Professor C. Richard Liu, PhD, Fellow and Ennor Medalist, ASME.
liuch@purdue.edu; 1 765 494 5413

C. V. SUMMARY

Professor Liu's professional interest is in creating innovative capability, quality and productivity for manufacturing processes and products through research and education. He is currently working on new aspects of integrated additive manufacturing at nano and micro scales. See I (a) below. Based on the economic and societal impact of his past research, he received several major awards at professional society and national levels. His areas of contributions include: (1) manufactured surface integrity and fatigue life; (2) sensor-based online modeling, prediction and adaptive compensation of machine tool error; (3) single-step superfinish hard machining process; (4) CAD/CAM Integration and (5) surface enhancement with nano/micro features. Academically, he has published over 170 refereed research papers and has been recognized as a pioneer and leader the area of surface integrity and performance. He has also developed a new graduate course on "Structured Engineering Innovation" (see attachment), which can ensure functional and system designs for achieving higher objectives of the design. This course has attracted high interest from industry. The highlight of his work is provided in the following.

I. HIGHLIGHT

I (a) CURRENT RESEARCH:

Dr. Liu's current research includes three areas:

(1) Additive manufacturing systems based on laser melt layer construction,
(2) **Additive nano-manufacturing based on laser induced chemical deposition, and**
(3) **Fatigue crack initiation modeling of a manufactured component.**

The work in the first area includes the study of the thermal-mechanical-microstructure-property-fatigue relationship of laser melt additive process. The materials include alloys and nano-enhanced metal matrix composites. His group has invented the method of creating graphene-reinforced nano-composites by laser sintering/melting layer by layer. See http://www.sciencedirect.com/science/article/pii/S1359645414005564 He is currently working on on-line process modeling for feedback control for ensuring quality and reliability.

The work in the second area has led to a novel, generic and scalable nano-manufacturing process, see http://pin.sagepub.com/content/early/2013/12/30/1740349913515202 , and a flexible nano-manufacturing system. Current research work include high rate generic methods for integrating the unit process and subassemblies for heterogeneous nanomaterials, and the study of the effect of processing on the structure, morphology and performance of nanomaterials, including self-powered nano/micro systems. One provisional patent is granted. The SnO_2 porous nanotube-arrays made as battery anodes are seen with excellent test result.

The work in the third area has resulted in a crystal plasticity based methodology for fatigue crack initiation life prediction, which is a dominate part of fatigue life. See https://www.researchgate.net/publication/260411321 . (4.1.110) In this work, a multi-scale computational methodology based on a crystal plasticity constitutive model was developed to

predict the micromechanical behavior of polycrystalline metals and the resultant damage formation during fatigue loadings.

I (b) RESEARCH RECOGNITION:

Professor Liu is widely recognized for his pioneering contributions in the fields of Surface Integrity. He is considered a pioneer leading to the establishment of the field of Manufactured Surface Integrity. His early research on the integrity of machined surfaces, which covers all high precision components for engineered products, resulted in over 70 refereed papers in this field [see papers in section 4.1]. His contributions have been progressively recognized by SME Outstanding Young Manufacturing Engineer Award (1981), ASME Blackall Award (1984), ASME William T. Ennor Award (2008), S. M. Wu Research Implementation Award, NAMRI (2011), and a number of invited keynote speeches.

This field has been growing, evidenced by the establishment of a global focused interest group at the International Institute of Production Research (CIRP) in 2007, and it is still expanding since.

In the last 8 years, he has extended the frontier of surface integrity research by including surface integrity variables in modeling **fatigue prediction**. Four of his journal papers have been identified by ScienceDirect as among the top 25 **most downloaded papers.** Recently, he has published a model for predicting fatigue crack initiation life based on crystal plasticity.

Detailed research works are discussed in II below. Details of honors and awards see section III.

II. DESCRIPTION OF RESEARCH CONTRIBUTIONS

Dr. Liu's research can be classified as in the following areas: (a) surface integrity and fatigue life of manufactured components; (b) sensor-based online modeling, prediction, planning and adaptive control for improving machine tool accuracy; (c) finish/superfinish hard machining process; (d) CAD/CAM integration, and (e) surface enhancement with nano/micro sized features and others.

II (a) <u>Surface Integrity and Fatigue Life of Manufactured Components:</u>

Dr. Liu was among the first few on record to recognize the importance of manufacturing processes on surface integrity and the fatigue performance of structural components in the 1970's. He was the one who first identified the root mechanism affecting the variables of the integrity of a machined surface, which was the dynamic thermo-elasto-plastic process of chip removal, leading to the alteration of the residual stresses, microstructures, micro-hardness and surface finish. This has laid a foundation for further scientific studies of the surface integrity in machining beyond direct experimental measurement, and extended the chip removal model below the machined surface. He continued his pioneering research in this field by further extending it for modeling the fatigue performance. This has resulted in the formation of a focused interest group in CIRP, a global production/manufacturing research institution headquartered in Europe, with about 200 researchers participating in 2007.

For his innovative research in the area of surface integrity, he was awarded 2008 **ASME Ennor Award** (the most prestigious in manufacturing research) *with the following citation:*

"… for his seminal research on the integrity and fatigue performance of finish machined surfaces leading to significant impact on cost, reliability and safety for load-carrying components made of hardened steels."

Currently Dr. Liu is developing a new area of research for modeling, predicting and improving the fatigue life of manufactured components. He and his student have found that the fatigue life of manufactured components is dominated by the effect of manufacturing, due to the residual stresses and micro-structures induced/altered by the processes. By properly selecting and controlling the processes used, not only the average value but also the variance of the fatigue life can be greatly improved. Examples from his research on superfinish hard turning showed that fatigue life could be varied by 50 times, depending on the process selected. See Figure 1.

The fatigue variance can also be reduced to 10% of the original. His research also showed that the safety factor required for 95% reliability of a component produced by conventional processes (grinding) could be 200 times larger than the one required for a carefully selected process, superfinish machining.

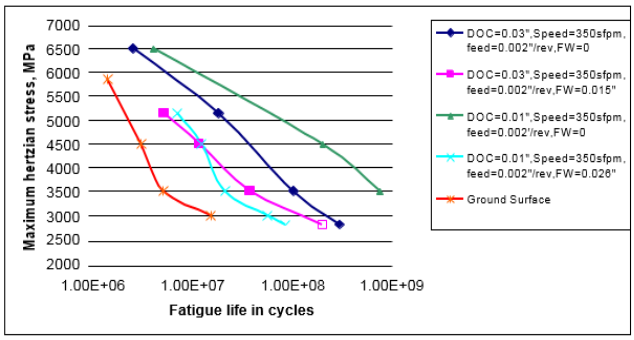


Figure 1. Fatigue life as affected by manufacturing conditions [Agha and Liu 2000]

Fatigue life predictions of manufactured components have not being accurate because of, among others, the following reasons: (1) the fact that Paris law cannot be applied in the range of very small cracks; (2) the life before the small crack is a major part of the fatigue life of an engineered component; and (3) the variables of manufactured surface integrity have not been implemented in fatigue models. After making progresses in resolving the above issues, Dr. Liu was able to develop models that could predict rolling contact fatigue life at a more accurate level so the cost for extensive testing can be greatly reduced. It is envisioned that these models will be particularly useful for designing new load-carrying components coupled with the design of manufacturing processes for better system reliability. Four papers published by Professor Liu and Y. Choi, his PhD student, in 2006, 2008, 2008 and 2009 have been declared by ScienceDirect as the Top 25 most downloaded articles in a specific quarter. (Selected among all the articles published in the journals). These four papers offered a new generation of modeling methodology for predicting fatigue life of manufactured components carrying Hertzian load.

Recently a crystal plasticity based methodology for fatigue crack initiation life prediction was published. (see 4.1.110) In this work, a multi-scale computational methodology based on a crystal plasticity constitutive model was developed to predict the micromechanical behavior of polycrystalline metals and the resultant damage formation during fatigue loadings.

II (b). Sensor-Based Online Modeling, Prediction and Adaptive Control for Machine Tool Error Compensation [4.1.14]:

In search of cost-effective methods for enhancing machine tool accuracy, Dr. Liu pioneered in developing theory and software methods for compensating machine tool errors. [I.1.44] His project

funded by and collaborated with NIST received (jointly with the NIST team) an IR 100 Award [4.1.14]. Started in 1985, he was funded by the Office of Naval Research ($1.3 million) for developing this idea further. Dr. Liu worked with 7 other faculty members and 15 graduate students. Under his direct supervision, he graduated 5 Ph.D. and 2 M.S. students in this area. The methodology developed has shown a capability for improving the accuracy of a CNC machine tool up to 10 times. See Figure 1.1. Thus making it feasible for using turning and milling processes as alternatives for grinding and superfinishing. The Saginaw Machine Tool Company and the GM Windsor Plant are among the companies that adopted this methodology. In Europe, a CNC controller company has also implemented this method into their software. Foxcon of Taiwan is recently applying this methodology **to improve the accuracy of over 10,000 machine tools.**

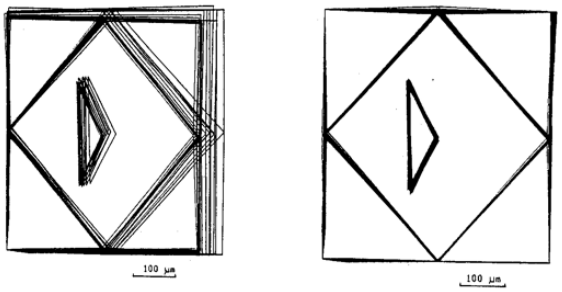
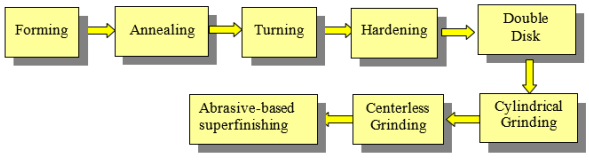


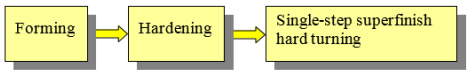
Figure 1.1 Workspace distortion without compensation (left) and with compensation (right)

II (c). Single-step Superfinish Hard Machining Process:

Dr. Liu was the first who proposed the development of single-step superfinish hard machining to replace the conventional soft machining, hardening, grinding and superfinishing. He has proven its feasibility. Since 1996, Dr. Liu has been cumulatively funded by NSF and industry with about $1.56 millions for studying the basic issues and for developing a process design methodology for **Single-step Superfinish Hard Turning,** a new production concept initiated by him. The primary aim of this study was to develop the enabling technologies for improving the processes used. He was able to reduce the number of processes required. See Figure 2. Using the simplified process, fatigue life and manufacturing cost can be simultaneously reduced. The structure of the research was, at the first time, to develop, link and integrate the models from process mechanics and thermal damage to fatigue prediction of machined parts. It has been shown that this new process has the potential of improving the fatigue life of a component made of hardened steel over one order of magnitude as compared with that produced by the conventional processes. See Figure 1. This technology has resulted in a basic patent issued to Purdue. This new processing technology will affect engineered products with over $10 billion annual sales. He has 8 Ph.D. and 4 MS students graduated in this area. This research was reported in ***INDUSTRY WEEK, IE HORIZON*** and other national and international magazines.



(a) Conventional method in production



(b) Developed innovative single-step hard machining (Liu and Mittal,1995)

Figure 2. Process simplification for manufacturing bearing races.

For his innovative research in finish/superfinish hard turning and machine tool error modeling and compensation, he was awarded the prestigious **North American Manufacturing Research Institute S. M. Wu Research Implementation Award** in 2011.

II (d). CAD/CAM Integration:

This area of research was mainly proposed to and supported by Purdue ERC of Intelligent Manufacturing Systems. He has graduated 7 Ph.D.'s in this area. Some of these students have influenced the national standards with the support of NIST. His own major contribution was the conception and development of the first successful new methodology based on machined features for a fully automated process planning system based on the geometric data from a solid modeler as the input, and generating all possible NC programs as the output. This had been a persisting problems solved by his team. [4.1.28 &47] Other contributions include the following:

1. The development of a new 2-D intelligent engineering drawing system, which offers unique representations of "all" engineering components.
2. A method for representing design tolerances and manufacturing requirement in 3-D solid modelers. [4.1.22,36,36]
3. Methods of knowledge management and idea generation in mechanical design. [4.1.45]
4. A new methodology based on machined features for computable representation, classification and retrieval of conceptual and geometric designs with good manufacturability. [4.1.28 &47] Now feature-based representation is widely used in 3-D geometric modelers for CAD/CAM integration.

II (e) Surface enhancement with nano/micro sized features and others

Dr. Liu was funded by NSF for studying the performance of coating of Nano/micro cBN particles on cutting tools. This program has been expanded to surface enhancement with metal matrix nanocomposite by laser sintering/melting process. His group has invented the method of creating carbon nanotubes-reinforced and graphene-reinforced nano-composites by laser sintering/melting layer by layer. (4.1:113 and 114). See Figure 3. This new nano metal matrix composites construction method will minimize the lingering problem of nano aggregation. This innovative method of including nano-enhancement in metals is a way for creating new nanocomposites by additive manufacturing for small lot size at low cost and high rate.

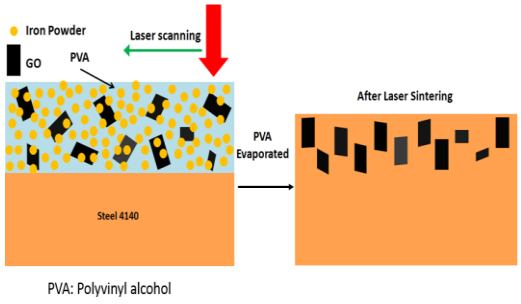


Figure 3 Integrating Single Layer Graphene-Oxides by SLS

Dr. Liu has also contributed to industrial research resulting in significant commercial impact. While working in industry, Dr. Liu conducted a study of the effect of mechanical energy on detergency, leading to significant advances in the science and engineering of clothes washing systems. The economic and performance impact of this study has given his company a major competitive advantage in product design, which has become the **dominant design in last 25 years.** This experience has offered a new perspective for him in teaching product and process innovation at Purdue.

He published a pioneering paper that applied Artificial Intelligence to Manufacturing Engineering [4.1.7-Don, et al 1984] and identified **INTELLIGENT MANUFACTURING** as a new frontier.

Later he led a project entitled "Intelligent Process Planning, Verification and Execution for Integrated Manufacturing Systems" with total funding of $699,094 from NSF/Purdue Engineering Research Center, supporting 3 faculty members and 9 Ph.D. students.

.

III. Awards, Honors and Distinctions

1981- Outstanding Young Manufacturing Engineer Award*, Society of Manufacturing Engineers, (One of five awarded.)
1984- Blackall Machine Tool and Gage Award*, ASME. 1984. (One award offered annually for best paper in manufacturing science and engineering)
1985- IR 100 Award*, 1985 (for one of most significant technological advances, co- recipient).
1985- Purdue Vice-President for Research Award.
1985- Certificate of Appreciation, ASME.
1986- Certificate of Appreciation, ASME.
1986- Purdue Research Foundation Award.
1987- Certificate of Appreciation, ASME.
1987- Certificate of Appreciation, Governor Orr, State of Indiana.
1989- Offered (through a national search) the position of Fluke Distinguished Professor of Manufacturing Engineering, University of Washington, Seattle, Washington, 1989.
1990 - Invited by Prime Minister P. C. Hau to attend the 4th National Forum of Science and Technology, Taiwan, R0C.
1991/1994- Industrial Technology Committee, Asian-Pacific Asso. of Science and Technology.
1992- Fellow, American Society of Mechanical Engineers, 1992 - present.
2001- Selected (through a national search) as the first candidate for an offer for Hardyman Chair of Mechanical Engineering, University of Kentucky, 2001.
2001- Listed in "Who is Who in America: Science and Engineering", Marquis Publishing Co.
2008- ASME William T. Ennor Manufacturing Technology Award* (society achievement award, recognizes innovative research leading to substantial economic/societal benefits).
2011- SOCIETY OF MANUFACTURING ENGINNEERS/NAMRI S. M. Wu Research Implementation Award* (an institute award "recognizes original research leading to a significant commercial/societal impact").
2012- Keynote Speaker, "Nanomaterials and Engineered Surface Enhancement", The 4th International Conference on Advanced Manufacturing,

IV. PUBLICATIONS:

4.1. Selected journal papers (graduate student marked in this color)

1. Liu, C.R. and Barash, M.M., "The Mechanical State of the Sub layer of the Surface Generated by Chip Removal Process, I: Cutting With a Sharp Tool," *ASME Transactions, Journal of Engineering for Industry*, Vol. 98, Series B, No. 4, pp. 1192-1201, November 1976.

2. Liu, C.R. and Barash, M.M., "The Mechanical State of the Sub layer of the Surface Generated by Chip Removal Process, II: Cutting with a Tool with Flank Wear," *ASME Transactions, Journal of Engineering for Industry*, Vol. 98, Series B, No. 4, pp. 1202-1208, November 1976.

3. Wang, I.C. and Liu, C.R., "Thermal-elastic Analysis of a Tri-Metallic Juncture with Welding Application," *Developments in Theoretical and Applied Mechanics*, Vol. 9, pp. 361-371, 1978.

4. Liu, C.R. and Barash, M.M., "Variables Governing Patterns of Residual Stresses in a Machined Surface," *ASME Transactions, Journal of Engineering for Industry*, Vol. 104, No. 3, pp. 257-264, August 1982. (ASME Blackall Best Paper Award 1984)

5. Donmez, A., Liu, C.R., Barash, M.M. and Mirski, F., "Statistical Analysis of Positioning Error of a CNC Milling Machine," *Journal of Manufacturing Systems*, Society of Manufacturing Engineers, Vol. 1, No. 1, pp. 33-42, 1982.

6. Liu, C.R. and Srinivasan, R., "Generative Process Planning-A Syntactic Pattern Recognition Approach," *Journal of Computers in Mechanical Engineering*, Vol. 2, No. 5, ASME, pp. 63-66, 1984.

7. Don, H.S., Fu, K.S., Liu, C.R. and Lin, W.C., "Metal Surface Inspection Using Image Processing Techniques," *IEEE Transactions, Journal of Systems, Man and Cybernetics*, Vol. SMC-14, No. 1, pp. 139-146, Jan./Feb. 1984.

8. Wu, D.J. and Liu, C.R., "An Analytical Model of Cutting Dynamics, Part I-Model Building," *ASME Transactions, Journal of Engineering for Industry*, Vol. 107, No. 2, pp. 107-111, May 1985.

9. Wu, D.J. and Liu, C.R., "An Analytical Model of Cutting Dynamics, Part II-Verification," *ASME Transactions, Journal of Engineering for Industry*, Vol. 107, No. 2, pp. 112-118, May 1985.

10. Liu, C.R. and Glaser, I., "The Structure of High Level Computer Language for Programmable Assembly," *International Journal of Computers and Industrial Engineering*, Vol. 9, No. 3, pp. 203-214, 1985.

11. Liu, C.R. and Liu, T.M., "Automated Chatter Suppression by Tool Geometry Control," *ASME Transactions, Journal of Engineering for Industry*, Vol. 107, No. 2, pp. 95-98, May 1985.

12. Srinivasan, R., Liu, C.R. and Fu, K.S., "Extraction of Manufacturing Details from Geometric Models," *International Journal of Computers and Industrial Engineering*, Vol. 9, No. 2, pp. 125-133, 1985.

13. Liu, C.R. and Lin, Z.C., "Effects of Shear Plane Boundary Condition on Stress Loading in Machining," *International Journal of Mechanical Science*, Vol. 27, No. 5, 1985.

14. Donmez, M.A., Blomquist, D., Hocken, R.J., Liu, C.R. and Barash, M.M., "A General Methodology for Machine Tool Accuracy Enhancement by Error Compensation," *Precision Engineering*, Vol. 8, No. 4, 1986.

15. Joshi, S., Chang, T.C. and Liu, C.R., "Process Planning Formalization in an AI Framework," *International Journal of Artificial Intelligence in Engineering*, Vol. 1, No. 1, pp. 45-53, 1986.

16. Ferreira, P. and Liu, C.R., "An Analytical Quadratic Model for Machine Errors," *Journal of Manufacturing Systems*, Vol. 5, No. 1, April 1986.

17. Ferreira, P.M. and Liu, C.R., "A Contribution to the Analysis and Compensation of the Geometric Error of a Machining Center," *Annals of CIRP*, (International Institution for Production Engineering Research), Vol. 35, No. 1, 1986.

18. Matsumoto, Y., Barash, M.M. and Liu, C.R., "Effect of Hardness on the Surface Integrity of AISI 4340 Steel," *ASME Transactions, Journal of Engineering for Industry*, Vol. 108, pp. 169-175, August 1986.

19. Matsumoto, Y., Barash, M.M. and Liu, C.R., "Cutting Mechanism During Machining of Hardened Steel," *Journal of Material Science and Technology*, The Institute of Metals, Vol. 3, pp. 299-305, 1987.

20. Ferreira, P.M. and Liu, C.R., "Generation of Workpiece Orientation for Machining Using a Rule Based System," *Journal of Robotics and CIM*, Vol. 4, No. 3/4, 1988.

21. Trappey, J.F.C., Liu, C.R. and Chang, T.C., "Fuzzy Non-Linear Programming: Theory and Application in Manufacturing," *International Journal of Production Research*, Vol. 26, No. 2, pp. 975-985, 1988.

22. Roy, U. and Liu, C.R., "Establishment of Functional Relationships between the Product Components in Assembly Database," *Computer-Aided Design*, Vol. 20, No. 10, pp. 570-580, 1988.

23. Wu, M.C., Bajaj, C. and Liu, C.R., "A Face Evaluation Algorithm for Solid in CSG Representation," *Computer-Aided Design*, Vol. 20, No. 2, pp. 75-83, 1988.

24. Trappey, J.C. and Liu, C.R., "A Literature Survey of Fixture Design Automation," *Journal of Advanced Manufacturing Technology*, 1989.

25. Roy, U., Pollard, M.D., Mantooth, K. and Liu, C.R., "Tolerance Representation Scheme in Solid Model: Part I," *Advances in Design Automation*, Vol. 1, 1989, *Computer-Aided and Computational Design*, ASME, DE-Vol.19-1, pp. 1-10, September 17-21, 1989.

26. Roy, U., Mantooth, K., Pollard, M.D. and Liu, C.R., "Tolerance Representation Scheme in Solid Model: Part II," A*dvances in Design Automation*, 1989, Vol. 1, *Computer-Aided and Computational Design*, ASME, DE-Vol.19-1, pp. 11-17, September 17-21, 1989.

27. Trappey, J. C., and Liu, C. R., 1990, "A literature survey of fixture design automation," International Journal of Advanced Manufacturing Technology, Vol. 5, pp. 240-255. (SCI)

28. Wu, M.C. and Liu, C.R., "Flexible Process Planning for Finish Machining Based on Process Requirement Modeling," *International Journal of Computer Integrated Manufacturing*, Vol. 4, No. 2, pp. 121-132, 1991.

29. Lin, Z.C., Lin, Y.Y. and Liu, C.R., "Effects of Thermal Load and Mechanical Load on the Residual Stress in a Machined Surface," *International Journal of Mechanical Sciences*, Vol. 33, No. 4, pp. 263-278, 1991.

30. Roy, U., Liu, C. R. and Woo, T., "A Review of Dimensioning and Tolerancing: Representation and Processing," *Computer-Aided Design*, Vol. 3, No. 7, pp. 466-483, September 1991.

31. Trappey, A.J.C., Liu, C.R. and Matrubhutam, S., "An Integrated System Shell Concept for Design and Planning," *Journal of Design and Manufacturing*, Vol. 2, pp. 1-17, 1992.

32. Trappey, A.J.C. and Liu, C.R., "Automated Fixture Configuration Using Projective Geometry Approach," *International Journal of Advanced Manufacturing Technology*, Vol. 8, pp. 297-304, 1992.

33. Jan, H.K., Chu, C.N. and Liu, C.R., "A Configuration Independent Error Model of Machine Tools: Hyper-patch Model and Metrology Pallet," *International Journal of Robotics and Computer Integrated Manufacturing*, Vol. 9, No. 3/4, pp. 201-210, 1992.

34. Mou, J. and Liu, C.R., "A Method for Enhancing the Accuracy of CNC Machine Tools for On-Machine Inspection," *Journal of Manufacturing Systems*, Vol. 11, No. 4, pp. 229-237, 1992.

35. Trappey, A.J.C. and Liu, C.R., "An Automatic Workholding Verification System," *Robotics and Computer-Integrated Manufacturing*, Vol. 9, No. 4/5, pp. 321-326, 1993.

36. Roy, U. and Liu, C.R., "Integrated CAD Frameworks: Tolerance Representation Scheme in a Solid Model," *Computers and Industrial Engineering Journal*, Vol. 24, No. 3, pp. 495-509, 1993.

37. Jang, J. and Liu, C.R., "Estimating the Reduction in Labor Hours due to a New Technology Under Uncertain Demand," *International Journal of Production Economics*, Vol. 29, pp. 211-222, 1993.

38. Ferreira, P.M. and Liu, C.R., "A Method for Estimating and Compensating Quasistatic Errors of Machine Tools," *ASME Transactions, Journal of Engineering for Industry*, Vol. 115, pp. 149-159, February 1993.

39. Lin, Z.C. and Liu, C.R., "The Influence of the Degree of Constraint on the Residual Stress of the Machined Workpiece," *Computer Methods in Applied Mechanics and Engineering*, Vol. 108, pp. 37-52, 1993.

40. Liu, C.R., "Automation of Manufacturing Industry in Taiwan (China)," Proceedings of the 2nd International Conference on Manufacturing Technology, December 1993.

41. Mou, J. and Liu, C.R., "A Methodology for Machine Tool Errors Correction -- An Adaptive Approach," *Computer Controlled Machines*, Proceedings of the ASME Winter Annual Meeting, PED-Vol. 64, pp. 69-81, 1993.

42. Jang, J. and Liu, C.R., "A Waiting Time Estimation in a Manufacturing System using the Number of Machine Idle Periods," *European Journal of Operational Research*, 74, 1994.

43. Mou, J. and Liu, C.R., "An Error Compensation Method for CNC Machine Tools using Reference Parts," *Transactions of the North American Manufacturing Research Institute of SME*, 1994.

44. Mou, J. and Liu, C.R., "An Adaptive Methodology for Machine Tool Errors Correction," *ASME Transactions, Journal of Engineering for Industry*, Vol. 117, No. 3, pp. 389-399, August 1995.

45. Mukherjee, A. and Liu, C.R., "Computable Representation of Function-Form Relationships for the Conceptual Design of Stamped Metal Parts," *Journal of Research in Engineering Design*, Vol. 7, pp. 253-269, 1995.

46. Liu, C.R. and Mittal, S., "Single Step Superfinishing Using Hard Turning Resulting in Superior Surface Integrity," *Journal of Manufacturing Systems*, Vol. 14, No. 2, pp. 124-133, 1995.

47. Wu, M.C. and Liu, C.R., "An Analysis on Machined Feature Recognition Techniques Based on B-Rep," *Journal of Computer-Aided Design*, Vol. 28, No. 8, pp. 603-616, 1996.

48. Liu, C.R. and Mittal, S., "Single-step Superfinish Hard Machining: Feasibility and Feasible Cutting Conditions," *Robotics and Computer Integrated Manufacturing*, Vol. 12, No. 1. pp. 15-27, 1996.

49. Mou, J. and Liu, C.R., "An Innovative Approach to Increase the Accuracy of Multi-Axis Machines for Process-Intermittent Inspection," *ASME Journal of Manufacturing Science and Engineering*, Vol. 118, No. 4, pp. 585-594, November 1996.

50. Muhkerjee, A. and Liu, C.R., "Conceptual Design, Manufacturability Evaluation and Preliminary Process Planning Using Function-form Relationships in Stamped Metal Parts," *Robotics and Computer Integrated Manufacturing*, Vol. 12, No. 1, pp. 15-27, 1996.

51. Lin, Z.C., Lai, W.L., Lin, H.Y. and Liu, C.R., "Residual Stresses with Different Tool Flank Wear Lengths in the Ultra-Precision Machining of Ni-P Alloys," *Journal of Materials Processing Technology*, Vol. 65, pp.116-126, 1997.

52. Mittal, S. and Liu, C.R., "A Method of Modeling Residual Stress in Superfinish Hard Turning," *Wear*, 218, pp. 21-33, 1998.

53. Wang, J.Y. and Liu, C.R., "A New Concept for Decoupling the Cutting Forces due to Tool Flank Wear and Chip Formation in Hard Turning," *Journal of Machining Science and Technology*, Vol. 2, No. 1, pp. 77-90, 1998.

54. Liu, C.R. and Mittal, S., "Optimal Pre-stressing the Surface of a Component by Superfinish Hard Turning for Maximum Fatigue Life in Rolling Contact," *Wear*, 219, pp. 128-140, 1998.

55. Wang, J.Y. and Liu, C. R., "Effect of Tool Flank Wear on the Heat Transfer, Thermal Damage and Cutting Mechanics in Finish Hard Turning," *CIRP Annals*, Vol. 48/1, pp. 80-83, 1999.

56. Yang, X and Liu, C.R., "Machining Titanium and its Alloys," *Journal of Machining Science and Technology*, Vol. 3, No. 1, pp. 107-139, 1999.

57. Liu, C.R. and Guo, Y., "Finite Element Analysis of the Effect of Sequential Cut and Tool-chip Friction on Residual Stresses in a Machined Layer," *Journal of Mechanical Sciences*, 42, pp. 1069-1089, 2000.

58. Guo, Y. B. and Liu, C.R., "Residual Stress Formation Mechanism and its Control by Sequential Cuts," *Trans. Of NAMRI / SME*, Vol. XXVIII, pp. 179-184, 2000.

59. Agha, Salah R. and Liu, C. Richard "Experimental Study on the Performance of Superfinish Hard Turned Surfaces in Rolling Contact," *WEAR*, 244, pp. 52-59, 2000.

60. Liu, C. R., and Yang, X., "The Scatter of Residual Stresses due to Machining and Grinding," *Journal of Machining Science and Technology*, Vol. 5, No.1, pp. 1-22, 2001.

61. Jang, J. J., Suh, Jungdae and Liu, C, Richard, "A New Procedure to Estimate Waiting Time in GI/G/2 System by Server Observation," *Computers and Operations Research*, 28, pp. 597-611, 2001.

62. Jang, Jaejin, Suh, Jungdae, Park, Namkyu and Liu, C. Richard, "A Look-Ahead Routing Procedure for Machine Selection in a Highly Informative Manufacturing System," *International Journal of Flexible Manufacturing Systems*, 13, pp. 287-308, 2001.

63. Guo, Y. and Liu, C. R., "Mechanical Properties of Hardened AISI52100 Steel in Hard Machining Processes," *Trans. ASME, Journal of Manufacturing Science and Engineering*, Vol. 124, No. 1, pp 1-9, February 2002.

64. Guo, Y. B. and Liu, C. R., "3D FEA Modeling of Superfinish Hard Turning," *Trans. ASME, Journal of Manufacturing Science and Engineering*, Vol.124, No.89, pp.189-199, May 2002.

65. Y.B. Guo, C.R. Liu, 2002, "FEM Analysis of Residual Stress Distribution and Formation Mechanisms in Machining," *Int. J. of Mach. Sci. Tech.*, 6(1), pp. 21-41.

66. Guo, Y. B. and C. R. Liu , 'FEM ANALYSIS OF MECHANICAL STATE ON SEQUENTIALLY MACHINED SURFACES', Machining Science and Technology, 6:1, 21 – 41, 2002.

67. Yang, Xiaoping, Liu, C. Richard and Grandt, A.F., "An Experimental Study on Fatigue Variance, Residual Stress Variance, and Their Correlation of Faced and Ground Ti 6Al-4V Samples," *Trans. ASME Journal of Manufacturing Science and Engineering*, **124**(4), pp. 809- 819, 2002.

68. Yang, Xiaoping and Liu, C. Richard, "A Methodology of Predicting the Variance of Fatigue Life Incorporating the Effects of Manufacturing Processes," *Trans. ASME Journal of Manufacturing Sciences and Engineering*, 124(3), pp. 745-753, 2002.

69. Yang, Xiaoping and Liu, C. R., "A New Stress-Based Model of Friction Behavior in Machining and Its Significant Impact on Residual Stresses Computed by Finite Element Method," *International Journal of Mechanical Sciences*, 44(4), pp. 703-723, 2002.

70. Gebraeel, N., Lawley, M., Liu, C.R. and Parmeshwaran, V., "Residual Life Predictions from Vibration Based Degradation Signals: A Neural Net Approach," *IEEE Transactions on Industrial Electronics*, Vol. 51, Number 3, pp.694-700, 2004.

71. Shi, J. and Liu, C.R., "Role of Nano-scale TiC Particles in Batch Annealing of Ti Stabilized Interstitial Free Steels," *Materials Science and Technology*, Vol. 20, pp.1192-1198, 2004.

72. Shi, J. and Liu, C.R., "Flow Stress Property of Hardened Steel with Tempering Effect," *International Journal of Mechanical Sciences*, Vol. 46(6), pp. 891-906, 2004.

73. Shi, J. and Liu, C.R., "Decomposition of Thermal and Mechanical Effects on the Microstructure and Hardness of Hard Turned Surface," *Journal of Manufacturing Science and Engineering*, Vol. 126(3), pp. 264-273, 2004.

74. Shi, J. and Liu, C.R., "The Influence of Material Models on Finite Element Simulation of Machining," *Journal of Manufacturing Science and Engineering*, Vol. 126(4), 2004, 849-851.

75. Zhang,XP, Liu, C. R., Yao,ZQ, "Investigational Advances in Residual Stresses by Hard Turning ", ADVANCES IN MATERIALS MANUFACTURING SCIENCE AND

TECHNOLOGY, MATERIALS SCIENCE FORUM 471-472(9): 523-527.(IDS:BBF53) 2004.

76. Shi, J. and Liu, C.R., "On Predicting Chip Morphology and Phase Transformation in Hard Machining," *International Journal of Advanced Manufacturing Technology*, Vol. 25(5), March 2005.

77. Shi, J. and Liu, C.R., "On Predicting Material Softening Effect in Hard Turning –Part I Construction of Material Softening Model," *Journal of Manufacturing Science and Engineering*, Vol. 127(3), 2005.

78. Shi, J. and Liu, C.R., "On Predicting Material Softening Effect in Hard Turning –Part II Finite Element Modeling and Verification," *Journal of Manufacturing Science and Engineering*, Vol. 127(3), 2005.

79. Yang, X. and Liu, C. R., "Investigating Machining Impact on Fatigue Variance – A Manufacturing Quality Perspective," *ASME Transactions, Journal of Manufacturing Science and Engineering*, Vol. 127, August 2005. pp 492-502.

80. Yang, X. and Liu, C. R., "The Impact of Hole Making Processes on the Fatigue Life Variance of the Machined Components," *Machining Science & Technology*, 9:463-479, 2005.

81. Huang, R., Xi, L., Liu, C. R. and Lee, J., "The Framework, Impacts and Commercial Prospects of a New Predictive Maintenance System-Intelligent Maintenance System," *Production Planning & Control*, Vol. 16, No. 7, pp 652-664, 2005.

82. Choi, Y., and Liu, C. R., 2006, "Rolling Contact Fatigue Life of Finish Hard Machined Surfaces: Part 1. Model Development," Wear, **261**, pp. 485-491. (ScienceDirect Top 25 Hottest Articles).

83. Choi, Y., and Liu, C. R., 2006, "Rolling Contact Fatigue Life of Finish Hard Machined Surfaces: Part 2. Experimental Verification," Wear, **261**, pp. 492-499.

84. Huang, R., Xi, L., Liu, C. R. and Lee, J., "Prognostics for Ball Bearing based on Neural Networks and Morlet Wavelet," *Materials Science Forum*, Vols. 505-507, 2006.

85. Shi, J., Wang, JY., and Liu, C.R. "Modeling White Layer Thickness Based on the Cutting Parameters of Hard Machining," Proc. IMechE Vol. 220 Part B: J. Engineering Manufacture, 220, B2, 2006, p.p. 119-128.

86. Shi, J. and Liu, C. R., "On predicting chip morphology and phase transformation in hard machining," Int. J. Advanced Manufacturing Technology, Volume 27, Numbers 7-8/ January, 2006. p.p. 645-654.

87. Choi, Y., and Liu, C. R., 2007, "Spall progression life model for rolling contact

verified by finish hard machined surfaces," 2007 Wear, **262**, pp. 24-35.

88. Huang, R., Xi, L., Liu, C. R., Qiu, H. and Lee, J., "Residual Life Predictions for Ball Bearing based on Self-Organizing Map and Back Propagation Neural Network," Mechanical Systems and Signal Processing, **21**(2007)193-207.

89. Zhang, X.P., C. R. Liu, Z. Q. Yao, "Experimental study and evaluation methodology on hard surface integrity," Int. Journal of Advanced Manufacturing Technology, 34(8):141-148, 2007. (SCI&EI)

90. C. Richard Liu and Youngsik Choi, 2008, "A New Methodology for Predicting Crack Initiation Life for Rolling Contact Fatigue Based on Dislocation and Crack Propagation," International Journal of Mechanical Sciences, Vol. 50, pp. 117-123. (ScienceDirect Top 25 Hottest Articles).

91. Huang, R., Xi, L., Liu, C. R. and Lee, J.,"Modeling and Analyzing a Joint Optimization Policy of Block Replacement and Spare Inventory with Random Lead-time: Existence and Uniqueness of Minimum," *IEEE Transactions on reliability*, Accepted for publication, 2008.

92. C. Richard Liu and Youngsik Choi, 2008, "Rolling Contact Fatigue Life Model Incorporating Residual Stress Scatter," International Journal of Mechanical Sciences, Vol. 50, pp. 1572-1577 (ScienceDirect Top 25 Hottest Articles).

93. Youngsik Choi and C. Richard Liu, 2009, "Performance of Nano/micro CBN Particle Coated Tools in Superfinish Hard Machining," International Journal of Machine Tools and Manufacture, Vol. 49, pp. 683-689 (ScienceDirect Top 25 HottestArticles).

94. Y. Choi and C.R. Liu, 2009, " Effect of Tool Wear on Rolling Contact Fatigue Performance of Superfinish Hard Machined Surfaces", *Int. J. Mechantronics and Manufacturing Systems*, Vol. 2, pp. 480-489.

95. Zhang, Xueping, Guo, Erwei, C. Richard Liu, 2009, "Optimization of process parameter of residual stresses for hard turned surfaces," J. Material Processing Technology, volume 209, Issue 9, May 2009, pp. 4286-4291.

96. Shichang Du, Lifeng Xi, Ershun Pan and C. Richard Liu, 2009, "Design of Measurement system for quality improvement in Multi-stage Manufacturing Systems", Int. J. Radio Frequency Identification Technology and Applications, Vol. 2, No.3-4/2009, pp165-182.

97. J. Byun, C.R. Liu, 2010, "IMPROVING CHUCKING ACCURACY AND REPEATABILITY BY REDUCING KINEMATIC REDUNDANCY," ASME J. of Mfg. Sci. Eng., Vol. 132, p. 064501

98. Shi, J., and Liu, C.R., "Two-step cutting as a tool for improving surface integrity and rolling contact fatigue performance of hard machined surfaces," Materials and Manufacturing Processes, 2010, 25(6), pp. 495 - 502.

99. ZHANG, X., Wu, S., Wang, H., and C. R. LIU, "Predicting the effects of cutting parameters and tool geometry on hard turning process using finite element method", *Journal of Manufacturing Science and Engineering, Transactions of the ASME, volume 133, issue 4. 2011.* **art. no. 1010.**

100. Shi, J., Shi, Y., and Liu, C.R., "Evaluation of three dimensional single point turning at atomistic level by molecular dynamics simulation," International Journal of Advanced Manufacturing Technology, 2011, 54 (1-4) pp. 161-171.

101. Dong Lin, Martin Yi Zhang, Chang Ye, Zhikun Liu, C. Richard. Liu, Gary J. Cheng, 2011, "Large scale, highly dense nanoholes on metal surfaces by Underwater laser assisted hydrogen etching near nanocrystalline boundary" Applied Surface Science, http://dx.doi.org/10.1016/j.apsusc.2011.12.065

102. D. Lin, S. Suslov, C Ye, YL Liao, C. R. Liu, GJ Cheng, 2012, "Laser Assisted Embedding of Nanoparticles into Metallic Materials ", *Applied Surface Science*, Vol. 258, Issue 7, 2012, pp2289-2296.

103. Voothaluru R., Liu C. R., and G. J. Cheng, 2012,"Finite Element Analysis of the Effect of Variations in Residual Stress in Laser Shock Peening of Steels", ASME Journal of Manufacturing Sciences and Engineering, DECEMBER 2012, Vol. 134 / 061010-1/8.

104. Rohit Voothaluru, C. Richard Liu, 2013, "Determination of Lattice Level Energy Efficiency For Fatigue Crack Initiation", Fatigue Fract Engng Mater Struct 00, 1–9, 2013.

105. Rohit Voothaluru, C. Richard Liu, 2014, "A Crystal Plasticity based Methodology for Fatigue Crack Initiation Life Prediction in Polycrystalline Copper", Fatigue & Fracture of Engineering Materials & Structures, Volume 37, Issue 6, pages 671–681, June 2014. Article first published online: 27 JAN 2014, DOI: 10.1111/ffe.12152

106. Dong Lin, S Suslov, C Ye, C. R. Liu, G. J. Cheng, 2013, Laser shock peened TiN nanoparticle integrated AISI 4140 and its mechanical properties improvement, *Journal of Applied Physics*, 113, 133509 (2013)

107. Xueping Zhang, C. Richard Liu, Liqiang Ding, 2013, "Finite element modeling on dislocation density and grain size evolution in machined surface", Accepted for publication, ASME Journal of Manufacturing Sciences and Engineering, MANU-13-1225.

108. Liu, Zhikun and Liu.C.Richard, 2013, "Laser Induced Chemical Solution Deposition of Nanomaterials: A Novel Process Demonstrated by Manufacturing SnO_2 Nanotubes," Manufacturing Letters, 1(2013), 35-42. (available online September 28, 2013)

109. Nian, Qiong, C. Richard Liu, Gary J. Cheng, 2013, "Laser assisted electro-deposition of earth abundant Cu2ZnSnS4 photovoltaic thin film" Manufacturing Letters, 1(2013), 54-58. (available online October 8, 2013) SME/NAMRIC, Elsevier.

110. Rohit Voothaluru, C. Richard Liu, 2014, "A Crystal Plasticity based Methodology for Fatigue Crack Initiation Life Prediction in Polycrystalline Copper", Fatigue & Fracture of Engineering Materials & Structures, Volume 37, Issue 6, pages 671–681, June 2014. Article first published online: 27 JAN 2014, DOI: 10.1111/ffe.12152

111. Liu, Z.; Liu, C. R., 2014,"Laser-induced solution synthesis and deposition: A generic method to make metal chalcogenide nanotubes at high rate with high consistency," Journal of Nanoengineering and Nanosystems, 2014, Vol. 228(2) 66–72, June 2014. (appear as the first paper in the issue, originally published online 30 December 2013, DOI: 10.1177/1740349913515202.)

112. Liu, Zhikun and Liu. C. Richard, 2014," Laser Induced Chemical Deposition of Ferrihydrite Nanotubes: Exploring Growth Rate and Crystal Structure", ASME J. Micro Nano-Manuf., Volume 2, Issue 1, pp 1-6. March 01, 2014 | (appear as the first paper in the issue.) Paper No: JMNM-13-1066; doi:10.1115/1.4026546: Received August 27, 2013; Revised January 17, 2014.

113. Lin D., C. Richard Liu, Gary J. Cheng, 2014, "Laser Sintering of Separated and Uniformly distributed Multiwall Carbon Nanotubes Integrated Iron Nanocomposites", Journal of Applied Physics 115, Issue 11, 113513 (2014); doi: 10.1063/1.4869214 View online: http://dx.doi.org/10.1063/1.4869214 .

114. Lin, Dong; C. Richard Liu, Gary J. Cheng, 2014 "Single-layer graphene oxide reinforced metal matrix composites by laser sintering: Microstructure and mechanical property enhancement", Acta Materialia, Volume 80, November 2014, Pages 183–193.

115. Liu, Zhikun, Zeyuan Cao, Biwei Deng, Yuefeng Wang, Jiayi Shao, Prashant Kumer, C. Richard Liu, Bingqing Wei, and Gary Cheng, 2013d, "Ultrafast and scalable laser liquid synthesis of tin oxide nanotubes and its application in lithium ion batteries", *Nanoscale*, 2014, 6, 5653.

Refereed Conference Papers

1. Liu, C.R. and Barash, M.M., "The Subsurface Condition Created by Chip Removal in a Low Carbon Steel Component," *Supplement to the Proceedings,* Institute of Mechanical Engineers, 1974.

2. Barash, M.M. and Liu, C.R., "Residual Stress and Other Indices of the Mechanical State of Machined Surfaces," *Advances in Materials Technology in the Americas - 1980*, Vol. 2, ASME, pp. 171-177, August 1980, (Editor: I. LeMay).

3. Matsumoto, Y, Barash, M.M. and Liu, C.R., "Residual Stress in the Machined Surface of Hardened Steel," *High Speed Chip Removal: Theory, Research, and Practice,* ASME Bound Volume, pp. 192-204, December 1984.

4. Liu, C.R., Lin, Z.C. and Barash, M.M., "Thermal and Mechanical Stresses in the Workpiece During Machining," *High Speed Machining*, ASME Bound Volume, PED-Vol. 12, pp. 181-192, December 1984.

5. Liu, C.R., Lin, Z.C. and Barash, M.M., "Effects of Plane Strain and Plane Stress Conditions on Stress Field in the Workpiece During Machining--An Elasto-plastic Finite Element Analysis," *High Speed Machining*, ASME Bound Volume, PED-Vol. 12, pp. 167-180, December 1984.

6. Srinivasan, R. and Liu, C.R., "Automated Generation of Material Removal Distribution in Processing Planning," *Computer-Integrated Manufacturing and Robotics*, ASME Bound Volume, pp. 293-302, December 1984.

7. Lin, Y.T. and Liu, C.R., "A Comparison of Self-Tuning and Forecasting Compensatory Methods in Geometrical Adaptive Control," *Sensors and Controls in Automated Manufacturing Systems*, ASME Bound Volume, November 1985.

8. Wu, M.C. and Liu, C.R., 1985, "Automated Process Planning and Expert Systems," *Proceedings of the 1985 IEEE International Conference on Robotics and Automation*, 1985.

9. Ferreira, P., Kochar, B. and Liu, C.R., "AIFix: An Expert System for Designing Work Holding Devices," *Automated Process Planning Systems*, ASME Bound Volume, November 1985.

10. Ferreira, P., Puls, F., Chang, T.C. and Liu, C.R., "A CAD/CAM System for Complex Surfaces," *Computer Aided/Intelligent Process Planning*, ASME Bound Volume, November 1985.

11. Donmez, M.A., Liu, C.R. and Barash, M.M., "A Generalized Mathematical Model for Machine Tool Errors," ASME Bound Volume, PED-Vol. 23/DSC-Vol. 4, 1985.

12. Srinivasan, R., and Liu, C.R., "Evolutionary Trends in Generative Process Planning," a chapter in Computer-Aided Design and Manufacturing, Methods and Tools, (Rembold and Dillmann, Editors), 2nd Ed., Springer-Verlag, 1986.

13. Donmez, A.K, Lee, K., Liu, C.R. and Barash, M.M., "A Real-Time Error Compensation System for a Computerized Numerical Control Turning Center," *Proceedings of 1986 IEEE International Conference on Robotics and Automation*, 1986.

14. Liang, G.R. and Liu, C.R., "Automatic NC Programming as a Decomposable Frame Problem," *Integrated Intelligent Manufacturing*, ASME Bound Volume, December 1986.

15. Yu, Y.C., Liu, C.R. and Kashyap, R.L., "A Variational Solid Model for Mechanical Parts," *Integrated Intelligent Manufacturing*, ASME Bound Volume, December 1986.

16. Chang, T.C., Liu, C.R. and Kashyap, R.L., "Integrated Process Planning Approach for Machining," *Proceedings, ORSA/TIMS National Meeting*, New Orleans, May 1986.

17. Chang, T.C. and Liu, C.R., "Process Planning Formalization in an A.I. Framework," *Proceedings, ASME Computers in Engineering Conference*, May 1986.

18. Liu, C.R., Ferreira, P.M., Liang, G.R. and Srinivasan, R., "Technological Developments in Intelligent Manufacturing Systems," *Intelligent Manufacturing Systems*, 1987.

19. Srinivasan, R. and Liu, C.R., "On Some Important Issues in Generative Process Planning of Machining Operations," *Proceedings of the 19th CIRP International Seminar on Manufacturing Systems*, June 1987.

20. Liang, G.R. and Liu, C.R., "Logic Approach to Surface Generating Problem," *Integrated and Intelligent Manufacturing*, ASME Bound Volume, 1987.

21. Liu, Z.C., Liu, Y.Y. and Liu, C.R., "A Model of Residual Stress in the Machined Workpiece," *Proceedings of the 20th Midwestern Mechanics Conference*, August 1987.

22. Lin, Y.T. and Liu, C.R., "Geometric Adaptive Control for Roundness Using Multi-probe Measurement," *Modeling, Sensing and Control of Manufacturing Systems*, ASME Bound Volume, PED-Vol. 27, December 1987.

23. Ferreira, P.M. and Liu, C.R., "A Method for Estimating and Compensating Quasistatic Errors of Machine Tools," *Quality: Design, Planning and Control*, ASME Bound Volume, December 1987.

24. Roy, U. and Liu, C.R., "Feature Based Representational Scheme of a Solid Modeler for Providing Dimensioning and Tolerancing Information," *Robotics and Computer-Integrated Manufacturing, an International Journal*, Vol. 4, No. 3/4, 1988, pp. 335-345. (Also presented at the International Conference on the Manufacturing Science and Technology of the Future, MIT, Cambridge, USA, June 1987.)

25. Trappey, J.F.C., and Liu, C.R., "Issues of Automatic Fixture Design in Computer Integrated Manufacturing Systems," Robotics and Automation (Santa Barbara Conference), IASTED, pp. 149-154, 1988.

26. Chao, P.Y. and Liu, C.R., "Intelligent Control of Machining Parameters," Proceedings, International Conference on CAD/CAM/CIM and Robotics: Contribution of Artificial Intelligence, ADESO, and March 1988.

27. Liu, C.R., et al., "Technological Development in Intelligent Manufacturing Systems," Chapter I, Intelligent Manufacturing Systems I, (V.R. Milacic, Ed.), Elsevier, Amsterdam, 1988.

28. Trappey, A.J.C. and Liu, C.R., "Issues of Automatic Fixture Design in Computer Integrated Manufacturing Systems," *Proceedings, IASTED International Conference, Robotics & Automation,* Santa Barbara, CA, pp. 149-154, 1988.

29. Chao, P.Y. and Liu, C.R., "Determination of Machining Parameters Based on a Heuristic Model of Machinability," *Advances in Manufacturing Systems Engineering*), ASME Bound Volume, December 1988.

30. Trappey, J.C. and Liu, C.R., 1989, "An Automatic Work-holding Verification System," Proceedings, International Conference on Manufacturing Science & Tech. of the Future (MSTF '89), Stockholm Sweden, June 6-9.

31. Wu, M.C. and Liu, C.R., "Process-Based Workpiece Representation for Generating Flexible Process Plans," Proceedings of the 3rd ORSA/TIMS Conference on Flexible Manufacturing Systems, Boston, August 1989.

32. Kreng, B.V., Liu, C.R. and Chu, C.N., "A Compact Three-Dimensional Error Model of Machine Tools," *Control Issues in Manufacturing*, ASME Bound Volume, December 1989.

33. Chao, P.Y., and Liu, C.R., "A Methodology for Determining Machining Conditions Based on Machinability Classification for Autonomous Machining Systems," *Control Issues in Manufacturing,* ASME Bound Volume, December 1989.

34. Liu, C.R. and Trappey, J.F., "A Structured Design Methodology and Meta Designer: A System Shell Concept for Computer-Aided Creative Design," *ASME Conference of Design Automation,* Bound Volume, Montreal, Canada, September 1989.

35. Roy, U., Banerjee, P. and Liu, C.R. "Design of an Automated Assembly Environment," *Computer Aided Design*, Vol. 21, No. 9, pp. 561-569, 1989. (Also published in *Robotics, Automation and Management in Manufacturing Bulletin*, Vol. 7, Issue 1, January 1990.)

36. Chao, P.Y. and Liu, C.R., "A Literature Review of Machinability," *Proceedings of the ASME Manufacturing International 90,* March 1990.

37. Trappey, A.J.C. and Liu, C.R., "Automatic Generation of Configuration for Fixturing an Arbitrary Workpiece Using Projective Spatial Occupancy Enumeration Approach," *Proceedings, Symposium on Advances in Integrated Product Design and Manufacturing,* ASME Winter Annual Meeting, Dallas, TX, November 25-30, pp. 191-202, 1990.

38. Trappey, A.J.C. and Liu, C.R., "An Integrated System Shell Concept for Computer Aided Design and Planning," *Proceedings, Joint US/German Conference on New Directions for Operations Research in Manufacturing, NIST,* Gaithersburg, MD, July 30-31, pp. 425-444, 1991.

39. Kreng, V.B. and Liu, C.R., "A Machine Learning Approach to Improve Design Creativity," *AAAI Conference, Workshop on Creativity,* July 1991.

40. Gupta, P., Trappey, A.J.C. and Liu, C. R., "Using Optimization Model to Control Work-Piece Rigidity and Deformation in Work-Holding to Achieve Precision Machining," Proceedings, Joint German/US Conference on Recent Developments and New Perspectives of OR in the Area of Production Planning and Control -- Lecture Notes in Economics and Mathematical Systems, Hagen, Germany, Springer-Verlag Publishing Company, June 25-26, 1992.

41. Jan, H.K. and Liu, C.R., "Artificial Neural Network as a Solution to Predict 3-D Workspace Distortion in Real-Time," *IEEE, International Neural Network Society, International Joint Conference on Neural Networks (IJCNN)\fR*, Baltimore, MD, Vol. 2, pp. 489-503, 1992.

42. Jan. H.K. and Liu, C.R., "Predicting Machine Low-Frequency Domain Errors by Finite Information Mapping Using Artificial Neural Network," *International Federation of Automatic Control (IFAC) Conference on Intelligent Manufacturing System*, Dearborn, MI, October 1-2, 1992.

43. Jan. H.K. and Liu, C.R., "Using Neurocomputing Based Multi-Channel Sensory System for Real-Time Manufacturing Quality Evaluation," *ASME Winter Annual Meeting, Symposium on Sensors and Signal Processing for Manufacturing*, Anaheim, CA, November 8-13, 1992.

44. Kreng, V.B. and Liu, C.R., "An Intelligent Knowledge Management Environment for Part-Machine Cell Formation," *Proceedings of the ASME Winter Annual Meeting*, December 1992.

45. Jan, H.K. and Liu, C.R., "Neural Adaptive Systems for Machining Errors Modeling," Neural Networks in Design and Manufacturing, (Editors: J. Wang and Y. Takefuji), World Scientific Publishing Company, Pte. Ltd., 1993.

46. Mou, J. and Liu, C.R., "A Robust Error Correction Method for Multi-Axis Machines," *Proceedings of the ASME Winter Annual Symposium on Mechantronics in Manufacturing*, 1994.

47. Lin, Z.C., Lai, W.L., Lin, H.Y. and Liu, C.R., "A Simulation of Super Precision Cutting Process of NiP Alloy," *Proceedings of the First Asia-Pacific International Conference on Progress of Cutting and Grinding*, pp. 195-200, September 1994.

48. Liu, C.R. and Mukherjee, A., "A Review of Design Research -- A Frontier in Concurrent and Integrated Engineering," *Proceedings of the Third International Conference on Manufacturing Technology*, pp. 104-112, 1995.

49. Liu, CR. and Agha, S., "Experimental Study of Pre-Stressing Capability of Superfinish Hard Turning through Residual Stress Generation," ASME Symposium on Quality of Traditionally and Non -traditionally Machined Surfaces, November 1997.

50. Mou, J. and Liu, C.R. "A Review on Machine Error Modeling and Compensation," Invited Presentation, *Proceedings of the International Conference on Precision Engineering*, Taipei, Taiwan, November 1997.

51. Wang, J.Y. and Liu, C.R., "On the Forces and Temperatures due to Flank Wear in Hard Turning," *Manufacturing Science and Engineering*, ASME MED, Vol. 8, pp.161-169, 1998.

52. Liu, C. R. and Yang, X., 1999, "A New Perspective of Residual Stress Induced by Machining and Grinding," *Proceedings of the ASME Manufacturing Engineering Division*, Vol. 10, 1999, *International Mechanical Engineering Congress & Exposition*, Nashville, TN, pp. 807-816, November 14 – 19, 1999.

53. Agha, Salah R. and Liu, C. Richard, "On Modeling the Fatigue Performance Based on Residual Stresses Generated by Superfinish Hard Turning," *MED Manufacturing Science and Engineering*, ASME, Liu, C. R., and Yang, Xiaoping, "Design for Manufacturing**,**" Handbook of Industrial Engineering, Wiley-Interscience and IIE, pp.1311—1331, 2001.

54. Shi, J. and Liu, C.R., "Decomposition of Thermal and Mechanical Effects on the Microstructure and Hardness of Hard Turned Surface," NSF Workshop on Unsolved Problems and Research Needs in Thermal Aspects of Material Removal Processes, Oklahoma State University, Stillwater, OK, June 10-12, 2003.

55. Shi and Liu, "Developing Complete Prediction Capability for Thermal Damages in Finish Machining of a Hardened Steel", Proceedings, IMECE 2005-79261, ASME International Mech Eng. Congress, 2005.

.

56. Zhang, Xue-Ping; Song, He-Chuan; Liu, C Richard**, "**White Layer of Hard Turned Surface by Sharp CBN Tool, Journal of Shanghai Jiaoting University (Science). Vol. E-10, no. 4, pp. 377-380. 2005.

57. Y. Choi and C.R. Liu, 2008, "Effect of Tool Wear on Rolling Contact Fatigue Performance of Superfinish Hard Machined Surfaces," Proceedings of the International Conference on Manufacturing Science and Engineering, MSEC_ICMP 2008-72078.

58. Byun, J., Liu, C.R., Improving chucking Accuracy and Repeatability by Reducing Kinematic Redundancy, Proceedings of the 2008 International Manufacturing Science and Engineering Conference, MSEC_ICMP2008-72147

59. Byun, J., Liu, C.R., Methods for Improving Chucking Accuracy, Proceedings of the 2008 International Manufacturing Science and Engineering Conference, MSEC_ICMP2008-72388

60. Wasawat Nakkiew, C. Richard Liu, 2009, Finite Element Analysis for Orthogonal Cuttings of Hardened AISI52100 by Advanced cBN-TiN Composite Coated Tools of two Depositing cBN Particle Sizes, ASME International Manufacturing Science

and Engineering Conference 2009 October 4-7, 2009.

61. C. Richard Liu, Jing Shi, Yuebin Guo and Xiaoping Yang, 2009 "Machining Surface Integrity and Multi-scale Simulation", Invited State of Art Speech, ASME, Int. Manufacturing Science and Engineering Annual Conference 2009.

62. Shenfeng WU, Xueping ZHANG and C. Richard LIU, "Predicting the effects of rake angle, cutting speed and feed rate effect on the chip morphology in hard turning", Proceedings of the 2010 ASME international Manufacturing Science and Engineering Conference. MSEC2010-34071.

63. Xueping ZHANG, Heping WANG and C. Richard LIU, "The effects of tool nose radius and lead angle on hard turning process using 3D finite element mothod", Proceedings of the 2010 ASME international Manufacturing Science and Engineering Conference**.** MSEC2010-34219. (Submitted to *ASME Transactions, Journal of Manufacturing Science and Engineering* for publication.)

64. Voothaluru R., Liu C. R., "Finite Element Analysis of the Effect of Overlapping Impacts of Laser Shock Peening", Proceedings of the 2010 ASME International Manufacturing Science and Engineering Conference, MSEC2010- 34164.

65. Xueping ZHANG, Shenfeng WU, and C. Richard LIU, "The periodical fluctuation of residual stress in hard turned surface and its relationship with chip formation", Proceedings of the 2011 ASME International Manufacturing Science and Engineering Conference. MSEC2011-50197. (submitted for publication in *ASME Transactions, Journal of Manufacturing Science and Engineering)*

66. Liqiang DING, Xueping ZHANG* and C. Richard LIU, "FINITE ELEMENT MODELING ON DISLOCATION DENSITY AND GRAIN SIZE EVOLUTION IN MACHINED SURFACE", ASME Int. Manufacturing Science and Engineering Conference, 2013.

67. Long Meng, Xueping Zhang, C.Richard Liu. Rapid FEM simulation on machining process by Python Language Programming, Journal of Advanced Material Research, (The 4th International Conference on Advanced Manufacturing (ICAM), 4 Mar. ~8 Mar., 2012, Yilan, Taiwan.(Ref. No. s0012)

68. Xueping Zhang, Shenfeng Wu, C.Richard Liu. Decomposing Thermal and Mechanical Effect on the Residual Stress Profile in Hard Turning Surface by Finite Element Method, 2012 ASME International Conference on Manufacturing Science and Engineering. June 4~8, 2012, Notre Dame, Indiana, USA. (No. MSEC2012-7220)

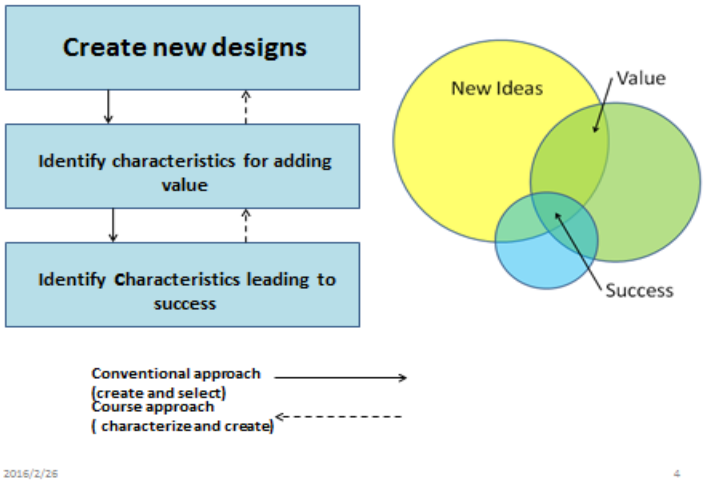
69. Dong Lin, Chang Ye, Sergey Suslov, Yiliang Liao, C. Richard Liu and Gary J. Cheng, 2013,"Mechanism of fatigue performance enhancement in a superhard nanoparticles integrated nanocomposites by a hybrid manufacturing technique", ASME Int. Manufacturing Science and Engineering Conference, 2013.

70. Wu, Yifu and C. Richard Liu, 2013 “Temperature distributions on substrates under various ambient conditions due to thermal shock of short pulsed laser” Winter Symposium on Photonics and Optoelectronics (W-SOPO 2013).

APPENDIX: A NEW COURSE ON INNOVATIVE DESIGN
IE59000 (Spring 2015, Spring 2016) Structured Engineering Innovation

Course background and motivation:
In all engineering disciplines, functional design courses are key for training students to become engineers. However, among the numerous functional designs based on specific functional needs, only a small fraction is likely to add value for specific system needs. Among these designs adding value, even a smaller fraction will enable success for the objectives set for a system. Therefore, there is a strong need in adding a new approach for teaching engineering design to ensure that the students can design for adding value and leading to success.

The objective of this course is to satisfy this need by teaching a new methodology developed by the instructor. This methodology systematically teaches the characteristics that a design must have in order to add value and lead to success. These characteristics are applied as guidance in new design process, shown in dotted arrows in the figure below.



These characteristics include the following requirements: strategic, functional, geometric, material, processing, production and quality. When these profiles are systematically applied, the approach becomes a structured and effective method of seeking design innovations that can add value, lead to success and even changing the game of competition, for a product, a process, a service, a system or a technology. This course was offered first time last Spring Semester, enrolled with 46 professional students from industry as a distance course and 15 students on campus. The learning from the class was effective, which was reflected in favorable class feedback (see a sample below).

Course Description:
Innovation is broadly defined in this course as: new ideas, designs, methods, products, processes, services and systems that add value and lead to success for a set of defined goals/objectives.

Thus we are not only interested in enhancing the creation of new designs but also to ensure that new designs will add values and lead to success for the predefined goals/objectives.
Next waves of major economic opportunities for an enterprise and/or an individual will most likely come from innovation. Innovation can change the game of competition, and is created usually by the activity of design. The objective of this course is to address this central issue of wealth creation and business survival by teaching a structured approach for achieving successful engineering innovation/design. In this course, we will provide an opportunity for the student to acquire the understanding of industrial innovation and a structured process leading to successful innovative design, thereby to enhance his/her own career and wealth. We plan to introduce several innovation structuring and creation methods newly developed by the instructor, based on the instructor's own experiences in industry and academia, for competitive new product, process and research designs. We will also facilitate the students to study structured and case-enhanced approaches for product and manufacturing innovation, including extending them to service area. Our preliminary plan is to cover the following: (1) a review of the instructor's own experiences in product and manufacturing innovations and lessons learned about structured innovation, (2) strategy based innovative designs, (3) manufacturing based innovative designs (4) materials based innovative designs, (5) function based innovative designs, (6) structures, drivers and causes leading to product, process, service and technology innovations, and (7) dynamics of industrial innovation. Practical examples may include innovations in electric cars, jet engines, commercial aircrafts, industrial equipment, mobile phones, laundry products, bearings, cutting tools, machining processes, 3-D printing/additive manufacturing, nanomanufacturing, nanotechnology applications and in related systems. Topics may include: "innovation structure of Tesla", "product strategy: Boeing 787 Dreamliner vs Airbus Jumbo A-380X", " innovation driver: how innovations in new materials have driven by jet engines", "enhancing competitiveness: how Harley Davison was rebuilt through innovation", "new product development: developing a competitive consumer product evolved to become industry standard", "Innovative R&D: R&D leading to a revolutionary processes for making load-carrying components", "industrial competition and innovation", etc.
The major homework for the student is to develop a term paper/case study and present it in power point slides with voice explanations. Video recording may be required. There are also small exercises used for illustrating some methods for developing innovative ideas.

About the instructor: Professor Liu is recognized by several important awards for a number of research innovations: (1) by SME/NAMRI Wu Research Award, for having created "single step finish/super-finish hard machining, leading to a new market and a science base for engineering a new generation of processes, machine tools, cutting tools and manufacturing systems"; (2) by ASME Ennor Award "for his seminal research on surface integrity and fatigue performance of manufactured surfaces", (3) by IR100 Award for his research leading to significant accuracy enhancement with software for machine tools. Currently he is working on a new high rate scalable method of making nanomaterials and a new modeling approach for predicting fatigue initiation life including multi-scale mechanisms. He is a pioneer for creating the concept of the existing global supply-chain based manufacturing structure, now a key competitive factor for industry. He developed an innovative process for making high quality bearings, which is been applied by several major US bearing suppliers and users. He also served as a research engineer in industry where he developed a dominant product. He has published over 170 peer reviewed research papers, and taught courses on Design, on Manufacturing and on Competitive Strategies for Products and Processes.
