Curriculum Vitae
DAVID E. HARDT

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PROFESSIONAL INTERESTS:

Manufacturing Process Control, Design of Manufacturing Processes and Equipment, Flexible Automation, Next Generation Manufacturing Concepts, Micro embossing processes, Micro-Contact Printing

EDUCATION:

B.S.	Mechanical Engineering,	Lafayette College, 1972
S.M.	Mechanical Engineering	Massachusetts Institute of Technology, 1974
Ph.D.	Mechanical Engineering	Massachusetts Institute of Technology, 1978

EMPLOYMENT:

Assistant Professor of Mechanical Engineering,	1979 - 1985
Associate Professor of Mechanical Engineering,	1985 - 1992
Director, Laboratory for Manufacturing and Productivity School of Engineering, MIT	1985 - 1994
Leaders for Manufacturing Professor,	1988 - 1993
Professor of Mechanical Engineering	1992 -
Co-Director, Leaders for Manufacturing Program	1995 - 1998
Ralph E. and Eloise F. Cross Professor of Mechanical Engineering	2006 -

PROFESSIONAL ACTIVITIES:

American Society of Mechanical Engineers: Member and Fellow
Chairman: Technical Panel on Manufacturing Technology, (1980 - 1988)
Chairman, Honors Committee (1988-1991)
Dynamic Systems and Control Division.
Publications Chairman 1988 American Control Conference
Vice Chairman, 1990 USA-Japan Symp. on Flexible Automation
Org. Comm. 1992 USA-Japan Symp. on Flexible Automation
Publications Chair, 1994 Japan - USA Symp. on Flex. Auto.
Conference Chair, 1996 Japan - USA Symp. on Flex. Auto.
Society of Manufacturing Engineers, Member and Fellow
Technical Committee Member 5th International Symposium on Nano-Manufacturing (ISNM) 2007-8
Planning and Review Committee Member Manufacturing Excellence Award for Singapore (MAXA) 2005-2009

ACADEMIC ADMINISTRATION AND COMMITTEES

Operating Committee Member, Leaders for Manufacturing Program	1988-1994
Search Committee, ME Department Head	1991
Strategic Planning Committee, ME Department	1997-2000
Head, Design, Manufacturing & Controls Division, ME Department	2000-2005
Committee on Student Life, MIT	2002-2005
Head, Design, Manufacturing and Product Development Area, ME Department	2005-2008
Co-Director, Leaders for Manufacturing Program	1994-1998
MIT Co-Chair Singapore – MIT Alliance Program in Manufacturing	2000-2014
Search Committee, MIT Dean of Engineering	2006-2007
Productivity in an Innovation Economy Commission	2010- 2013
Chair, Search Committee MechE Department Head	2013
Associate Department Head for Teaching, Mechanical Engineering	2012- 2013
Graduate Officer, Department of Mechanical Engineering, MIT	2008-2013

GOVERNMENT COMMITTEES, SERVICE, ETC.

Advisor to Congressional Office of Technology Assessment, Panel on Impact of Automation on Labor	Mar. 1983	Sept. 1983
Member, Com. on Welding Control National Materials Advisory Board National Research Council	Dec. 1984	Mar. 1986
Associate Editor, ASME Manufacturing Reviews	Nov. 1987	Nov 1990

Associate Editor, Journal of Manufacturing Systems	Jan. 1990	Jan 2003
Ad Hoc Committee on the MITI IMS proposal	Sept 1990	Sept, 1991
Co-Chair, NSF Grantees Symposium	Jan 1993	Jan. 1994

Chair, Integration Committee Next Generation Manufacturing Project (NST, NIST, DoD)	July 1999	July 2001
National Research Council, Committee to evaluate NIST Mfg. Engineering Lab	Jan 2000	Jan 2005
National Research Council Associateships review panel	Mar 2004	Mar 2007
Singapore National Manufacturing Excellence Award Program – Partner and Judge	Sep 2005	Sep 2009
Advanced Manufacturing Partnership Workforce subcommittee	Sep 2011	April 2012
Associate Editor Arabian Journal of Science and Engineering	Sep 2015	Sep 2017

Non-academic experience:

- Board of Advisors, MyTide Theraputics Inc.
- Board of Advisors, Digital Alloys Inc.
- Board of Advisors, New Valence Robotics
- Board of Advisors, Industrial ML
- Board of Advisors, Dimensional Photonics, Inc.
- Board of Directors, Simpler Inc.
- Trustee Acton Conservation Trust

TEACHING EXPERIENCE:

Undergraduate:	Graduate:	Professional:
Mechanics	Mfg. Process Control	Flexible Automation
Dynamics	Advanced System	Advanced Process Control
Experimentation	Dynamics & Control	Next Generation Mfg.
Classical Control	Mfg. Process & Equip.	
Manufacturing	Additive Manufacturing	
System Dynamics		

CURRICULUM DEVELOPMENT

Developed and continue to head the MIT Master of Engineering in Manufacturing degree, established in 2005 .

Developed an EdX MicroMasters program in the “Principles of Manufacturing” and contributed 2 of the 8 modules to the program.

Biographical Information

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Professor Hardt has been a member of the Mechanical Engineering faculty since 1979, and is a founding member of the Engineering Systems Division at the Massachusetts Institute of Technology (MIT). His disciplinary focus is system dynamics and control as applied to manufacturing. His teaches focuses on control, dynamics and manufacturing processes. His research has been on flexible automation, and process control, with an historical emphasis on welding and forming processes, and a current focus on polymer micro embossing. In welding, he pioneered the use of multivariable control techniques for modeling and control of GMAW, and demonstrated the use of adaptive control in these systems. In the forming processes, he has concentrated on the use of in-process measurements and real-time modeling to reduce sensitivity to machine and material variations, and has developed a flexible tooling and closed loop shape control concept for 3D sheet parts. The later has implemented in the aerospace industry with specific uses for repair part manufacture. His more recent work has been in the hot micro-embossing process for micro-fluidic device manufacture in micro-contact process scale-up using roll to roll processes. In both cases the theme of the work is novel equipment design and overall equipment and process statistical control

Prof. Hardt has taught classes in both Mechanical Engineering and Manufacturing, and has led the creation of a professional graduate degree: Master of Engineering in Manufacturing" at MIT. This is the first professional degree offered by the ME Department at MIT, and is the culmination of many years of course and curriculum development.

Recently he led the development of a MicroMaster credential on the EdX platform in the "Principles of Manufactguring" and contributed 2 of the o8 modules.

Prof. Hardt served as Director of the MIT Laboratory for Manufacturing from 1985 - 1992 and as Engineering Co-Director for the MIT Leaders for Manufacturing Program from 1993 to 1998. As Co-Director of LFM, he has been a Co-Principle Investigator for the Next Generation Manufacturing Project. This project involved the participation of hundreds of manufacturing professionals, and combined the efforts of over 12 Industry associations to develop an industry view of the future of manufacturing enterprises. From 1999-2005, he was the MIT co-Chair of the Innovation in Manufacturing Systems and Technology Programme, part of the Singapore

MIT Alliance (SMA), and following that as co Chair of the SMA-2 programme “Manufacturing Systems and Technology” from 2006 – 2014.

Prof. Hardt also served as Associate Department Head for Teaching and Graduate Officer in the Mechanical Engineering Department.

Professor Hardt has supervised 22 PhD theses, 124 SM theses and 26 Master of Engineering Theses, and served on the PhD committees of 26 students.

He currently serves on the technical advisory board of three companies: Mytide Therapeutics, Industrial ML and Digital Alloys.

Publications

1. Books

1. Hardt, D.E., Ed. Measurement and Control in Batch Manufacturing, ASME
2. Hardt, D.E., Ed. Information Control Problems in Manufacturing Technology, (Proc. of the 4th IFAC/IFIP Symposium), October, 1982.
3. Hardt, D.E., and Book, W.J., Eds. Control of Manufacturing Processes and Robotic Systems, ASME Publication #H00279, New York, November 1983.
4. Hardt, D.E., Srinivasan, C., and Komanduri, R., Eds. Modeling, Sensing and Control of Manufacturing Processes, ASME Publication #H00370, November 1986.
5. Hardt, D.E., Ed. Control Issues in Manufacturing Processes, ASME Publication #G00461, November, 1988.
6. Hardt, D.E., Neal, R., M., and Patterson, R., Next-Generation Manufacturing: A Framework for Action Agility Forum, January 1997.
7. Hardt, D.E., "Process Control of Thermosetting Composites: context and Review", Chapter 11 in Advanced Composites Manufacturing (Gutowski, Editor) John Wiley & Sons 1997.
8. Hardt, D.E., "Forming Processes: Monitoring and Control ", Chapter 10 in The Mechanical Systems Design Handbook: Modeling, Measurement, and Control., Nwokah & Hurmuzlu, eds. CRC Publishing, 2001

2. Papers in Refereed Journals

1. Hardt, D.E., "Determining the muscle forces in the leg during normal walking: an application and evaluation of optimization methods," Trans. of ASME, Journal of Biomechanical Engineering, 100, 1978, pp. 72-78.
2. Hardt, D.E., and Mann, R.W., "A five body, three-dimensional dynamic analysis of walking," J. Biomech., l3, no. 5, 1980, pp. 455-458.
3. Hardt, D.E., Roberts, M.A., and Stelson, K.A., "Closed Loop Shape Control of a Roll Bending Process," Transactions of ASME, Journal of Dynamic Systems, Measurement and Control, 104 , no. 4, 1982.
4. Zacksenhouse, M. and Hardt, D.E., "Weld Pool Impedance Identification for Size Measurement and Control," Transactions of ASME, Journal of Dynamic Systems, Measurement and Control, l05, no. 4, 1983.
5. Ettouney, O. and Hardt, D.E., "A Method for In-Process Failure Prediction in Cold Upset Forging," Transactions ASME Journal of Engineering for Industry, 105, no. 3, 1983, pp. 161-167.
6. Zalucky, A., and Hardt, D.E., "Active Control of Robot Structure Deflections," Transactions of ASME Journal of Dynamic Systems, Measurement and Control, 105, no. 1, Mar. 1984, pp. 63-69.
7. Hardt, D.E., Garlow, D.A. and Weinert, J.B., "A Model of Full Penetration Arc-Welding for Control System Design", J. of Dynamic Systems, Measurement and Control,, 107, Mar. 1985.

8. Hardt, D.E. and Katz, J.M., "Ultrasonic Measurement of Weld Penetration," Welding Journal, Sept. 1984, pp. 273s-281s.
9. Hardt, D.E. and Chen, B., "Control of a Sequential Brakeforming Process," J. of Engineering for Industry, 107, May 1985, pp. 141-145.
l0. Bates, B. and Hardt, D.E., "A Real-Time Calibrated Thermal Model for Closed-Loop Weld Bead Geometry Control," J. of Dynamic System, Measurement and Control, l07, 1985.
11. Hale, M.B., and Hardt, D.E., "Dynamic Analysis and Control of a Roll Bending Process," IEEE Control Systems Magazine, Apr. 1987.
12. Slocum, A.H., Hardt, D.E., and Greenspan, L., "Development of a Six D.O.F Position and Orientation Sensing Device: Design Theory and Testing," Int. Journal of Machine Tools and Manufacture, 28, no. 4, 1988.
13. Doumanidis, C.C., and Hardt, D.E., "A Model for In-Process Control of Thermal Properties during Welding," J. of Dynamic Systems, Measurement and Control, Mar. 1989.
14. Tam, A., and Hardt, D.E., "Weld Pool Impedance for Pool Geometry Measurement: Stationary and Non-Stationary Pools", J. Dynamic Systems, Measurement and Control, Dec. 1989.
15. Webb, R.D., and Hardt, D.E., "A Transfer Function Description of Sheet Metal Forming for Process Control," ASME J. of Engineering for Industry, 1990.
16. Doumanidis, C.C., and Hardt, D.E., "Multivariable Adaptive Control of Thermal Properties During Welding," ASME J. of Dynamic Systems Measurement and Control, 113, Mar. 1990, pp 82-92.
18. Doumanidis, C.C., and Hardt, D.E., "Simultaneous Control of Heat Affected Zone and Cooling Rate During Arc Welding," Welding Journal, May 1990.
19. Suzuki, A., Hardt, D.E., and Valvani, L., "Application of Adaptive Control Theory to On line GTA Weld Geometry Regulation," ASME J. of Dynamic Systems Measurement and Control, 113, Mar. 1990, pp 93-103.
20. Sharon, A, Hogan, N. and Hardt, D.E., "The Macro/Micro Manipulator: An Improved Architecture for Robot Control," IEEE Trans on Robotics and Automation, Dec. 1988.
21. Sharon, A, Hogan, N. and Hardt, D.E., "Controller Design in the Physical Domain," J. of Franklin Institute, 328, 1991, pp. 697-721.
22. Hardt, D.E., Wright, A., and Constantine, E., "A Design Oriented Model of Plate Forming for Shipbuilding," Journal of Ship Production, Nov. 1990.
23. Hardt, D.E., Wright, A., and Constantine, E., "A Model of Sequential Bending for Manufacturing Simulation," ASME J. of Engineering for Industry, 114, May, 1992, pp. 181-187.
24. Fenn, R. and Hardt, D.E., "Real-Time Control of Sheet Stability During Forming," ASME Journal of Engineering for Industry, Dec. 1992.
25 Hardt, D.E., "Modeling and Control of Manufacturing Processes: Getting More Involved", ASME J. of Dynamic Systems Measurement and Control, 115, June. 1993, pp 291-300.
26. Song, J.B., and Hardt, D.E., "Closed-Loop Control of Weld Depth Using a Thermally-Based Depth Estimator", Welding Journal, September, 1993.

27. Song, J.B.,and Hardt, D.E. "Adaptive Control of Gas Metal Arc Welding" ASME J. of Dynamic Systems Measurement and Control, Sept., 1994.
28. Walczyk, D. and Hardt, D.E., "Rapid Tooling for Sheet Metal Forming using Profiled Edge Laminations -Design Principles and Demonstration," ASME Journal of Manufacturing Science and Engineering to be published Aug. 1998.
29. Walczyk, D. and Hardt, D.E., "Design and Analysis of Reconfigurable Discrete Dies for Sheet Metal Forming," to be published SME Journal of Manufacturing Systems Fall 1998..
30. Walczyk, D. and Hardt, D.E., "Rapid Tooling for Sheet Metal Forming using Profiled Edge Laminations -Design Principles and Demonstration," ASME Journal of Manufacturing Science and Engineering Nov. 1998.
31. Walczyk, D. and Hardt, D.E., "A Comparison of Rapid Fabrication Methods for Sheet Metal Forming Dies, ASME Journal of Manufacturing Science and Engineering 1998.
32. Walczyk, D. and Hardt, D.E., "Rapid Tooling for Sheet Metal Forming using Profiled Edge Laminations -Design Principles and Demonstration," ASME Journal of Manufacturing Science and Engineering Aug. 1998.
33. Walczyk, D. and Hardt, D.E., "A Comparison of Rapid Fabrication Methods for Sheet Metal Forming Dies, ASME Journal of Manufacturing Science and Engineering 121, May 1999, pp 214-224..
34. Hardt, D.E., Norfleet, N.A., Valentin, V.M, and Parris, A., "In-Process Control of Strain in a Stretch Forming Process",.ASME Journal of Engineering Materials and Technology 123, 4, - October 2001 - pp. 496-503.
35. D. V. Tran, Y. C. Lam, V. M. Murukeshan, J. C. Chai, H. Y. Zheng, and D. E. Hardt, "Femtosecond Laser-induced damage and ablation of crystalline silicon: A study in the incubation effect", International Journal of Manufacturing Science and Technology (2004), Vol. 6, No. 2, pp. 26–33.
36. Y. C. Lam, D. V. Tran, H. Y. Zheng, V. M. Murukeshan, J. C. Chai, and D. E. Hardt, "Surface damage of crystalline silicon by low fluence femtosecond laser pulses", Surface Review and Letters, Vol. 11, No. 2 (2004) 217–221.
37. D. V. Tran, Y. C. Lam, B.S. Wong, H. Y. Zheng, and D. E. Hardt, "Quantification of thermal energy deposited in silicon by multiple femtosecond laser pulses", Optics Express, Vol. 14, Issue 20, pp. 9261-9268 (October 2006).
38. Tran, D. V., Lam, Y.C., Zheng, H.Y., Wong, B.S., and Hardt, D.E., "Direct Observation of the Temperature Field During Ablation of Materials by Multiple Femtosecond Laser Pulses" Applied Surface Science, Vol. 263, No. 17, June 2007. pp.1790-1794.
39. Rzepniewski, A, K, and Hardt, D.E. "Development of General Multivariable Run-by-Run Control Methods with Application to a Sheet Metal Forming Process", ,International Journal of Machine Tools and Manufacture, 2007
40. Gang Fu, SB Tor , N P Loh, B Y Tay and D E Hardt A Micro Powder Injection Molding apparatus for high aspect ratio metal micro-structures production, Journal of Micromechanics and Microengineering, (2007) pp 1803-1809.

41. B Saha, E Liu, S B Tor, N W Khun , D E Hardt and J H Chun, "Replication performance of Si-N-DLC-coated Si micro-molds in micro-hot-embossing 2010 J. Micromech. Microeng. 20, No. 4, 2010.
42. Fu, G, Tor, S.B., Loh, N.H. and Hardt , D.E., Micro-hot-embossing of 316L stainless steel micro-structures, Applied Physics A: Materials Science & Processing, August 2009.
43. Hale, M, Eusener, T, and Hardt, D.E., "Process Robustness of Hot Embossing Microfluidic Devices" ASME Journal of Manufactuirng Science, online, June 2010
44. Hardt, D.E., Anthony, B.W. and Tor, S.B. 'A teaching factory for polymer microfabrication – μFac', Int. J. Nanomanufacturing, Vol 6, pp 137-151, August, 2010.
48. Fu, G, Tor, S.B., Loh, N.H. and Hardt , D.E., "Fabrication of robust tooling for mass production of polymeric microfluidic devices" J. Micromech. Microeng. 20 (2010) 085019(6pp)
49. Mazzeo, A. D., Lustrino, M.E., and Hardt, D.E, "Bubble Removal in Centrifugal Casting of Polymers: Combined Effects of Buoyancy and Diffusion", *Polymer Science and Engineering*, 2011.
50. B. Saha, E. Liu, S.B. Tor, D.E. Hardt J.H. Chun N.W. Khun, "Improvement in lifetime and replication quality of Si micromold using N:DLC:Ni coatings for microfluidicdevices", *Sensors and Actuators B* 150 (2010) 174–182.
51 Fu, G, Tor, S.B., Hardt , D.E and., Loh, N.H., "Effects of processing parameters on the micro-channels replication in microfluidic devices fabricated by micro injection molding" Microsyst Technol (2011) 17:1791–1798
52 Dirckx, M.E. and Hardt, D.E., "Analysis and Characterization of Demolding of Hot Embossed Polymer Microstructures", , J. Micromech. Microeng. 21 (2011) 085024 (10pp).
53 Mazzeo, A. D., Lustrino, M.E., and Hardt, D.E, "Bubble Removal in Centrifugal Casting of Polymers: Combined Effects of Buoyancy and Diffusion", Polymer Science and Engineering, (52), no.1 2012, 80-90.
54 Petrzelka, J.E. and Hardt, D.E. "Static load-displacement behavior of PDMS microfeatures for soft lithography." J. Micromech. Microeng. 22 (2012)
56 Mazzeo, A.D. and Hardt, D.E., "Centrifugal Casting of Microfluidic Components With PDMS", Trans. ASME, J. Micro and Nano-Manufacturing, Vol. 1, No. 2, pp 1-8, 2013.
57 B. Saha, M. Dirckx, D. E. Hardt, S. B. Tor, E. Liu, J. H. Chun, "Effect of sputtering power on friction coefficient and surface energy of co-sputtered titanium and molybdenum disulfide coatings and its performance in micro hot-embossing", Microsystem Technolgy April 2013.
58 Petrzelka, J.E. and Hardt, D.E. "Static load-displacement behavior of PDMS microfeatures for soft lithography", J. Micromech. Microeng. 22, no.7, 075015 (12pp)
59 Nietner, L.F. and Hardt, D.E., "Direct-Write Photolithography for Cylindrical Tooling Fabrication in Roll-to-Roll Microcontact Printing", ASME Journal of Micro-Nano Manufacturing, Sept. 2015.
60 Saha, B., Toh, W.Q., Liu, E., Tor, S.B., Hardt, D.E., and Lee, J., "A review on the importance of surface coating of micro/nano-mold in micro/nano-molding processes",

Journal of Micromechanics and Microengineering, Volume 26, Number 1, November 2015.

61 Mustafa, Aalim M., Hawwa, Muhammad A., and Hardt David E., "Vibration of an Axially Moving Beam Supported by a Slightly Curved Elastic Foundation," to be published - *Journal of Vibration and Control*, May 2017.

62 Hizir, F.E. and Hardt, D.E. "Phase-field modeling of liquids splitting between separating surfaces and its application to high-resolution roll-based printing technologies', Physics of Fluids **29**, 052007 (2017) `

62 Hawwa, Muhammad A., Ali, Sajid, and Hardt David E., "Vibration of an Axially Moving Web within a Roll-to-Roll System," J. Vib. Eng. Technol. (2018). https://doi.org/10.1007/s42417-018-0047-y

63 Xian Du, David Hardt, Brian Anthony, "Real time imaging of thiol-gold on a moving web in roll-to-roll process by condensation figures", *IEEE Transactions on Industrial Electronics,* May , 2020. (DOI: 10.1109/TIE.2019.2914632)

64 F E Hizir, Hale, M.B. and Hardt, D.E., "Manufacturing conductive patterns on polymeric substrates: development of a microcontact printing process", *J.. Micromech. Microeng*. **30** 2020.

3. Proceedings of Conferences

1. Hardt, D.E., "Optimal Solutions for Muscle Forces During Walking," Proc. Joint Automatic Control Conference, San Francisco, Aug. 1980.
2. Hardt, D.E., Gossard, D.C., "A Variable Geometry Die for Sheet Metal Forming: Machine Design and Control," Proc. Joint Automatic Control Conference, 1981.
3. Hardt, D.E., Olsen, B.A., Allison, B.T., and Pasch, K., "Sheet Metal Forming with Discrete Die Surfaces," Proc. 9th North American Manufacturing Research Conference, 1981, pp. l40-l45.
4. Hardt, D.E., Roberts, M.A., and Stelson, K.A., "Material Adaptive Control of Sheet Metal Roll Bending," Proc. Joint Automatic Control Conference, 1981.
5. Hardt, D.E., and Webb, R.D., "Sheet Metal Die Forming Using Closed-Loop Shape Control," Annals of CIRP, 1982.
6. Zalucky, A., and Hardt, D.E., "Active Control of Robot Structure Deflections," Robotics Research and Advanced Applications, ASME Publication # H00236, Nov. 1982.
7. Hardt, D.E. and Chen, B., "Control of a Sequential Brakeforming Process," Control of Manufacturing Processes and Robotic Systems, ASME Publication # H00279, Nov. 1983.
8. Hardt, D.E., Garlow, D.A. and Weinert, J.B., " A Model of Full Penetration Arc-Welding for Control System Design," Control of Manufacturing Processes and Robotic Systems, ASME Publication # H00279, Nov. 1983.
9. Hardt, D.E. and Katz, J.M., "Ultrasonic Measurement of Weld Penetration," Control of Manufacturing Processes and Robotic Systems, ASME Publication # H00279, Nov. 1983.
10. Hardt, D.E., McMillen, M.D. and Nactigal, C.L., "Lumber Manufacturing In-Process Control," Control of Manufacturing Processes and Robotic Systems, ASME Publication # H00279, Nov. 1983.
11. Hardt, D.E., and Hale, M., "Closed Loop Control of a Roll Straightening Process," Annals of CIRP, 1984.
12. Hardt, D.E., and Webb, R.D., "Closed-Loop Control Three Dimensional Sheet Forming," Proceedings, Eleventh NSF Conference on Production Research and Technology, May 1984.
13. Sharon, A., and Hardt, D.E., "Enhancement of Robot Accuracy using Endpoint Feedback and a Macro-Micro Manipulator System," Proc. Third ACC, June 1984.
14. Bates, B.E. and Hardt, D.E., "A Real-Time Calibrated Thermal Model for Closed-Loop Weld Bead Geometry Control," Sensing and Control of Manufacturing Processes and Robots, ASME Special Publication, Nov. 1984.
15. Webb, R.D., and Hardt, D.E., "Spatial Frequency Based Closed-Loop Control of a Sheet Forming Process", Sensing and Control of Manufacturing Processes and Robots, ASME Special Publication, Nov. 1984.
16. Hardt, D.E., "Measuring Weld Pool Geometry from Pool Dynamics," Modeling and Control of Casting and Welding, ASM, January, 1986.

17. Hale, M., Doumanidis, C., Hardt, D.E., "Multivariable Control of Arc Welding Processes", International Trends in Welding Research, American Society for Metals, May l8-22, 1986.
18. Lee, C., and Hardt, D.E., "Closed-Loop Control of Sheet Metal Stability During Stamping," 1986 North American Manufacturing Research Conference, May 28-30, 1986.
19. Hale, M.B., and Hardt, D.E., "Dynamic Analysis and Control of a Roll Bending Process," Proc. American Control Conference June 1986.
20. Hardt, D.E., "Modeling and In-Process Control of Sheet Deformation Processes", Intelligent Processing of Materials and Advanced Sensors, TMS, Oct. 1986.
21. Doumanidis, C., and Hardt, D.E., "A Dynamic Model for Control of Thermal Properties in Welding," Modeling, Sensing and Control of Manufacturing Processes, ASME, Nov. 1986.
22. Hardt, D.E., Jenne, T., Domroese, M., and Farra, R., "Real- Time Control of Twist Deformation Processes," Annals of CIRP, 1987.
23. Suzuki, A., and Hardt, D.E., "Application of Adaptive Control to Weld Geometry Control," Proc. ACC, June 1987.
24. Doumanidis, C.C, Hale, M.B. and Hardt, D.E., "Non-Linearities in Welding System Dynamics," Proc. 5th Symposium on Energy Engineering Sciences, Argonne, June 1987, pp. 184-197.
25. Sharon, A., Hogan, N., and Hardt, D.E., "More Analysis and Experiments on a Macro/Micro Manipulator System," Modeling and Control of Robotic Manipulators and Manufacturing Processes, ASME, Dec. 1987, pp. 417-422.
26. Sharon, A., Hogan, N., and Hardt, D.E., "High Bandwidth Force Regulation Using a Macro-Micro Manipulator System," Proc. IEEE Int. Conf. on Robotics and Automation, Apr. 1988.
27. Hardt, D.E., and Doumanidis, C.C, "Thermal Modeling for Control in Welding Processes," Thermal Aspects of Manufacturing, ASME, Dec. 1988.
28. Hardt, D.E., and Suzuki, A., "Application of Adaptive Control Theory to On line GTA Weld Geometry Regulation," Control Issues in Manufacturing Processes, ASME, Nov. 1988.
29. Doumanidis, C.C., and Hardt, D.E., "Control of Thermal Properties During Welding: an Application of Adaptive Control," Control Issues in Manufacturing Processes, ASME, Nov. 1988.
30. Sharon, A., Hogan, N., and Hardt, D.E., "Controller Design in the Physical Domain (Application to Robot Impedance Control)," Proc. IEEE Int. Conf. on Robotics and Automation, Apr. 1989.
31. Hardt, D.E., "Modeling of Forming Processes and their Control," Proc. Automation of Design and Manufacturing in Large Marine Structures, Nov. 1988.
32. Hardt, D.E., Wright, A., and Constantine, E., "A Design Oriented Model of Plate Forming for Shipbuilding," Proc., National Shipbuilding Research Program Symposium, Annapolis, Sept. 1989.
33. Fenn, R. and Hardt, D.E. "Real-Time Sheet Forming Stability Control," Proc. International Deep Draw Research Group, June, 1990.

34. Hale, M.B., and Hardt, D.E., " Multivariable Geometry Control of Welding - Part I: Process Modeling," Symposium on Manufacturing Process Modeling and Control, ASME, Nov., 1990.
35. Hale, M.B., and Hardt, D.E., " Multivariable Geometry Control of Welding - Part II: Process Control," Symposium on Manufacturing Process Modeling and Control, ASME, Nov., 1990.
36. Song J.B. and Hardt, D.E. "Development of a Heat-Transfer Based Depth Estimator for Real-Time Welding Control", Symposium on Manufacturing Process Modeling and Control, ASME, Nov., 1990.
37. Constantine, E. , and Hardt, D.E., "A Design Oriented Model of Plate Bending" Computer Based Concurrent Engineering, ASME, Nov. 1990.
38. Fenn, R. and Hardt, D.E., "Real-Time Control of Sheet Stability During Forming", Proc. ASME Symposium on Monitoring and Control of Manufacturing Processes, 1990.
39. Hardt, D.E., "Modeling and Control of Welding Processes," Proc. Fifth Engineering Foundation Conference on Modeling of Casting, Welding, and Advanced Solidification Processes, TMS, Sept., 1990
40. Song, J.B, and Hardt, D.E., "Multivariable Adaptive Control of Bead Geometry in GMA Welding," ASME Symposium on Welding Processes and Control, Nov. 1991.
41. D.E. Hardt, M. B. Hale, "Multi-Output Process Dynamics of GMAW: Limits to Control", Proc. Third International Conference on Welding Research, ASM, Gatlinburg, June, 1992.
42. Song, J.B, and Hardt, D.E., "Simultaneous Control of Bead Width and Depth Geometry in Gas-Metal Arc Welding" Proc. Third International Conference on Welding Research, ASM, Gatlinburg, June, 1992.
43. Song, J.B, and Hardt, D.E., " Thermal Based Weld Pool Depth Estimator for Real-Time Control" Proc. Third International Conference on Welding Research, ASM, Gatlinburg, June, 1992.
44. Masmoudi, R. , and Hardt, D.E., " High-Frequency Torch Weaving for Enhanced Process Controllability: Effect on Coupling of Pool Width and Heat Affected Zone Width" Proc. Third International Conference on Welding Research, ASM, Gatlinburg, June, 1992.
45. Hardt, D.E., Boyce, M.B., Ousterhout, K.B., and Karafillis, A, "Flexible Forming of Three Dimensional Sheet Metal Parts Using Discrete Tooling", Sheet Metal 1992, Proc. of the International Conference, Birmingham Polytechnic, U.K., April, 1992, pp., 193-202.
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Major New Products, Processes, Designs or Systems

Reconfigurable Tooling for Aerospace Part Manufacture. A full scale production ready prototype of a discrete tool and the accompanying shape control system is begin implemented in an airframe manufacturers production line.

Flexible automation design for electrical connector assembly. A series of production ready prototypes of novel flexible automation equipment was delivered to the sponsor, employing in-process sensing to achieve the required precision.

New fast cycle microembossing machine using novel heating – cooling system. This is both a lab test-bed and an initial prototype for a new class of production machines with low cost, high quality and short cycle time.

Rapid Degassing and Curing Process for Curable Resin Molding of Microfluidic Devices. This process reduces cycle times to several minutes from hours, and ensures void free, double-sided parts.

Micro-Factory for Polymer Microfluidic Device Manufacture. A complete table-top system to automatically produce a basic microfluidic device comprising an embossing station, bonding station, inspection station and functional test station. A novel robotic manipulation system integrates the steps and provides precise part alignment.

Lab-scale Continuous roll to roll Micro-contact printing system. As medium scale testbed for high speed large area printing of micron scale features on flexible substrates. This device incorporates state of the art precision manipulation with 10's of nm resolution, and has a unique contact region visualization capability.

Centrifugal Casting and Maskless Lithography system for cylindrical stamps for micro-contact printing.