

# Tribology in steel rolling technology

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Metal rolling processes are characterised by a combination of large plastic deformation, significant tribological factors and complex loading modes. In hot rolling process, the surface of work roll is initially heated up to 650°C while in contact with hot steel strips for  $10^{-2}$ - $10^{-3}$ s, and subsequently cooled by water to around 50 °C during the same cycle. The work-roll surface are subjected to high loading ( $<1$ GPa), high temperature between 850-1100°C and high rolling velocity ( $>10$ m/s), the work-roll surface inevitably degrades (e.g. oxidation, wear, abrasion, fatigue, etc.). For cold rolling the loading is even higher and strip speeds up to 30m/s.

The metal deformation is closely related to the friction and lubrication conditions between the roll and the material surfaces. Oil in water emulsions are introduced at the roll bite in cold and hot rolling to reduce friction, roll wear and to provide some cooling. The lubricant composition can affect the friction and dynamics of the rolling process. At the strip-lubricant-roll interface, tribology has a significant influence on the dimensional accuracy and the surface quality of strip.

Friction at the interfaces between two rolls and a strip being plastically deformed by the rolls can directly affect the rolling pressure and consequently the mechanical deformation of the whole rolling mill and in particular the roll gap that control the final strip thickness. Roll wear affects the control of the strip shape and profile, flatness, and its surface finish.

The thermal cyclic working of hot rolls causes a superficial oxide scale to form which plays an important role on the wear of roll surfaces and the surface quality of rolled materials. The interface between the roll and the steel consisting of oxide scales of work roll, lubricant and oxide scale of strip will affect the rolling process in terms of friction and thermal conductivity. This will result in changes in rolling forces, power consumptions, roll wear and surface quality and even the mechanical and metallurgical properties of the bulk materials.

This presentation will discuss the above tribological aspects in hot and cold rolling of steel. It covers lubrication mechanics, measurement of friction and its effects on the product quality, oxidative and abrasive wear of the strip and work roll. Experimental and modelling results will be presented.

## **Curriculum Vitae : Kiet Tieu , FTSE**

PhD in Mechanical Engineering, University of Western Australia, 1975

### *Academic, research, professional experience:*

- 2014- Senior Professor
- 1998- Professor of Mechanical engineering.
- 1997-2007 Head of Department/Head of School of Mechanical, Materials and Mechatronic Engineering
- 1974-1982 Head of Research and Investigation Engineering, BlueScope Steel

### **Honorary Appointments :**

- Visiting Professor to top tier universities in China such as HUST, Northeastern University, USTB.

### **Memberships :-**

- ARC College of Expert (2014-2017)
- Fellow of the Australian Academy of Technological Science and Engineering since 2007 ;
- ARC –INTREADER ;
- Member of Engineering Faculty Research Committee for 16 years
- Member of University Research Committee for 2 years
- Member of ARC Review of Engineering and Environmental Journals;
- Chair of 15th International Conference in Advances in Materials and Processing Technologies, Australia

### **Editorial Board**

- Co-Editor in Chief J. Modelling and Numerical Simulation of Materials Science;
- Member of the Editorial Board of International J. Surface Science and Engineering, International J. Iron and Steel Research.
- Guest Managing Editor in 2012-2013 for SCI journals : Metallurgical and Materials Trans B, Thin Solids Film, Computational Material Science, Steel Research International, J.Materials Research Innovation, Intl. J. Materials and Products Technology, J.Nano Research, International Journal of Materials and Manufacturing Processes, J. Materials Science Forum.

### **Awards**

- Awarded in 2011 the Quangcheng Friendship Award by the Jinan Municipal's government, and the Qilu Friendship award by the Shandong Provincial People's Government (China) for outstanding international collaborative research on strip shape control in hot rolling.
- Received in 2012 the William Johnson International Gold Medal for "Lifetime Achievements in Materials Processing Research and Teaching" by the

International Committee for Advances in Materials and Processing Technologies (AMPT).

- 2014 Vice Chancellor Award for Research Supervision

**Research Supervision** : In the last 5 years, 28 PhDs have graduated.

### Research interests

- Strip shape in hot and cold rolling
- Lubrication in hot and cold rolling
- Computational mechanics in rolling : 3D slab method, 3D-FEM, Crystal plasticity FEM for stress analysis, texture evolution
- Severe plastic deformation : Accumulative roll bonding, high pressure torsion, ECAP
- Tribology in metal forming

### **RESEARCH OUTCOMES (from 2004)**

He has been awarded 35 ARC DP/Linkage/LIEFs

#### Recent projects on steel rolling technology and tribology:

- (i) Australian Research Council : A new adaptive composite phosphate polymer for metal forming; (2015-2018)
- (ii) Australian Research Council: A physically based abrasive wear model for high speed steel at high temperature;(2013-2015)
- (iii) Australian Research Council: Lubrication mechanics in hot strip rolling.(2011-2013)
- (iv) BaoSteel (China) : Oxidation and Friction in hot rolling of stainless steel (2007-2010)
- (v) BaoSteel (China) : Advanced modelling and experimental investigations of wear mechanism of high-speed steel (2013-2015)
- (vi) BlueScope Steel (Australia): Performance of metallic coating on steel strip (2010)
- (vii) BlueScope Steel (Australia): Characterisation and adhesive performance of resin coatings on metal coated steel, (2012-2014);
- (viii) BP/Castrol (Australia): Performance of a new aqueous lubricant in cold rolling, (2006-2007);
- (ix) BP/Castrol (Australia) and Nishin Steel (Japan): Investigation of aqueous polymer lubricant in stainless steel rolling, 2007-2008;
- (x) Jinan Steel (China), Control of flatness and shape in the hot finishing mill, 2008-2009;
- (xi) Posco Steel (Korea): Optimising strip shape in cold rolling of Si steel, (2009-2010).
- (xii) Posco Steel (Korea): Optimising strip shape in tandem hot strip rolling, (2008-2009)

- (xiii) Posco Steel (Korea): “Behavior of mass flow of head and tail of hot strip, and its control at the finishing mill” (2007-2008)
  - (xiv) Bluescope steel (Australia): Optimisation of strip shape and profile in 5 stand cold mill (2004-2006)
- 5 projects in CRC Rails/Rail Innovation and 2 projects in Energy Pipeline CRC

**Contract Research:**

- 2004-2014 Sixteen (16) major contract research for BP/Castrol (1 contract), Nishin Steel (Japan) (1), Bao steel (China) (2), Benxi Steel (China) (1), Jinan Steel (China) (1) and Posco Steel (Korea) (3), Pacific National (1), Port Kembla Port Authority (1), Pacific National (1), BlueScope Steel Metallurgy Centre (3).

**Research management**

- He is currently coordinator of the Engineering Mechanics Research Centre (17 years) in Engineering Manufacturing strength. He has also been Coordinator of the Rolling Mechanics Research Group in the Engineering Materials Institute for 10 years. Both these research centres is well known internationally in computational and experimental mechanics, tribology and rolling technology.

**Publications**

Prof. Tieu has published a total of 589 refereed papers (329 Journal & 260 Conference articles), 3 patents, 37 major contract research reports. He has published widely in several fields of rolling mechanics (hot and cold rolling), tribology, computational mechanics, materials engineering.

**Some relevant publications from 2004 (not all are listed):**

1. W. Caesarendra, B. Kosasih, **A.K. Tieu**, C.A.S. Moodie, Application of the largest Lyapunov exponent algorithm as a feature extraction method for low speed slew bearing condition monitoring, *Mechanical Systems and Signal Processing*, accepted May 2014.
2. Yu H.L., **Tieu K.**, Lu C., Lou Y.S., Liu X.H., Godbole A., Kong C. Tensile fracture of ultrafine Al 6061 sheets by asymmetric cryorolling for microforming. *International Journal of Damage Mechanics*, accepted 2014-5-10.
3. Yu H.L., **Tieu K.**, Lu C., Godbole A. An investigation of interface bonding of bimetallic foils by combined accumulative roll bonding and asymmetric rolling techniques. *Metallurgical and Materials Transactions A*, 2014, DOI: 10.1007/s11661-014-2311-4.
4. Yu H.L., **Tieu K.**, Lu C., Liu X., Godbole A., Li H.J., Kong C., Qin Q.H. A deformation mechanism of hard metal surrounded by soft metal during roll forming. *Scientific Reports*, accepted 2014-5-3. (**IF 2.927**)
5. Yu H.L., Lu C., **Tieu A.K.**, Kong C. (2014) Fabrication of ultrafine-grained Aluminum sheets by four-layer accumulative roll bonding. *Materials and Manufacturing Processes*, DOI: 10.1080/10426914.2013.872259.
6. Su L., Lu C., Deng G., **Tieu A.K.** (2014) Microstructure and Mechanical Properties of AA5005/AA6061 Laminated Composite Processed by Accumulative Roll Bonding. *Metallurgical and Materials Transactions B*. DOI: 10.1007/s11663-013-9869-x.
7. Su L.H., Lu C., Deng G.Y., **Tieu A.K.**, Zhang L.C., Guagliardo P., Samarin S.N., Williams J.F. (2014) Vacancy-type defects study on ultra-fine grained aluminium processed by severe plastic deformation, *Science of Advanced Materials*, doi:10.1166/sam.2014.1809.
8. Cheng K., Lu C., **Tieu A.K.** and Zhu H. (2014) Microstructural Evolution and Mechanical Property of AA5050 Alloy Deformed by Accumulative Roll Bonding. *Metallurgical and Materials Transactions B*. DOI: 10.1007/s11663-013-9842-8.
9. Cheng K., Lu C. and **Tieu A.K.** (2014) Abnormal Ductility Increase of Commercial Purity Al During Accumulative Roll Bonding. *Metallurgical and Materials Transactions B*. DOI: 10.1007/s11663-013-9843-7.
10. Zheng X., Zhu H., **Tieu A.K.** and Kosasih B. (2014) Roughness and lubricant effect on 3D atomic asperity contact. *Tribology Letters*, 53: 215-223.
11. Michal G., C. Lu, **Tieu A.K.** (2014) Multiscale model of elastic nanocontacts. *Computational Materials Science*, 81: 98-103.

12. Su L.H., Lu C., Gazder A.A., Saleh A.A., Deng G.Y., **Tieu A.K.**, Li H.J. (2014) Shear texture gradient in AA6061 aluminium alloy processed by accumulative roll bonding with high roll roughness, *Journal of Alloys and compounds*, 594: 12–22.
13. Caesarendra W., Kosasih B., **Tieu A.K.** and Moodie C.A.S. (2014) Circular domain features based condition monitoring for low speed slewing bearing. *Mechanical Systems and Signal Processing*, 45: 114-138.
14. Zhu H., Zhu Q., **Tieu A.K.**, Kosasih B. and Kong C. (2013) A simulation of wear behaviour of high-speed steel hot rolls by means of high temperature pin-on-disc tests. *Wear*, 302: 1310-1318.
15. Zheng X., Zhu H., Kosasih B. and **Tieu A.K.** (2013) A molecular dynamics simulation of boundary lubrication: The effect of n-alkanes chain length and normal load. *Wear*, 301: 62-69.
16. Zheng X., Zhu H., **Tieu A.K.** and Kosasih B. (2013) A molecular dynamics simulation of 3D rough lubricated contact. *Tribology International*, 67: 217-221.
17. Yu H.L., **Tieu A.K.**, Lu C., Zhu H. and Liu X.H. (2013) The wave motion of the rolling force during variable gauge rolling. *Steel Research International*, 84: 1203-1208.
18. Yu H.L., **Tieu A.K.**, Lu C., Deng G.Y. and Liu X.H. (2013) Occurrence of surface defects on strips during hot rolling process by FEM. *The International Journal of Advanced Manufacturing Technology*, 67: 1161-1170.
19. Yu H.L., **Tieu A.K.**, Lu C., Liu X.H., Godbole A. and Kong C. (2013) Mechanical properties of Al-Mg-Si alloy sheets produced using asymmetric cryorolling and ageing treatment. *Materials Science and Engineering A*, 568: 212-218.
20. Yu H., Lu C., **Tieu A.K.**, Godbole A., Su L., Sun Y., Liu M., Tang D. and Kong C. (2013) Fabrication of ultra-thin nanostructured bimetallic foils by Accumulative Roll Bonding and Asymmetric Rolling. *Scientific Reports*, 3: 2373-.
21. Wei P., Lu C., **Tieu A.K.**, Deng G., Wang H. and Kong N. (2013) Finite element analysis of high pressure torsion. *Steel Research International*, 84: 1246-1251.
22. Su L., Lu C., **Tieu A.K.**, Deng G. and Sun X. (2013) Ultrafine grained AA1050/AA6061 composite produced by accumulative roll bonding. *Materials Science and Engineering A*, 559: 345-351.
23. Su L., Lu C., Deng G., **Tieu A.K.** and Sun X. (2013) Microstructure and mechanical properties of 1050/6061 laminated composite processed by accumulative roll bonding. *Reviews on Advanced Materials Science*, 33: 33-37.
24. Zhu H.T., Zhu Q., Kosasih P.B., **Tieu A.K.** (2013) Investigation on mechanical properties of a high-speed steel roll material by nano-indentation. *Materials Research Innovations*, 17: 35-39.

25. Kong N., **Tieu A.K.**, Zhu H.T., Zhu Q. (2013) Application of solid lubricant during warm rolling process of interstitial free steel. *Materials Research Innovations*, 17: 79-84. **(IF 0.321)**
26. Zhang X.Z., Zhu H.T., Huang W., Shi B.J., **Tieu A.K.** (2013) Investigation on slab continuous straightening technology and deformation analysis. *International Journal of Materials and Product Technology*, 47: 126-137.
27. Hadi S., **Tieu A.K.**, Lu C., Zhu H.T. (2013) A micro deep drawing of ARB processed aluminium foil AA1235. *International Journal of Materials and Product Technology*, 47: 175-187.
28. Lin B., **Tieu A.K.**, Zhu H., Kosasih B., Novareza O. and Triani G. (2013) Tribological performance of aqueous copolymer lubricant in loaded contact with Si and coated Ti film. *Wear*, 302: 1010-1016.
29. **A.K. Tieu**, Q. Zhu, H.T. Zhu, C. Lu, (2011) An investigation into the tribological behaviour of a work roll material at high temperature, *Wear*, 273: 43-48.
30. Q. Zhu, H.T. Zhu, **A.K. Tieu**, C. Kong, (2011) Three dimensional microstructure study of oxide scale formed on a high-speed steel by means of SEM, FIB and TEM, *Corrosion Science*, 53: 3603-3611
31. Li, H.C., Jiang, Z.Y., **Tieu, A.K.**, Sun, W.H., Wei, D.B., (2011) Experimental study on wear and friction of work roll material with 4% Cr and added Ti in cold rolling. *Wear*, 271(9-10): p. 2500-2511
32. Li, H.J., Jiang, Z.Y., Wei, D.B., Han, J.T., **Tieu, A.K.** (2011) Study on surface asperity flattening during uniaxial planar compression. *Wear*, 271(9-10): p. 1778-1784
33. Liu, Q., Fu, W., Lu, C., **Tieu, A.K.**, Li, M., (2011) Size effect in micro multi-point sheet forming, *Advanced Science Letters* 4 , pp. 2054-2058
34. Su, L.H., Lu, C., **Tieu, A.K.**, He, L.Z., Zhang, Y., Wexler, D., (2011) Vacancy-assisted hardening in nanostructured metals, *Materials Letters* 65 , pp. 514-516
35. Q. Zhu, H.T. Zhu, **A.K. Tieu**, M. Reid, L.C. Zhang. (2011) In-situ investigation of oxidation behavior in high-speed steel roll material under dry and humid atmospheres. *Corrosion Science*, 52: 2070-2715.
36. Q. Zhu, H.T. Zhu, **A.K. Tieu**, C. Lu. (2010) High temperature oxidation behavior of a high speed steel material. *Steel Research International*, 81: 134-135.
37. H.T. Zhu, **A. K. Tieu**, R.J. Dippenaar, C.D. Carter, J. Ziegelaar, (2010) Effect of hot rolled coil profile containing ridges on ridge-buckle defects of cold rolled thin strip. *International Journal of Material Forming*, 2010, 3(1); 21-27.
38. Deng, G.Y., Lu, C., **Tieu, A.K.**, Su, L.H., Huynh, N.N., Liu, X.H., (2010) Crystal plasticity investigation of friction effect on texture evolution of Al

single crystal during ECAP, *Journal of Materials Science* 45 , pp. 4711-4717

39. Lu, C., **Tieu, A. K.** and Wexler, D., (2009), Significant enhancement of bond strength in the accumulative roll bonding process using nano-sized SiO<sub>2</sub> particles, *Journal of Materials Processing Technology*, 209 (10), pp. 4830-4834
40. Yang, L. M., **Tieu, A. K.**, Dunne, D. P., (2009), Cavitation erosion resistance of NiTi thin films produced by Filtered Arc Deposition, *Wear*, 267 (1-4), pp. 233-243
41. Wei, D.B., Huang, J.X., Zhang, A.W., Jiang, Z.Y., **Tieu, A.K.**, (2009) Study on the oxidation of stainless steels 304 and 304L in humid air and the friction during hot rolling *Wear* 267 (9-10), pp. 1741-1745
42. Li HC, Jiang ZY, **Tieu AK**, Zhu H. (2009) Tribological features of roll surface in cold metal rolling , *Intl. J. Surface Science and Engineering*, 3(5-6) pp407-422
43. Wei DB, Huang JX, Zhang AW, **Tieu AK** et al. (2009) Deformation of oxide scale and surface roughness transfer during hot rolling of stainless steel 304L, *Intl. J. Surface Science and Engineering*, 3(5-6) pp 459-470
44. Bai, Z., Du, X., Jiang, Z., **Tieu, A.K.**, Xu, J. (2009) Mechanics of scratch marks in cold rolling of thin strip, *Advanced Materials Research* 76-78, pp. 548-553
45. Zhang, X.Z., Jiang, Z.Y., **Tieu, A.K.**, Zhu, H.T. (2009) Analysis of surface temperature and thermal stress field of slab continuous casting *Advanced Materials Research* 76-78, pp. 554-559
46. Kosasih, B. P., **Tieu, A.K.**, Zhu, H.T. A, (2008), CFD study of lubricant flow with oil droplets in rolling inlet zone, *Computational Fluid Dynamics Journal*, 17(7), 42-51
47. Lu, C., Du, X., Zhu, H. T., **Tieu, A. K.**, Kim, S., (2008), Numerical investigation of strip deformation behavior between stands of hot finishing mill, *Steel Research International* 79(2) 742
48. Kim, S., Lu, C., Du, X. Z., **Tieu, A. K.**, (2008), Dynamic response of strip deformation behaviour to looper movement in hot strip mill, *International Journal of Modern Physics B* 22 (31-32), pp. 5661-5666
49. Xie, H.B., Jiang, Z.Y., **Tieu, A.K.**, Liu, X.H., Wang, G.D. (2008) Prediction of rolling force using an adaptive neural network model during cold rolling of thin strip *International Journal of Modern Physics B* 22 (31-32), pp. 5723-5727
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51. Du, X. Z., Yang, Q., Lu, C., **Tieu, A. K.**, Kim, S., (2008), Numerical simulation of strip profile in a 6-high cold rolling mill, *International Journal of Modern Physics B-B* 22 (31-32), pp. 5655-5660
52. Lu, C., Wei, D. B., Jiang, Z. Y. and **Tieu, A. K.**, (2008), Experimental and theoretical investigation of the asperity flattening process under



- large bulk strain, *Journal of Engineering Tribology*, 222, 271-278
53. Wang, J. S., Jiang, Z. Y., **Tieu, A. K.**, Liu, X. H. and Wang, G. D., (2008), A flying gauge change model in tandem cold strip mill, *Journal of Materials Processing Technology*, 204, Issues 1-3, 152-161
  54. Li, H.C., Jiang, Z.Y., **Tieu, A.K.**, Sun, W.H., Li, H.J., Wei, D. (2008) Surface roughness and wear of work roll containing Ti in cold strip rolling, *Advanced Materials Research*, 32, pp. 157-160
  55. Kosasih, P. B., **Tieu, A. K.**, (2007), Mixed film lubrication of strip rolling using O/W emulsions, *Tribology International*, 40, 709-716.
  56. **Tieu, A. K.**, Kosasih, P. B., (2007), Experimental and numerical study of O/W emulsion lubricated strip rolling in mixed film regime, *Tribology Letters*, 25 (1), 23-32.
  57. **Tieu, A. K.**, Tang, J., Jiang, Z., Sun, W. and Lu, C., (2007), Surface roughness transformation and deformation of the scale in hot rolling, *International Journal of Interface Science and Engineering*, 1(1), 125-143.
  58. Lu, C. and **Tieu, A. K.**, (2007), Measurement of the forward slip in cold strip rolling using a high speed digital camera, *Journal of Mechanical Science Technology*, 21, 1528-1533.
  59. **Tieu, A. K.**, Zhu, H. T., Lu, C. You, C., Jiang, Z. Y., D' Alessio, G., (2006), Modeling of Friction Coefficient in Cold Strip Rolling, *Materials Science Forum*, 505-507, 1285-1289.
  60. Jiang, Z. Y., **Tieu, A. K.**, Sun, W. H., Tang, J.N., Wei D.B., (2006), Characterisation of thin oxide scale and its surface roughness in hot metal rolling, *Materials Science and Engineering: A*, 435-436, 434-438.
  61. **Tieu, A. K.**, Kosasih, P. B., A. Godbole (2006), Thermal effect on mixed film lubrication strip Rolling with O/W emulsion lubricant, *Tribology International*, 39, 1591-1600.
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  63. Tang, J. N., **Tieu, A. K.**, Jiang, Z. Y. (2006), Modeling of the development of initial crack under hot rolling condition. *Materials Science Forum*, 505-507, 1291-1296.
  64. Tang, J. N., **Tieu, A. K.**, Jiang, Z. Y. (2006), Modeling of oxide scale surface roughness in hot metal forming, *Journal of Materials Processing Technology*, 177(1-3), 126-129.
  65. Wang, D.D., **Tieu, A.K.**, D'Alessio G. (2005), Computational intelligence based process optimisation for tandem cold rolling, *Journal Materials and Manufacturing Processes*, 20(3), 479-496
  66. **Tieu, A.K** and Liu, Y. J., (2004). Friction Variation in Cold Rolling Process, *Tribology International*, 37 (2004) 177-183

67. Sun, W.H., **Tieu, A.K.**, Jiang,Z., H.T. Zhu and C. Lu, Oxide scale growth of low carbon steel at high temperatures, *Journal of Materials Processing Technology* (2004) , Vol 155-156, pp1300-1306
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### Keynote addresses

69. **Kiet Tieu**, Cheng Lu. H.T. Zhu and Jea Sook Chung, (2010) Optimization of pass schedule to improve the strip shape in hot strip rolling, Keynote address, In, Proceedings of the Fourth Baosteel Biennial Academic conference, November 16-18, 2010, Shanghai, China, C49-C53.
70. **Tieu, A. K.**, Zhu, H. T., Dippenaar, R. J., Lu, C. and Jiang Z. Y., (2008), Keynote address Effect of high spot in hot rolled coil on ridge-buckle defect in cold rolled strip, , **Keynote address** 4th *Symposium on Advanced Steel Processing and New Rolling Technologies*,, Shenyang, China, Sep. 2008, 16 - 22.
71. **Tieu, A. K.**, Zhu, H. T., Lu, C. et al., Keynote address (2008), Ridge and ridge-buckle defects in cold rolling, , **Keynote address** 3<sup>rd</sup> Baosteel Biennial Academic Conference, Shanghai, China, Sep. 2008, C45- C49.
72. **Tieu, A.K.**, Lu, C., Kosasih, P.B., Jiang, Z., Zhu, H., (2006), Contact Mechanics in Strip Rolling, **Keynote address** 2<sup>nd</sup> *Baosteel Biennial Academic Conference*, 25-26 May 2006, Shanghai, China, Vol. 1, 201-207.
73. **Tieu A. K.**, Jiang Z., Lu C., P.B. Kosasih (2005), Friction and Asperity Contact in Strip Rolling, **Keynote address**, *The 3<sup>rd</sup> International symposium on Advanced Structural Steels and New Rolling Technologies*, Nov. 2005, Shenyang, China.

### Conferences

74. Kong, N., **Tieu,K.**,Zhu,H., Zhu, Q. (2014) Tribological behaviour of ultra low carbon steel coated with solid lubricant in ferritic temperature range, 19<sup>th</sup> Intl.Colloqium Tribology, Stuttgart Germany, Jan 2014, paper ID 9.7
75. Kong, N., **Tieu,K.**,Zhu,H., Zhu, Q. (2013) Flow stress and pyroplastic behaviour of ultra low carbon steel in warm temperature range, 16<sup>th</sup> International Conference on Advances in Materials and Processing Technologies, Taiwan, 2013, paper ID:227
76. **Tieu A.K.**, Deng G.Y., Lu C., Su L.H., Zhu H.T., Liu M., Liu X.H. (2013) An insight into the deformation and orientation development of severely plastic deformed aluminium. 2013. [AIP Conference Proceedings](#), Volume 1532, 2013, Pages 206-213. **Invited**, 11th *International Conference on Numerical Methods in Industrial Forming Processes, NUMIFORM 2013*, Shenyang; China; 6 July 2013 through 10 July 201.

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80. Yu H.L., Lu C., **Tieu A.K.**, Godbole A. (2013) Recent developments in flat rolling technologies. *Proceeding of The 8th Pacific Rim International Conference on Advanced Materials and Processing*, Hawaii, August, 2013, 2139-2146.
81. Wu Y.Y., Yu H.L., Lu C., **Tieu A.K.** (2013) Transition of ductile and brittle fracture during DWTT tests. *13th International Conference on Fracture*, Beijing, June, 2013.
82. Novareza O., Kosasih B.Y., **Tieu A.K.** and Zhu H.T. (2014) Tribological performance of aqueous copolymers solutions in metallic contact. *Materials Science Forum*, 773-774: 678-686.
83. Lin B.J., Zhu H.T., **Tieu A.K.** and Triani G. (2014) AFM and ellipsometry studies of ultra thin Ti film deposited on a silicon wafer. *Materials Science Forum*, 773-774: 616-625.
84. Lin B.J., Zhu H.T., **Tieu A.K.**, Kosasih B.Y. and Triani G. (2014) The effect of molecular structure on the adsorption of PPO-PEO-PPO triblock copolymers on solid surfaces. *Materials Science Forum*, 773-774: 670-677.
85. Kosasih B., Caesarendra W., **Tieu A.K.**, Widodo A., Moodie C.A.S and Tieu A.K. (2014) Degradation trend estimation and prognosis of large low speed slewing bearing lifetime. *Applied Mechanics and Materials*, 493: 343-348.
86. Kong N., **Tieu A.K.**, Zhu H.T., Zhu Q. and Gandy P. (2014) Effects of lubrication in ferrite rolling of interstitial free steel. *Materials Science Forum*, 773-774: 186-191.
87. S. Hadi S., **Tieu A.K.**, Lu C., Su L.H. and Yu H.L. (2014), Grain refinement in the formability of aluminium thin cup. *Materials Science Forum*, 773-774: 166-175.
88. O. Novareza, P.B. Kosasih, **A.K. Tieu**, H. Zhu, Effect of Bulk Temperature on the Tribological Performance of Aqueous Symmetric Tri-block Copolymers (PPO-PEO-PPO and PEO-PPO-PEO) Based Lubricant. *International Tribology Congress ASIATRIB*, 2010, pp. 1134.

89. Lihong Su, Cheng Lu, Tim McNeice and **A. Kiet Tieu**, (2010) Effect of nano-sized particles on bond strength in accumulative roll bonding, ICONN 2010, Sydney
90. H.T. Zhu, Zhu Qiang, Lu Cheng, **Tieu Kiet**. (2010) Tribological characterization of a high speed steel roll material at elevated temperature. In: Proceedings of the 10th international conferences on steel rolling, September 15-17, 2010, Beijing, China, 1806-1811.
91. H.T. Zhu, M. Wilson, **A.K. Tieu**, P.B. Kosasih and R. Walker, (2010) Performance of a New Aqueous Synthetic Lubricant in Cold Rolling of Stainless Steel, International Tribology Congress - ASIATRIB 2010, Perth, Australia, 5-9 December 2010, paper ID 1130.
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