are considered. The basic concepts and models of explosion physics and response of condensed matter under shock wave loading are given. An insight is given to the main types of industrial high explosives. The unit provides solutions to many practical engineering problems.

Learning outcomes

At the conclusion of the workshop, students will be able to:

1. Apply acquired knowledge of the areas of high energy rate technologies in industry.
2. Understand main modern means of generation of shock and compression waves in condensed matter.
3. Know and understand main concepts of physics of explosion and shock waves.
4. Learn and use relations for calculations of response of condensed matter under shock-wave loading.
5. Design and develop schemes for high energy rate production technologies.
6. Apply consistent relations and algorithms for calculations of base technological parameters of explosive forming, welding, hardening, cutting, compaction of powders, polymorphic transformations and phase transitions.
7. Know main kinds of industrial high explosives and its peculiarities for using in explosion technologies.
8. Know main means for initiation and translation of detonation.
9. Represent applications of high energy rate technologies in mining, military industry etc.

Continuing Professional Development (CPD) policies of Engineers Australia[1]

Continuing Professional Development (CPD) is essential to maintaining up-to-date technical skills and knowledge of processes, technology and legislation. CPD enables engineers to attain and maintain Chartered Status[2] within the Engineers Australia[3].

CPD activities recognised by the Engineers Australia include[4]:
"Short courses, workshops, seminars and discussion groups, conferences, technical inspections and technical meetings, including Engineers Australia meetings, where these are delivered or facilitated by recognised practitioners in the field"

CPD does not have to be obtained through Engineers Australia, however, short courses/workshops/conferences/technical meetings, etc., count towards CPD if these courses, etc., are delivered or facilitated by recognised practitioners in the field[5].

CPD Requirements[6]:

Chartered Professional Engineers, Chartered Engineering Technologists and Chartered Engineering Officers should be aware of their obligation under Bye-law 24 of the Royal Charter to meet the Continuing Professional Development Policy.

Objectives

CPD activities are to extend or update a practitioner's knowledge, skill or judgement in their area of or areas of practice and enable them to:
- maintain technical competence;
- retain and enhance their effectiveness in the workplace;
- be able to help, influence and lead others by example;
- successfully deal with changes in their career; and
- better serve the community.

Minimum and Specific Requirement

A practitioner's CPD records must document a minimum of 150 hours of structured CPD over a three-year period. For all practitioners, of the 150 hours:
- at least 50 hours must relate to the practitioner's area(s) of practice;
- at least 10 hours must cover risk management;

[1] Continuing Professional Development, Engineers Australia, online: http://www.engineersaustralia.org.au/education/continuing-professional-development/continuing-professional-development.cfm (last visited on 28.08.2009)
[2] Chartered Status represents:
- the highest standards of professionalism;
- leadership;
- up-to-date expertise;
- quality and safety; and
- the ability to undertake independent practice.

[3] Ibid.
[4] Ibid.
[5] Ibid.
[6] Ibid.

- at least 15 hours must address business and management skills; and
- the remainder must cover a range of activities relevant to the practitioner's career & interests.

For engineering academics and teachers; in addition to the 150 hours, practitioner's must demonstrate at least 40 hours industry involvement in any three-year period. (If the industry involvement satisfies the other CPD criteria, it may be included as part of the submitted CPD hours. Otherwise, the industry involvement is an additional requirement.).

Compliance of the Workshops for Intensive Professional Development organised by the Australian Institute of High Energetic Materials with the CPD policies of Engineers Australia

The Workshops for Intensive Professional Development organised by the Australian Institute of High Energetic Materials fully comply with the CPD policies of Engineers Australia:

- The workshops are organised and delivered by an internationally recognised group of scientists. A minimal requirement to deliver a workshop within the Australian Institute of High energetic Materials is a possession of a Postgraduate Degree and at least 3 years of industrial practice. Most of our lecturers are Visiting Professors from the best internationally recognised universities. All Visiting Professors are Doctors of Philosophy and/or Science with decades of successful scientific, engineering and educational career behind them;
- The objectives of the workshops are to provide the participants with in-depth knowledge and top level technical competence in their area of professional activities. In most cases, the topics of the workshops are not covered in any of the undergraduate university courses in Australia;
- The teaching material is well supported with practical examples; it aims improvement of the business and management skills of the participants, and whenever it is necessary, it covers areas of risk management;
- In average, Workshops for Intensive Professional Development can contribute with 40 to 70 hours to the CPD records of the participants. Whenever it is in a reasonable conjunction with the main teaching material, 10-15% of the time is spent on topics that aim improvement of the business and risk management skills of participants.

Workload

Lectures	From Day 1 to Day 10 4 hours daily (Monday to Friday. 9:00-13:00) Total: 40 hours
Tutorials	From Day 1 to Day 9 3 hours daily (Monday to Friday 14:00-17:00) Total: 27 hours
Assignments, tests	3 hours
Private study	Lecture revisions and additional research and reading
Total	70 hours

Workshop prerequisites

Diploma or BSc in Mechanical or Mining Engineering.

Continuous improvement

Australian Institute of High Energetic Materials strives for the highest possible quality in teaching and learning. To monitor how successful the Institute is in providing quality teaching and learning we regularly seek feedback from our students and staff.

Feedback is welcome at any time throughout the duration of the workshop. A Workshop Evaluation Survey will be carried out at the end of the workshop. Students are strongly encouraged to complete the survey as it is important tool to improve the quality of teaching. The feedback is anonymous and provides the Institute with evidence of aspects that students are satisfied and areas that need improvement.

Teaching and Learning Method

The workshop consists of 40 hours of lectures and 27 hours of tutorials distributed in 10 working days. Enrolment in this workshop requires full time commitment of the students. Students are required to attend all lectures and to participate in the tutorial sessions. There will be an assignment to complete after each tutorial. These assignments will be marked at the end of the sessions, and every assignment will contribute with 5% to the final marks. A final 2 hour test will be carried out at the end of the workshop. The final test will contribute with 55% to the final marks. To achieve a pass in the workshop, students must achieve an overall mark of 50% or above. A **Proficiency Certificate**[1] will be issued to those students who have successfully completed the workshop.

Workshop allocation

The workshop will be carried out in the lecture theatres of Monash University in Clayton, Victoria.

Workshop Resources

Prescribed text(s) and readings

1. I.A. Balagansky, High Energy Rate Technologies. - Lectures Notes, Novosibirsk State Technical University, 2010.
2. Shock-Wave Phenomena and the Properties of Condensed Matter / G.I. Kanel, S.V. Razorenov, V.E. Fortov.- Springer-Verlag New York Inc., 2004.- 321 p.p.
3. Explosive Compaction of Powders and Composites / R.A. Pruemmer, T. Balakrishna Blat, K. Siva Kumar, K. Hokamoto.- Science Publishers, 2006.- 194 p.p.
4. Roger Cheret, “Detonation of Condensed Explosives”, Springer-Verlag, New York, (1994).
5. P. A. Persson, R. Holmberg, J. Lee, “Rock Blasting and Explosive Engineering”, CRC Press, Boca Raton, Florida (1994).
6. C. L. Mader "Numerical Modelling of Explosives and Propellants", CRC Press (2007).

[1] A Proficiency Certificate is a type of professional certificate issued by the Australian Institute of High Energetic Materials, which reflects on specialised knowledge and skills attained in the Workshops. A Person can obtain a Proficiency Certification by completing the following requirements: (i) meeting full time attendance requirements; (ii) completing all tests and assignments scheduled for the Workshop; and (iii) successfully passing the final exam.

Workshop schedule

Day	Lecture	Tutorial
GENERATION OF SHOCK WAVES IN CONDENSED MATTER		
1	1. Powder and light gas guns (powder guns, light gas guns, and ballistic shock tubes). 2. Explosion projection devices (throwing by means of cylindrical high explosive charges, layered throwing systems, explosion conical generators). 3. Explosion projection devices (throwing by sliding detonation, systems using implosion principle, explosion tubular accelerators). 4. Electric and electromagnetic accelerators (electric guns, railtron accelerators, Magnet-cumulative generators).	1. Viewing and discussion of movie on mining applications of high energy rate technologies (Mining technologies of Dyno Nobel). 2. Viewing and discussion of movie on military applications of high energy rate technologies (Russian Arms, Nigny Tagil). 3. Viewing and discussion of movie on military applications of high energy rate technologies (Nuclear weapons, Sarov).
2	5. Application of sources of radiation for generation of shock waves in solid bodies. 6. Devices for conservation of shock-compressed substances (Planar dynamic loading, cylindrical dynamic loading, Spherical squeezing of preservation ampoules).	4. Discussion on topic of using areas of the methods for generation of shock waves in condensed matter. 5. Discussion of advantages and disadvantages of the methods for generation of shock waves in condensed matter. 6. Calculation of parameters of devices for conservation of shock-compressed substances.
RESPONSE OF CONDENSED MATTER UNDER SHOCK-WAVE LOADING		
2	7. Shock wave and rarefaction wave, shock adiabatic curve and Riemann’s isentrope (uniaxial isentropic flows). 8. Shock wave and rarefaction wave, shock adiabatic curve and Riemann’s isentrope (shock waves).	

3	9. Shock wave and rarefaction wave, shock adiabatic curve and Riemann's isentrope (decomposition of discontinuities and wave interactions). 10. Shock wave and rarefaction wave, shock adiabatic curve and Riemann's isentrope (generation of negative pressures during reflection of a compressive pulse from a plate surface, spall fracture) 11. Shock wave and rarefaction wave, shock adiabatic curve and Riemann's isentrope (elastic-plastic response of solids under shock-wave loading). 12. Explosion and Detonation, Theories of Chapman-Jouguet and Zel'dovich-von Neumann-Döring (general structure of plane steady detonation waves).	7. Discussion of lecture materials. 8. Discussion of lecture materials. 9. Discussion of lecture materials.
4	13. Explosion and Detonation, Theories of Chapman-Jouguet and Zel'dovich-von Neumann-Döring (general structure of plane steady detonation waves). 14. Explosion and Detonation, Theories of Chapman-Jouguet and Zel'dovich-von Neumann-Döring (detonation failure diameter). 15. Explosion and Detonation, Theories of Chapman-Jouguet and Zel'dovich-von Neumann-Döring (Initiation of detonation by shock waves). 16. Explosion and Detonation, Theories of Chapman-Jouguet and Zel'dovich-von Neumann-Döring (Initiation of detonation by shock waves).	10. Calculations of main parameters of shock and rarefaction waves in condensed matter. 11. Calculations of main parameters of detonation waves. 12. Discussion on topic of detonation initiation by shock and compression waves, sensitization and desensitization of high explosives.
HIGH ENERGY RATE TECHNOLOGIES		

5	17. Historical review and modern status of methods of explosive processing (historical review). 18. Historical review and modern status of methods of explosive processing (modern status of methods of explosive processing). 19. Historical review and modern status of methods of explosive processing (examples of use of explosion energy in the industry). 20. Historical review and modern status of methods of explosive processing (other applications of explosion).	13. Discussion of lecture materials. 14. Discussion of lecture materials. 15. Discussion of lecture materials.
6	21. Explosive forming (basic concepts and schemes). 22. Explosive forming (action of underwater explosion onto metal sheet). 23. Explosive forming (calculation formulae of base technological parameters). 24. Explosive forming (calculation formulae of base technological parameters)	16. Calculations of main technological parameters of explosion forming. 17. Calculations of main technological parameters of explosion forming. 18. Calculations of main technological parameters of explosion forming.
7	25. Explosive welding (basic concepts and schemes). 26. Explosive welding (choice of technological parameters, account of losses of energy at detonation). 27. Explosive welding (influence of parameters of welding on the quality of connection). 28. Explosive welding (modern methods and schemes).	19. Calculations of main technological parameters of explosive welding. 20. Calculations of main technological parameters of explosive welding. 21. Calculations of main technological parameters of explosive welding.
8	29. Explosive hardening (basic concepts and schemes, planar waves, sliding waves). 30. Explosive hardening (mechanisms of explosive hardening). 31. Explosive cutting (extended shaped charges, covering charges, Detonating cords). 32. Explosive compaction of powders (direct shock pressing).	22. Calculations of main technological parameters of explosive hardening. 23. Calculations of main technological parameters of explosive hardening. 24. Calculations of main technological parameters of explosive cutting.

9	33. Explosive compaction of powders (key parameters of explosive compaction). 34. Explosive compaction of powders (bonding mechanisms). 35. Chemical reactions in a shock wave, polymorphic transformations and phase transitions in shock-compressed solids (diamond synthesis, synthesis of cubic boron nitride). 36. High Explosives for high energy rate technologies (classification and application areas of explosives).	25. Calculations of main technological parameters of explosive compaction of powders. 26. Calculations of main technological parameters of explosive compaction of powders. 27. Calculations of main technological parameters of explosive compaction of powders.
10	37. High Explosives for high energy rate technologies (classification and application areas of explosives). 38. High Explosives for high energy rate technologies (main kinds of high explosives for industrial application and its parameters). 39. Means for initiation and translation of detonation 40. Computer modelling of explosion and shock waves.	Final tests (3 hours)