

Conference on Asset and Maintenance Management (CAMM) 2011

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Welcome address from Conference Chairs

Dear Participants, sponsors, delegates and committee members

Welcome to the second Conference on Asset and Maintenance Management (CAMM2011) in Gladstone on 18 March, 2011.

This conference aims to showcase some of the latest developments in this field to bring practitioners up-to-date with knowledge in these areas and show how CQUniversity Australia can help provide solutions to asset management and maintenance problems. Those who could be benefited by this conference are:

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|------------------------|-------------------------------------|
| ▪ Practitioners | ▪ Professional Bodies |
| ▪ Maintenance Planners | ▪ Suppliers |
| ▪ Engineers | ▪ Business Managers |
| ▪ Superintendents | ▪ Health and Safety Officers |
| ▪ Technicians | ▪ Environmental Officers |
| ▪ Engineering Managers | ▪ IT Professionals |
| ▪ Asset Managers | ▪ Operations Research Professionals |
| ▪ Accountants | ▪ Academics |
| ▪ Consultants | ▪ Students |
| ▪ Contractors | |

The technical sessions include presentations from national and international experts on:

- Power plant asset and maintenance management
- Rail asset and maintenance management
- PAS55
- Quantitative techniques for assessing risks and performance improvement,
- Asset Management Information Systems.

The conference will also include a panel discussion on challenges and issues confronting industry in the area of asset and maintenance management. The conference will conclude with a networking session. There is workshop on 17th March from 1-5pm. The third Conference on Asset and Maintenance Management CAMM2012 to be held at Gladstone in March 2012. We hope you all enjoy the second Conference on Asset and Maintenance Management (CAMM2011) and find it useful.

Regards

Gopinath Chattopadhyay (chair), Head of Engineering Post Graduate Programs

Malcolm Leinster, Adjunct Professional Fellow CQUniversity Australia (co-chair) and

Glenn Schumacher (Shoey), General Manager, NRG Gladstone Operating Services (co-chair)

PELM, Gladstone Campus.

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Technical committee

Richard Clegg, CQUniversity(Chair)
Gopi Chattopadhyay
Malcolm Leinster
Subhash Sharma
Rosa Kalantary-Baker
Peter Barnwell
Patrick Keleher
Mick Rudge
Deryk Anderson
Sharyn Grant
Kerry Simper

Organising committee

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Gopi Chattopadhyay
Malcolm Leinster
Richard Clegg
Patrick Keleher
Rosa Kalantary-Baker
Joanne Simper
Tracey Elliott
Christelle Catuogno
Sue Oakley
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Operating Services
Ben Hayden, NRG Gladstone Operating Services
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Kerry Simper RioTinto
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Deryk Anderson, Consultant / CQUniversity
Roza Kalantary-Baker, Consultant /
CQUniversity
Don Cameron, CS Energy
Ron Elliott, Downer EDI
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Masud Khan , CQUniversity

Student Committee

Md Gyas Uddin
Ajay Desai
Pubudu Warusamanna

Major Sponsors and Supporting Organisations

NRG, Gladstone (Platinum)
QAL, Gladstone (Platinum)
Fluor Australia (Silver)
CQUniversity (Gold)
CRC for Rail Innovation (Silver)
Asset Management Council (Afternoon Tea)
Engineers Australia, Gladstone (Supporting)
Comadem International (Supporting)
Australian Society of Operations Research
(Supporting)

Conference on Asset and Maintenance Management (CAAM) 2011

CQUniversity, Australia – Gladstone Campus, Leo Zussino Building.

Friday 18 March, 2011

8:30 – 9:00 Registration

9:00 – 10:30 Session 1

9:00 – 9:05 Welcome – Prof. Gopinath Chattopadhyay

9:05 – 9:10 Official Opening: Professor Scott Bowman, Vice-Chancellor and President, CQUniversity

9:15 – 10:00 Speaker 1 and 2 – Glenn Schumacher, Ben Hayden

Gladstone Power Station - Gladstone Power Station – Strategic Budgeting using Asset Management Principles

10:00 – 10:30 Speaker 3 – Mick Rudge, The role of the supervisor in changing organisational culture

10:30 – 11:00 Morning Tea

11:00 – 12:30 Session 2

11:00 – 11:30 Speaker 4 – Ajay Kapoor, Rail and Wheel life management

11:30 – 12:00 Speaker 5 – Ian Telford, Rail Asset Management in QRNational

12:00 – 12:30 Speaker 6 and 7 – Gopi Chattopadhyay and Malcolm Leinster

Continuing Development of Courses in Asset Management

12:30 – 13:30 Lunch and Poster Session

13:30 – 15:45 Session 3

13:30 – 14:15 Speaker 8 – John Abbott “Asset Productivity Improvement: Experience is a marvellous thing!”

14:15 – 14:45 Speaker 9 – Rob Lupton, Tarong Asset Management Systems (TAMS)

14:45 – 15:15 Speaker 10 – Peter Kohler, ISO Asset Management Standard:

Current status of draft and what is expected in the future

15:15 – 15:45 Afternoon Tea

Session 4

15:45 – 16:15 Speaker 11 – Government, Industry Presentation: Impact of extreme weathers on assets: How to reduce risks

16:15 – 17:00 Panel Discussion – Facilitated Session

Excellence in the Areas of Asset and Maintenance Management

17:00 – 17:05 Summary, close, next conference, vote of thanks

By: Co-Chair: Malcolm Leinster

17:05 – 18:30 Networking Events (in the foyer of LZB Building)

Workshops

Thu 17th March 2011

Session A: Rail: Chair: Prof. Colin Cole

1:00 – 1:15 Registration

1:15 – 2:15 Session 1: Ajay Kapoor: Rail wheel contact mechanics

2:15 – 2:35 Session 2: K Ding, A Kapoor: Modelling Crack Initiation in Rail Subjected to Low Cycle Rolling Contact Fatigue

2:35 – 2:55 Session 3: Nirmal K Mandal: Ratchetting of railhead material: an idea to improve its fatigue life

2:55 – 3:15 Session 4: I. Salehi, P.J. Mutton, A. Kapoor: The influence of geometrical features on the probability of fatigue crack initiation in Aluminothermic welds.

3:15 – 3:30 Tea break

Session B: Maintenance

Co-Chair: Nirmal Mandal

3:30 – 3:50 Session 5: A.M. Sri Asih, K. Ding, A. Kapoor: Modelling rail wear transition and mechanism due to frictional heating

3:50 – 4:10 Session 6: Sagheer Ranjha, Kan Ding, Ajay Kapoor: Mechanical Response of Railhead Influenced by Wheel Rail Contact Conditions

4:10 – 5:00: Discussions, Questions and collaborations

Session C: Maintenance

Chair: Subhash Sharma

3:15 – 3:30 Registration

3:30 – 5:00 Tutorial on Maintenance Strategy (For PG MM Students and Practitioners)

Presenter: Mick Rudge

The tutorial will provide an overview of the Maintenance function and how the maintenance strategy can be developed. It will show where the equipment life plans fit the model and discuss the suitability of different strategies, such as Run to failure, Fixed time maintenance, Condition based maintenance, Design out maintenance, Top Down Bottom UP (TDBU) Reliability Centred Maintenance (RCM) Total Productive Maintenance (TPM). It covers how to measure the effectiveness of current strategies and decide on the optimum equipment life plan strategies.

Conference on Asset and Maintenance Management (CAMM 2011)

Title and abstracts for Technical sessions

Speaker 1 and 2, Title: Gladstone Power Station – Strategic Budgeting using Asset Management Principles

Glenn Schumacher

Glenn (Shoey) Schumacher is the General Manager of NRG Gladstone Power Station (Queensland's largest power station) and is a Director of NRG Gladstone Operating Services Pty. Ltd. He has held a number of roles in not only the Power Industry but also across a number of heavy industries and manufacturing in locations from Bernie, Tasmania to Gladstone, Queensland. Those roles have included the fields of maintenance, production and engineering / technical services. Glenn has a particular passion and interest in milling (pulverising) plant and processes. Glenn is the current Chairman of the Gladstone Industry Leadership Group (GILG).



He holds a Bachelor Engineering – Mechanical (*UTS*), Master of Engineering – Power Generation (*UQ*), Master of Business Administration (*Deakin*), Graduate Certificate of Human Resource Management (*USQ*). Glenn is a Fellow of the Institute of Engineers Australia, a Chartered Professional Engineer, a NPER3 Registered Engineer, a Registered Professional Engineer - Queensland, a Member of The College of Mechanical Engineering, a Member of the Institute of Energy Australia, an Associate Fellow of the Australian Institute of Management, and a Member of The Australian Institute of Company Directors. Shoey is Engineers Australia 2010 Queensland Professional Engineer of the Year.

Speaker 1, 2, Title: Gladstone Power Station – Strategic Budgeting using Asset Management Principles

Safety in modern industry relies on many elements including and not limited to business systems & processes, human factors & behaviours and plant integrity & condition. The aging Australian power generation fleet will become increasingly reliant on ensuring plant integrity and condition is managed, to minimise risk exposure to the Operator and personnel on site. Asset Management has a key role to play in ensuring plants can economically and safely operate up to and beyond their original design life. This paper will discuss the balance between economics and safety in asset management at Gladstone Power Station.

Ben Hayden



Ben Hayden is the current Manager Technical Services at Gladstone Power Station, where he is responsible for the overall NRGGOS Asset Management System and provision of site engineering services. Ben commenced his career as a Graduate Mechanical Engineer with AUSTA Electric at Tarong Power Station. After almost 2 years, a brief rotation to Swanbank Power Station was followed with an appointment as the Turbine Area Engineer at CS Energy's Callide Power Station. Over a period of 10 years, Ben worked in several positions including Production and Technical Services Superintendent. In 2006, Ben moved to Gladstone Power Station as Mechanical Engineer Technical Support, before advancing into the role of Asset Management Specialist and more recently, Manager Technical Services. A University of Queensland graduate and Registered Professional Engineer of Queensland (RPEQ), Ben also has completed a MBA (Technology Management), the Masters of Engineering (Power Generation) with CQU and is a Certified Senior Practitioner in Asset Management. A passion in most things Power Generation, a power station background combined with interest in maximising plant life and ROI provides a sound platform on which Ben oversees the application of PAS55 and various asset management tools at Queensland's largest power station.

Speaker 3, Title: The role of the supervisor in changing organisational culture

Changing organisational culture is extremely important and at the same time very complex process. This paper is based on extensive survey originally conducted to gain an understanding of whether or not the factors required for a motivated work force were in place in the organisation. This was needed for an audit of the company the participants were working and analysing impact of proposed restructure. Results were analysed and the result revealed that the elements missing or being performed poorly are in the control of the 1st line supervisor. Real life data from industries are collected and analysed for research findings to be useful for managerial decisions.

Mick Rudge



Michael (Mick) Rudge currently works as maintenance organisation consultant, trainer and mentor to Australian organisations. He has had over 25 years experience in the management of industrial assets and maintenance as a practitioner, manager and consultant across a variety of industries including, manufacturing and food processing. Mick comes from mechanical engineering area by profession. Trained and worked as a fitter then leading hand at Gordon Edgell Pty Ltd. In 1988 he moved to Masterfoods Australia and worked as a Technician, Planner, and Reliability Engineer. On the completion of Masters Degree in Maintenance Management at CQUniversity in 2000 Mick became Maintenance Manager. He then moved into a production shift manager's role with responsibilities for both production and maintenance outcomes until 2006. He then took up a position as Maintenance Manager at International Sea Product's. He has been working as a Maintenance consultant and lecturing in Maintenance Organisation and Auditing in the Maintenance Management Program at CQUniversity Australia. During this time he has been heavily involved in or responsible for the development of a maintenance systems and equipment life plans, the introduction of Computerised Maintenance Management Systems (CMMS) and numerous restructurings of major organisations. He is a regular speaker and presenter on asset and maintenance management at national forums and has presented papers in conferences in the area of "Computerised Maintenance Management systems" and Total Quality Management". Mick is an active consultant in these fields, assisting clients with the improvement of their organisational issues to achieve their business objectives.

Speaker 4, Title: Rail and Wheel life management

Rail and wheel undergo repeated traversals of contact load, which causes failure in the form of wear and rolling contact fatigue. Repeated loading subjects the sub-surface material to a cycle of stress and depending on the intensity of this stress the material may remain elastic, or produce plastic flow in each load pass. The continuous improvement in operational efficiency means that the system is always operating at the limit and plastic flow at each load pass becomes inevitable. The material fails and produces wear debris and crack-like flaws, which grow due to repeated elastic loading of the rail and wheel. If not checked the possibility of a rail fracture and derailment is very real - such accidents in the past have caused loss of life and serious financial penalty for the company. The talk will review recent scientific thinking on this problem. Remedies which several rail operators around the world use will also be discussed.

Ajay Kapoor



Professor Ajay Kapoor is Associate Dean - Research at the Faculty of Engineering and Industrial Sciences at Swinburne University, and a member of the Council (the university governing body). He holds an Adjunct Professorship at Central Queensland University. Prior to joining Swinburne in Aug 2007, he held a professorship in the School of Mechanical and Systems Engineering at Newcastle University, UK and was Deputy Director of Newcastle based rail research centre NEWRAIL.

He has over 25 years of experience of conducting basic and applied research in mechanics and is internationally known for his work in failure of materials, wear and rolling contact fatigue. He has obtained research funds of A\$6.6M as Principal Investigator and A\$66M as Co-investigator, and has contributed 1 Book, several patents, over 160 papers, articles and reports in this area including 3 prize winning publications. With a citation count of over 800, his H-index is 17, and his work on railways resulted in a successful Sheffield University spin out company.

His current research interests include Design for Aging, Electric Vehicle, Rolling Contact Fatigue and Wear in railways, Surgical Engineering (feedback to surgeon during cataract eye surgery, knee implantation and hip implantation) and Engineering Education pedagogy.

AK is member of the Editorial Board of the prestigious IMechE Journal of Rail and Rapid Transit, I.Mech.E – Journal of Strain Analysis, International Journal of Surface Science and Engineering, and Transport Problems – International Scientific Journal and is on the panel of reviewers for several other international journals.

AK has extensively consulted on rolling contact fatigue and wear. Following the Hatfield accident, he was appointed expert witness for Her Majesty's Crown Prosecution Service and also acted as expert witness for Fischer Scoggins LLP and Davies Arnold Cooper for railway related court cases. AK has been an active member of the Executive Committee – UK and Ireland Section of the American Society of Mechanical Engineers. In the past he has served the committee as Treasurer (1998 – 2000) and as Chairman (2002 – 2006).

Speaker 5, Title: Rail Asset Management and Maintenance

Life cycle management of Rails is extremely important for rail infrastructure owners and operators. This presentation is on Planning, Installation, Establishing, Maintenance and Removal of rails. It explains the life cycle management, defect growth and corrective and preventive measures to reduce the risks and costs. Real life data is analysed and illustrative examples are presented to help parishioners take managerial decisions.

Ian Telford



Ian Telford has been working as an engineer in the railway industry for 8 years. Over this time he has had roles in structural engineering, track maintenance and track design. Currently Ian works for QR National in Rail Services as a Grind Quality Engineer. Rail Services provide rail profiling services and rail technical support to clients across Australia. Ian is involved in measurement, reporting and analysis of grind production and quality; introducing and maintaining systems to store rail quality data; and providing information and rail support to clients. Ian is nearing completion of a Master's degree in Engineering specialising in Railway Infrastructure.

Speaker 6, 7 Title: Continuing Development of Courses in Asset Management

The power generation industry was experiencing a shortage of experienced engineers as a result of high demand for engineers across industry, retirements of established engineers, and the loss of industry-wide training schemes. A partnership was formed between three Queensland Government owned power generation companies and three leading Queensland Universities to develop a high quality skills development program as a key initiative in their attraction and retention strategy and to overcome this shortage by providing accelerated learning tailored to the needs of the industry. A course in asset management systems was developed to reflect the best known practices in asset management. The course content includes an overview of the most relevant standards, principally dealing with the publicly available specifications (PAS) BSI PAS 55, and qualitative and quantitative techniques for continual improvement in the areas of reliability, availability, maintainability and safety (RAMS). The model used is work integrated learning in a block mode in a blended learning environment. This paper focuses on continuing development of practical and effective Asset Management Courses.

Gopi Chattopadhyay



Professor Gopi Chattopadhyay is Head of Engineering Post Graduate Studies in CQUniversity Australia. He is a lead researcher in Centre for Railway Engineering (CRE) and Process Engineering and Light Metal (PELM) research centres with expertise in asset management, maintenance, reliability, risk and cost modelling. Gopi has Bachelor of Engineering (Mechanical), Master of Engineering in Industrial Engineering, Master of Business Administration and PhD in Mechanical Engineering in the area of reliability, warranty cost modelling from the University of Queensland. He

has 14 years of experience as engineer and manager in design and operations management including maintenance and 17 years of experience in Universities. Gopi had or currently has research projects with Queensland University of Technology, Monash University, Rail CRC, Asset Management CRC, Qld Rail, Swedish Rail, Lulea University of Technology, Sweden, Saarland University, Germany, Indian Institute of Technology India, Qld Health and many other reputed national and international research centres. Research outputs include more than \$3million dollar research grants, 11 research higher degree student completion and more than 130 refereed publications and book chapters.

Speaker 6 and 7, Title: Continuing Development of Courses in Asset Management

Malcolm Leinster



Malcolm Leinster is a Mechanical Engineer with over 40 years experience in heavy industry, including over 35 years in the electric power generation industry. He has been involved for much of that time in the planning, construction, operation and maintenance of major generating assets. He graduated from Queensland Institute of Technology with a Bachelor of Technology (Mechanical Engineering) degree, and has a Graduate Diploma in Applied Computing from CQUniversity Australia. He has represented his industry on various committees and research projects, some of which are still undergoing development. Since official retirement in 2005 he has continued to work on creep-related problems, life assessment, quantitative risk assessment and asset management. He has contributed to the writing and presentation of courses in Advanced Power Plant and Asset Management at CQUniversity Australia, where he is an Adjunct Professional Fellow. He has a long-term interest in the promotion of science in schools.

Speaker 8, Title: “Asset Productivity Improvement: Experience is a marvelous thing!”

This Session is on asset productivity improvement. Experience is a marvellous thing. This presentation shows how to apply lessons learnt for continual improvement in the area of asset management.



John A ABBOTT

B.Eng, LLB, CPEng, RPEQ, MIEAust, MAICD

Regional Director – Asia Pacific,

Fluor Global Services

Fluor Corporation

John Abbott leads the Fluor Global Services Business Line in the Asia Pacific region. He has responsibility for the long-term, site oriented, service contracts executed in the region. Under these contracts Fluor typically provides support to client's production facilities by providing a diverse range of Asset Centric solutions such as: Capital program management and Design, Asset Improvement, Asset Engineering, Asset Maintenance, Capital execution and construction and Plant Operations.

John is an experienced professional with over 32 years experience in all aspects of operations management, project development, engineering design, and plant operations and maintenance. He has worked in a variety of industries, and also for many of the major corporations such as Exxon, Southern Pacific Petroleum, Rio Tinto and Orica. John is an effective change manager, with extensive experience in turning around the performance of under-performing production businesses, plants and operations. He has been with Fluor for 5 years.

John has bachelor's degrees in both Mechanical Engineering and Law from the Queensland University of Technology. He has been involved for many years with the University of Central Queensland in the development of post graduate and masters programmes in maintenance and asset management.

John is a Director of Fluor Australia Pty Ltd, and all its related entities in Australia. He is also a Commissioner of the two Fluor entities in Indonesia, and a Director of the Fluor entity in Singapore.

Speaker 9, Title: Tarong Asset Management Systems (TAMS)

This presentation looks at the asset management approach at Tarong Energy and the systems developed to support the business. An overview of TAMS will be provided highlighting key aspects and design concepts of the system.

Rob Lupton



Rob has over 27 years experience in the electrical industry in a variety of roles. Starting out as an Electrical Fitter Mechanic, Rob studied electrical engineering and IT. His career has included roles in maintenance management, ERP implementation, IT systems development, asset management, strategic planning, business development, project management and risk management. Rob Lupton is currently the Manager Project Governance and Asset Services, Tarong Energy. In this role, Rob is responsible for the Tarong Energy project management policy and framework, and the provision of project services. He also leads an asset management services team responsible for long term planning for the generation portfolio. Rob designed and developed the Tarong Energy Asset Management System (TAMS).

Speaker10, Title: ISO Asset Management Standard: Current status of draft and what is expected in the future

The understanding of the principles of Asset Management has developed significantly over the last decade and a number of approaches, standards, specifications and models have been developed across the world. The Institute of Asset Management (UK – BSI PAS 55) and the Asset Management Council (Australia - Capability Assurance) have individually developed various views on Asset Management. Both organisations have been working together on behalf of the Global Forum for Maintenance and Asset Management (GFMAM) to develop and recommend a global view. The GFMAM has been established with a major objective of sharing collaboratively collected advancements, knowledge and standards in maintenance and Asset Management.

This Asset Management Landscape, being jointly developed by the AM Council and IAM, will provide an overview of Asset Management to see how the current models and practices fit, and provide a basis for a global conversation and, in time, a global alignment on the why, what and how of asset management. This paper will discuss:

- ISO Asset Management Standard: Current status of draft and what is expected in the future; and
- An update on progress toward an international standard for asset management.

Peter Kohler



Peter Kohler is the Principal Analyst - Asset Sustainability with the NSW. Independent Transport Safety and Reliability Regulator (ITSRR). Prior to this, Peter was the Managing Director of Capability by Design Pty Ltd, a risk engineering and management consultancy. Peter has worked extensively with the Royal Australian Navy as a Captain, Engineer. AM Council Roles include Sydney Chapter Chair, National Chair, Director, ICOMS Conference Chair, Chair TDT committee, Glossary, Certification Project Team.

Special Workshops – 17th March 2011

Rail Workshop

Professor Ajay Kapoor

Title: Rail wheel contact mechanics

The workshop will introduce concepts of,

- Contact of surfaces, estimating contact area and contact pressure
- The process of shakedown, estimating shakedown limits
- Basics of crack propagation

The presentation will talk about the underlying science and the current work in this area.

Modelling Crack Initiation in Rail Subjected to Low Cycle Rolling Contact Fatigue

K Ding, A Kapoor

Faculty of Engineering and Industrial Sciences, Swinburne University of Technology,
Hawthorn, VIC3122, Australia

Abstract

Rail replacement caused by rolling contact fatigue (RCF) is one of the most expensive activities for the railway industry. In order to reduce the replacement cost and enhance good maintenance of rail tracks, it is necessary to understand the rail damage behaviour. This paper presents an application of the finite element (FE) technique and the direct low cycle fatigue (DLCF) algorithm to predict the crack initiation in rail. The DLCF technique adopted for this study is more computationally effective than the traditional ones. Especially, for the 2D FE model of a rail with an assumption of plane strain conditions, the fatigue analysis is fast enough to provide useful results on a normal PC (roughly a few thousand cycles in a day). As the rail-wheel contact area is of the order of a thumbnail, and the resulting contact stresses are concentrated in a small region, the model uses finite elements for the small contact region and infinite elements for the surrounding medium. The moving contact load with fully sliding condition is estimated using Hertz contact theory. The normal and tangential tractions are programmed into two subroutines as a loading function for ABAQUS (v6.9). A damage mechanics based model is used to evaluate the damage degradation in rail during the DLCF analysis. The accumulated inelastic hysteresis energy is used as failure criterion in the material model. The numerical study is focused on two locations of the track: (I) an area where the train accelerates, such as going out of a station; (II) an area where the train decelerates, such as coming into a station. These scenarios simulate possible squat formation, which is generally found at locations having frequent acceleration and deceleration.

Keywords: railways, finite element analysis, direct low cycle fatigue (DLCF) algorithm, rail-wheel contact, inelastic hysteresis energy, scalar damage variable and crack initiation,

Ratchetting of railhead material: an idea to improve its fatigue life

Nirmal K Mandal
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CQUniversity, Rockhampton, Queensland
Australia

Railhead material in the vicinity of rail joints (IRJs) exhibits early failure due to severe plastic deformation and damage. It is because of high dynamic wheel load at the endpost of rail joints. Although ratchetting failure of the railhead in tangent and curved tracks due to low frequency dynamic wheel loads is well documented in the literature, there is a paucity of information on the failure of the railhead in the vicinity of rail ends/endposts of IRJs due to the complex high frequency impact loading that occurs at those critical locations, primarily due to reduction in the relative stiffness of the rail joint assembly.

A 3D Finite element analysis result is presented to show the ratchetting damage of railhead material based on different load factors (P_0/k). This presentation focuses on shakedown behaviour of railhead material. For a load factor higher than plastic shakedown limit, railhead material fails by ratchetting and a load factor lower than shakedown limit; it fails by high cycle fatigue. A better way to find out a work point on shakedown diagram is being illustrated to improve the fatigue life of railhead material.

The influence of geometrical features on the probability of fatigue crack initiation in Aluminothermic welds

I. Salehi¹, P.J. Mutton², A. Kapoor¹,

¹ Faculty of Engineering and Industrial Sciences, Swinburne University of Technology, Hawthorn, VIC, Australia; ² Institute of Railway Technology, Monash University, Clayton, VIC, Australia

Thermite welding as an on-site rail welding method suffers from the variations of the produced quality due to its cast-like nature and the operator-dependency of the installation process. Fatigue failure as a result of surface defects or harsh geometrical features in the presence of high axle loads and tractive forces gives rise to the so-called straight break fractures. In this study multi-axial fatigue criterion is used to investigate the effect of geometrical features in the possibility of crack initiation at the weld collar edge. A thermo-structural finite element model of a rail segment containing a thermite weld combined with a customized computer code performs the analysis of fatigue crack initiation. Two thermite welds used in Australian iron ore heavy haul railways with different collar design in terms of flank angle and toe radius are investigated for fatigue behaviour. The effect of fatigue damage under the track support conditions is also included in the current analysis in order to quantify the effect of ballast deterioration, which is a common problem at the vicinity of thermite welds. The results are consistent with the practical observations showing that the amount of fatigue damage critically depends on the geometrical features of the collar edge, especially at the underhead fillet which undergoes severe fatigue at some operational conditions. The condition of track support also shows to be highly influential in the probability of fatigue crack nucleation at regions of the weld foot.

Keywords: Thermite Welding, Straight Break, Finite Element Method, Multiaxial Fatigue Criterion

Modelling rail wear transition and mechanism due to frictional heating

A.M. Sri Asih, K. Ding, A. Kapoor

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Hawthorn, VIC 3125, Australia

Abstract

Wear rate in a rail wheel system is found to be a function of slip ratio between rail and the wheel. For very low values of slip ratio, the wear rate increases with slip up to the point of first wear transition. Between the first and second wear transitions the wear rate remains fairly uniform with slip ratio. After the second wear transition, the wear rate shows a rapid increase with the slip ratio. The first wear transition occurs when the contact condition changes from partial slip to full slip, while the second transition occurs due to thermal effects. The work presented here models the transition of rail wear due to frictional heating at the contact region.

As the wheel passes over, the rail material in the contact region accumulates plastic deformation by a process known as ratcheting. The material fails when the accumulated strain reaches a critical value, and results in formation of wear debris and initiation of rolling contact fatigue cracks. A brick model is used to simulate material behaviour and failure leading to wear. The wheel loading is modelled as Hertzian line contact and traversed over the surface repeatedly. The slip at the interface produces heat and increases the material temperature. Thermal stresses develop making the stress state more severe, and the material softens due to increase in temperature. The stress state and the current value of yield stress at each depth govern the amount of plastic shear strain experienced with each wheel pass. As the material accumulates plastic deformation the yield stress increases due to strain hardening. Both hardening due to deformation and softening due to thermal effects are considered in calculating the plastic strain. The brick model considers spatial variation in material properties and hence different elements accumulate strain at a different rate and fail at different times. By summing up the volume of material failed, the wear rate of the surface is calculated. The results show that the wheel rail interface temperature increases with slip. When the temperature is over 200°C, the material strength drops causing an increase in the strain accumulated per wheel pass. The material reaches the critical strain quickly and causes a significant increase in the wear rate. With increasing slip/roll ratio the rate of wear is found to increase, resulting in second wear transition which has been modelled in this work.

The results presented here include the effect of peak contact pressure, friction coefficient, slip/roll ratio, and the vehicle speed on wear rate.

Keywords: rail wear, wear transitions, ratcheting, brick model, thermal stress, softening, plastic strain, slip

Mechanical Response of Railhead Influenced by Wheel Rail Contact Conditions

Sagheer Ranjha, Kan Ding, Ajay Kapoor

Faculty of Engineering and Industrial Sciences,

Swinburne University of Technology, Hawthorn, VIC3122, Australia

In most rail-wheel contact cases, especially on curved rail tracks, additional stresses occur in the rail due to potential centrifugal force and cant deficiency. The localized high stress generated on the rail gauge corner of the outer rail region could potentially cause fatigue crack initiation. The aim of this study is to examine the rail gauge corner of the outer rail region influenced by the lateral (L) and vertical (V) rail-wheel contact loads and the contact position. The longitudinal bending stresses in the rail under-head radius position are of special interest as tension spikes were found at this location in the field measurements. The study was undertaken by the finite element method (FEM) with a static stress analysis. The analysis revealed that the longitudinal stress at the rail gauge corner of the outer rail region is highly dependent on two factors: the offset of the contact patch location from the rail centreline and the L/V ratio. The peak tensile stress is increased, but the depth below the contact surface at which the stresses become tensile is reduced when increasing the offset of contact patch location and L/V ratio. Both these enhance the tendency for rolling contact fatigue cracks to turn downwards into transverse defects. This is because an increase in tensile bending stresses together with both residual and thermally induced stresses can facilitate crack growth once the crack has reached a critical length.

Keywords: Longitudinal bending stress, Finite element method, Rail-wheel contact, Contact patch position, Stress state, Railway

Maintenance Workshop

Maintenance Strategy tutorial: Presenter: Mick Rudge

The tutorial will provide an overview of the Maintenance function and how the maintenance strategy affects the different elements of the model. It will show where the equipment life plans fit the model and discuss the suitability of different strategies, such as Run to failure, Fixed time maintenance, Condition based maintenance, Design out maintenance, Top Down Bottom UP (TDBU) Reliability Centred Maintenance (RCM) Total Productive Maintenance (TPM). We will analyse and discuss some key findings regarding the effectiveness of current programs and ways of determining the optimum equipment life plan decisions.