AC 2010-586: IT'S THE MANUFACTURING STUPID! THE NEW US INDUSTRIAL REVOLUTION

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Awards, Professional Activities, Publications

Dr. Norman was awarded the Department Of The Army, ACHIEVMENT MEDAL FOR CIVILIAN SERVICE (Jun 1993). He is a graduate of the Department of Defense; National Security Management Course, Maxwell School of Citizenship and Public Affairs, Syracuse University and Paul H. Nitze School of Advanced International Studies, Johns Hopkins University (April – May, 1996). He received a Special Commendation Award from the US General Accounting Office for service on the Independent Review Panel for the Safety of the Zilwaukee Bridge, Zilwaukee, Michigan (1988). Dr. Norman served on a six member US Army Review Panel for the Advanced Construction Technology Centers of Excellence at the Massachusetts Institute of Technology and the University of Illinois (1989-1994). He was awarded a visiting Fellowship, Research Awards for Foreign Specialists (earthquake engineering and design) from the Director General, Public Works Research Institute, Tsukuba, Japan (Feb-Mar, 1994). He received appointment as a Visiting Scholar in the Department of Computational and Applied Mathematics, William Marsh Rice University, Houston Texas (Mar-May 1999).

Dr. Norman has published over thirty five national and international technical papers and DOD reports. He was a Charter Member of the Board of Editors, The International Journal of Theoretical and Applied Research in Shock and Vibration and the Committee on Fracture Mechanics, American Concrete Institute. He has served as a member on the: Committee on Computational Mechanics, Engineering Mechanics Division, ASCE and the Committee on Inelastic Behavior of Materials, Engineering Mechanics Division, ASCE.

Work Experience

Currently, Dr. Norman is a consult Engineer with Applied Research Associates, Inc and Managing Partner for Advanced Technologies Applications, LLC. Dr. Norman's primary interests include developing new research, development, and applications programs supporting government and private industry in product / process design improvements based on new rapid applications software, enhanced constitutive models using multi-scale concepts, and software verification and validation based on real world applications.

2003-2007: Director, Center for Advanced Vehicular Systems, Extension, Mississippi State University

Developed and implemented strategic plan and operational concept for technology transfer of R&D products developed at Mississippi State University to Nissan, Tier-1 suppliers, and small to medium size industries in Mississippi.

2001-2003: R&D Thrust Leader for Computational Manufacturing, Center for Advanced Vehicular Systems (CAVS), Mississippi State University

Developed vision and operational concept for applying computational solid mechanics and enhanced constitutive models in analysis and design optimization for vehicular systems. Integrated multi-scale R&D concepts focused on improving structural design at the macro-level through better understanding material deformation mechanisms at the micro-level.

1969-2001: USA Engineer Research & Development Center (formerly Waterways Experiment Station) Vicksburg, MS. Research Structural Engineer

Developed and managed major research programs in the areas of analysis and design of hardened facilities such as; missile silos, buried Command Posts, and hardened aircraft shelters. Research and Development also included developing improved analysis and design procedures for concrete dams and appurtenant structures subjected to earthquake loads. Lead a major multi-year R&D program focused on developing and critically assessing constitutive models used in design of very hard missile silos.

Education

Ph. D., University of Texas at Austin, Structural Engineering and Mechanics M.S., Mississippi State University, Structural Engineering B.S., Mississippi State University, Civil Engineering

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"It's the Manufacturing Stupid"
The New US Industrial Revolution

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Abstract

The need for innovation in US manufacturing is discussed. However, this is not the usual innovation we think of in terms of automation, nanomanufacturing, or IT, innovation here is the application of cutting edge computational mechanics technologies in improving product/process design. These technologies include multi-scale material models, with optimization, integrated in an effective modeling and simulation based design framework. The paper presents five components of an improved manufacturing philosophy, which if adopted and pursued with constancy of purpose will help US companies become more innovative and globally competitive. The first component, "Innovation, Thinking Outside the Box", is discussed in terms of the development, during World War II, of a more effective aircraft battle damage repair method. The second component, "Build on Past Lessons Learned", references work and key philosophies of Frederick Terman in the context of establishing the partnership between California universities and industries resulting in what is now called Silicon Valley. Also, some key aspects of the profound work of W. Edwards Deming in defining quality and productivity, which lead to the transformation of Japanese industry after World War II, is presented and discussed. The third component, "Integrate Advanced Technologies in Improved Product / Process Design Paradigms", is discussed in the context of using multi-scale concepts for enhancing product / process design. The forth component," Implement Improved Design Paradigms in a Modeling and Simulation Based Design Framework", calls for integrating this enhanced design paradigm in an effective modeling and simulation based design framework. Here the findings of the NSF Blue Ribbon Panel on, Simulation-Based Engineering Science (May 2006) are used to argue the need for "Modeling and Simulation Based Design for Manufacturing (MSBDM)". This framework allows the manufacturing engineer to reduce variation, improve quality and safety, and approach design optimization in a timely manner. Finally in, "Bridge the Culture Gap between Academia and Industry", the fifth component, a case is made for collaboration to address what is often referred to as the "innovation paradox". The bridge is based on a collaborative partnership among leaders in industry, academia, state and federal government.

Introduction

The title of this paper includes the phrase: The New US Industrial Revolution. This may appear to be quite ambitious to many readers but most would agree that we have quite an ambitious challenge in significantly improving our (US) position in the competitive global economy. Manufacturing can and should play a critical and

essential role in our (US) response to this economic development challenge. Furthermore, the framework or philosophy for achieving global competitiveness is not intended here to focus on one or two states or even a region of the US. The focus is on the entire United States, management leadership and technology applications must be applied with constancy of purpose, energy, and passion. Finally, there must be an effective collaboration between US industry and academia in defining R&D needs, transferring technology, and integrating R&D products into education and workforce training programs.

In his book, The World is Flat, Thomas Friedman says, the United States needs a dramatic burst of American innovation. Recent studies from 2004 – 2006 by the President's Council of Advisors on Science and Technology, Council on Competitiveness, the National Academies, and the MIT Industrial Performance Center agree that innovation is the key to long-term success in global competition. It seems that most everyone agrees that innovation is essential for success in the global economy. What's more important (and should be of serious concern to US leaders) is the fact that our competitors including; India, China, Japan,…, clearly understand the critical requirement of innovation and are doing something about it. In the Innovative Flanders Symposium report, Alan Wolff[1] wrote; "On the road into Suzhou, a large rooftop sign proclaimed "Development is an Immutable Truth" in English under massive Chinese characters. The message was from Deng Xiao Ping, and although it has been translated in various other ways over time, the message is unmistakable: There is one acceptable path for China and that is economic development. This sentiment might not seem remarkable in any country seeking to industrialize. But in China, it carried special force".

However, when we think of innovation, are we overlooking something, is it just innovation in the narrow context of new inventions? If we accept the broader definition of innovation, "…act or process of inventing or introducing something new", we really may be on to something. In other words we don't have to invent a new widget to be innovative, we might simply improve (optimize) the widget's design, performance, durability, and manufacturing process. Many manufacturing processes have changed very little since the mid 1900's. While there have been significant advances in manufacturing, most of the focus has been on process automation, Information Technology (IT), micro and nano manufacturing. The technology area which has lagged most significantly has been in developing a clear understanding of the coupled physics and mechanics governing diverse manufacturing processes and the evolution of material properties, internal states, and product geometries which occur during these processes. Today's computers, current modeling and simulation capabilities, along with theoretical and experimental developments in the area of multi-scale material modeling provide a new and improved technology baseline for solving these real world manufacturing problems.

First let's make one thing perfectly clear, the aim of this paper is not to present ideas for making short term profits, for a select few, in a manufacturing setting. The goal here is to present a framework or philosophy, which if adopted and pursued with constancy of purpose, can help US companies become innovative, competitive, stay in business and provide good long-term jobs in the twenty first century environment. Fully accomplishing this goal requires, buy-in from industry, academia, and government along with effective planning and leadership at the local, state, and national levels.

This framework consists of five components:

1. Innovation, Thinking Outside the Box
2. Build on Past Lessons Learned
3. Integrate Advanced Technologies in Improved Product / Process Design Paradigms
4. Implement Improved Design Paradigms in a Modeling and Simulation Based Design Framework
5. Bridge the Culture Gap between Academia and Industry

These components will be discussed in the following sections of this paper. Also, the maturity of the advanced technologies discussed here is mostly at the R&D stage, not in final design guidance form. However, helping move these cutting edge technologies to effective real world applications in product / process design improvements is precisely the goal of this paper.

A Framework for Global Competitiveness in Manufacturing

1. Innovation, Thinking Outside the Box

During World War II Art Stein [2] headed an Air Force unit in Europe which performed battle damage repair for bombers flying missions in the European theatre. Art worked as a researcher in this area at Aberdeen Proving Grounds back in the states and was highly regarded for his work, especially for his insightful and innovative approaches to solving complex problems. Soon after arriving in theatre he began leading his unit in their repair mission. Each day (or night) a group of twenty, or so, bombers would leave on a bombing mission and later that day only seventeen or eighteen would return. These returning aircraft suffered considerable damage due to anti-aircraft fire. Art and his team worked quickly and effectively using modern and sophisticated repair techniques and procedures so that these damaged aircraft could return to their combat roles. Each day this process would be repeated for those aircraft lucky enough to return. After a few days of this, Art made a somewhat profound observation. He instructed his team that not only did they need to repair areas of visible damage on these returning aircraft but they also needed to strengthen areas where there was little or no damage, because those were the areas where the aircraft which didn't return were probably getting hit. This was the beginning of the protective design concept based on "Vulnerable Area Analysis". While many engineers understand the nature of material damage, crack growth, and failure in structural systems and can design effective repair methods, Art Stein saw beyond the obvious repair component of the problem to identify fundamental weaknesses in the system, "Vulnerable Areas".

The intent here is not to suggest that management simply read the above paragraph and instruct their staff to think outside the box. The manufacturing sector in the US has suffered significant damage over the past quarter century. Our approach to repair has been to move our factories outside the US where the cost of labor is cheap and therefore profits are high. Is this the approach Art Stein would have taken or would he have considered broader objectives in terms of maintaining jobs and the economic development infrastructure in the US? Would he have looked only at profit margin and not considered improved product process designs, quality, productivity, marketing, incentives, collaborative pooling of workforce clusters,….?

Management is all about leadership and management must create and maintain an environment for innovative thinking in terms of product / process quality, productivity, and continuous improvement. Management must create a "learning organization" as defined by Peter Senge[3]:

… where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together.

Linus Pauling said ***"The best way to get a good idea is to get a Lot of ideas"***. Often structured brainstorming sessions can be very effective in developing innovative ideas and concepts. It is important for management leaders to recognize that the best ideas that will come out of these sessions are probably not in their heads.

2. Build on Past Lessons Learned (many of the comments regarding Terman are from: Net Valley, Saturday, Dec 12, 2009, "Fred Terman, The Father of Silicon Valley", by Carolyn E. Tajnai, Manager Stanford Computer Forum, May, 1985)

Arguably, the most phenomenal success in US manufacturing and economic development was the partnership developed between key California universities and industries making up what is now called Silicon Valley. Developing and sustaining this partnership was primarily due to the exceptional capabilities and insight of Frederick Emmons Terman. Terman[4], was "…beyond any reasonable doubt responsible for the concentration of economic accomplishment in what has become to be known as California's Silicon valley…" When money was needed to fund Stanford's postwar growth , in the 1950's, university leaders decided to offer long term leases to industry for part of its over 8,000 acres. Hence, The Stanford Industrial Park was founded with the goal of creating a center of high technology close to a cooperative university. Terman referred to the park as "our secret weapon", and quickly suggested that leases be limited to high technology companies that might be beneficial to Stanford.

Actually, Terman had been concerned about the lack of good employment opportunities in the area for Stanford engineering graduates as early as the 1930's. His best graduates had to go to the east coast to find employment, especially in the field of radio engineering (what we now call electronics). His response to this problem was to establish the then-new radio technology locally. Always encouraging his graduates to start companies of their own, a first step was to bring together two of his former students, William Hewlett and David Packer. Terman did a number of "little things" to help get their business started such as suggesting that a new idea in electronics (the "resistance-tuned oscillator") could be used to make a cost effective instrument (a lot simpler and cheaper than anything else on the market). Hewlett came up with excellent solutions to a couple of nagging technical problems resulting in a reliable, marketable instrument. Moving into a duplex and a backyard cottage, at the same address near Stanford and working out of a small garage behind the house, the Hewlett-Packard Company was incorporated in January 1939. Currently, employing over 80,000 people with sales over $6B per year, it is one of the world's largest producers of computers, electronic measuring devices, and equipment.

Varian Associates became the first company to move into a building in the park in 1953. Several other companies including: Eastman Kodak, General Electric, Beckman Instruments, Hewlett-Packard, Lockheed and others soon followed. ***To better understand industry needs, Terman would take the trouble to contact chief engineers of important electronics companies to find out which device or design approach was widely used. These were the design approaches he focused on in his teaching, research, journal publications, and textbook publications*** (his electronics texts were at one time the second most valuable book property of the McGraw-Hill Book Company, being exceeded in popularity only by a standard treatise of engineering drawing). A former student and protégé of Terman's, Professor Oswald Villard of the Stanford School of Engineering recalled:" Along with enormous energy, Terman always had a clear idea of what he wanted to do and what to do to meet his objectives. He was phenomenal in his self-discipline. After spending a full day at the university, he would go home and work on his books." At a dinner honoring Terman in 1965, David Packard reminisced: "At that time, Professor Terman had already developed a broad knowledge of and a personal acquaintance with the business and industry related to his academic discipline. He would often tell us about the corporate history, as well as the current activities, of all the important firms in this newly developing industry. ***The highlight of his course for me was the opportunity to visit some of the laboratories and factories in this area. One day Professor Terman remarked that many of the firms we visited, and many other firms throughout the country in this field, had been founded by men with little or no formal education. He suggested that someone with a formal engineering education, and perhaps a little business training, might be even more successful***."

Terman, also strongly believed (as did his father Lewis, inventor and co-developer of the Stanford Binet Intelligence test) that exceptionally gifted individuals were very important to any organization and who with their followers (collaborators) would form "steeples of excellence". Once these exceptionally gifted individuals learned more about industry needs by spending time in industry design offices and on the plant floor they were even better prepared to address real world issues of quality and productivity.

It would be disingenuous to discuss past lessons learned in quality and productivity, in manufacturing, without referencing the profound work of W. Edwards Deming. In his book, Out Of The Crisis[5], Deming states: “Quality begins with the intent, which is fixed by management. The intent must be translated by engineers and others into plans, specifications, tests, production. The principles explained here, along with the chain reaction (see Figure 1. below) and techniques taught to hundreds of engineers, commenced the transformation of Japanese industry… A new economic age had begun”.

Improve Quality → Costs decrease because of less rework, fewer mistakes, fewer delays, snags; better use of machine-time and materials → Productivity improves

→ Capture the market with better quality and lower price → Stay in business → Provide jobs and more jobs

Figure 1. Chain Reaction

Deming knew that continuous improvement of quality was the golden thread which passed through every component of the entire production line from incoming materials to the consumer, and redesign of product and service for the future. Deming’s revolutionary work in Japan occurred in the late forties and early fifties. During this time frame a rational understanding of the plastic straining of metals during shaping processes such as rolling and drawing existed (e.g. “The Mathematical Theory of Plasticity”, R. Hill, 1950). However, applications of these theories to manufacturing processes were mostly limited to idealized geometries and materials subjected to simple load paths using modest numerical procedures. Earnest development of the finite element method began in the mid to late fifties but the focus was mostly on the analysis of airframes and civil engineering structures subjected to life-cycle performance loads. While Deming had advanced degrees in mathematical physics he did not concentrate on classical mechanics like: deformations, induced anisotropy, damage, fracture, etc. produced in materials during manufacturing processes. Most of his “theoretical / analytical” focus was on simple but powerful statistical methods which could be used to detect the existence of special (assignable) causes of variation, and that continuous improvement of processes is essential in reducing this type variation. Deming defined a stable process, one with no indication of a special cause of variation, as being in statistical control. Improvement of the process could be effectively addressed once statistical control has been achieved and maintained.

Here is precisely where new and advanced cutting edge technologies can be applied through modeling and simulation based concepts (discussed in the next two sections) to improve product / process designs. These technologies can be used to quantitatively

predict the affects of special and common causes of variation on the process and therefore on overall product quality and productivity .These concepts can then be integrated with modern statistical strategies (e.g. Six-Sigma, Kaizen, Lean, etc.) to better define and reduce the overall affects of causes of variation leading to optimization in product / process design. Statistical methods took fire in America around 1942, following a series of 10-day intensive courses for engineers initiated by Stanford University, on a suggestion from Deming. Deming stated that, "brilliant applications attracted much attention, but the flare of statistical methods by themselves, in an atmosphere in which management did not know their responsibilities, burned, sputtered, fizzled, and died out". Effective integration of advanced technologies with statistical strategies completes a balanced product / process design improvement strategy which can provide clear and robust added value in improving quality, productivity, and a company's bottom line profits.

3. Integrate Advanced Technologies in Improved Product / Process Design Paradigms

Early development of the Finite Element Method (FEM) began in the mid to late 1950s along with associated, improved, numerical (computational) methods. Also, significant advances were being made in high performance computing by the mid 1980's. However, not until recently have advances in theoretical, computational, and experimental methods allowed for an effective end to end solution for product / process design improvements which fully address Deming's major concerns for quality and productivity. For example, using multi-scale material models in an enhanced modeling and simulation based design framework, as discussed by Horstemeyer and Wang[6], allows the manufacturing engineer to reduce variation, improve quality and safety, and approach design optimization in a timely manner. Most traditional structural analysis and design methods assume homogeneous isotropic materials which can be effectively modeled as a continuum. For example consider the analysis and design of an automotive frame. Material properties for the frame are usually determined from test coupons taken from the metal plate material before stamping occurs. Several coupons are tested to establish average values for properties such as modulus, yield stress, ultimate strength, and fatigue strength. It is hoped that these average values, which are further modified by safety factors, will provide safe conservative predictions, in terms of failure, when the frame is analyzed subjected to design performance loads. Actually, the frame goes through a series of thermo mechanical loadings during the different manufacturing processes which cause defects (micro-cracks, micro-voids, etc.) in the material to evolve to their final state after vehicle assembly. These manufacturing processes (for the frame) include: casting, hot rolling, cold rolling, stamping, and welding, with each potentially having an effect on defect evolution, material properties, and finally the initial stress state of the assembled frame. A potential problem here is that the averaging of coupon test data is only applicable to those coupons tested and specific defects existing in those coupons at the time of testing. This can result, among other things, in predicting failure at the wrong location in the structural component. Horstemeyer analyzes each manufacturing process using internal state variables (ISV) which are based on microstructure property relations. When these relations are included in the ISV rate equations, history effects can be captured. The method for selecting appropriate microstructure property relations for the ISV is based on a multi-scale modeling methodology which includes experimentation. A key challenge in developing multi-scale methods which are useful and practical in real world design settings is bridging the scales. While there are several promising numerical techniques for accomplishing the bridging, Horstemeyer currently advocates human observation and evaluation based on relevant experimental data. Multi-Scale methods can lead to safe light weight designs, improved predictions of lifecycle performance, and more accurate warranty specifications. Since each manufacturing process's thermo mechanical loads and boundary conditions are considered in the end to end analysis, multi-scale methods can clearly be used to optimize the manufacturing process and ultimately product design.

4. Implement Improved Design Paradigms in a Modeling and Simulation Based Design Framework

"What first strikes the visitor (to the USA) with amazement is the superiority of this country in matters of technology and organization. … The high price of labor was the stimulus which evoked the marvelous technical devices and methods of work…. The opposite extreme is illustrated by over-populated China or India, where the low price of labor has stood in the way of the development of machinery…. Once the machine is sufficiently highly developed it becomes cheaper in the end than the cheapest labor."

Albert Einstein[7], 1921

Today, the United States has lost much of this manufacturing advantage and jobs, as industry has moved machines to where cheap labor exists. However, as previously discussed there is still significant room for improvement in manufacturing product / process design paradigms. This improvement is best attained by integrating an advanced multi-scale theory in a comprehensive modeling and simulation based design framework: Modeling and Simulation Based Design for Manufacturing (MSBDM). Recent developments in high performance computing, including massive parallel processing, have enabled the potential use of multi-scale material models in a real world simulation based design framework. Indeed, the National Science Foundation's Blue Ribbon Panel on Simulation-Based Engineering Science (SBES) presents a compelling argument for revolutionizing engineering science through simulation. The panel chaired by J. Tinsley Oden, in its report[8], states that ***SBES is central to advances in biomedicine, nanomanufacturing, homeland security, microelectronics, energy and environmental sciences, advanced materials, and product development***. While SBES provides the most effective way to test and evaluate innovative process and product design concepts, US leadership in this area is rapidly eroding. The report points out that nations competing in the global marketplace (e.g. Europe, Asia, etc.) have increased their investments in research while the US has seen a steady reduction in its proportion of scientific advances in related technology areas. ***A major finding of the report is that regaining and sustaining leadership in SBES will require changes in our educational system as well as changes in how basic research is funded in the US***.

Through the development of MSBDM, US manufacturers will be provided with a cutting edge computing infrastructure applicable to essentially all manufacturing processes. Product / process design improvements (indeed approaching optimization) often require simulation of very complex geometries, rapid geometry modification and reanalysis, and analysis of material removal process steps following deformation processing. A potential concept for accomplishing this rapid analysis of complex geometries is presented by Rashid and Selimotic[9], "Variable-Element-Topology Finite Element Method (VETFEM)". Rapid geometry modification and reanalysis is accomplished through leveraging VETFEM via a robust computational geometry processor[10]. The role of this processor is to perform rapid Boolean intersection operations between hex meshes and surface representations of the body to be analyzed. Effective analysis of large deformation inelastic problems, fracture simulation, and material removal process steps is accomplished through a computational procedure[11] for remapping material state information from one finite element mesh to another. These computational methods integrated along with multi-scale material models in MSBDM could provide manufacturing and design engineers with very powerful tools for addressing global competition in product / process design improvements.

5. Bridge the Industry Academia Culture Gap

In most states in the US, a culture gap exists between industry and academia, which leads to what is often referred to as the "innovation paradox". Simply put, the innovation paradox is due to a lack of understanding of industry needs and how industries operate by academicians and failure to transfer R&D technologies developed through university research to industrial product / process design by industry leaders. Frederick Terman clearly understood industry needs and he provided an effective bridge between industry and academia in California's Silicon Valley. Effectively addressing the many culture gaps in terms of the US in total will require many different bridges with a variety of spans, capacities, and functions. This will require a collaborative effort among leaders in industry, academia, state and federal government.

States and their Institutions of Higher Learning face a great challenge / opportunity in responding to today's global economic environment. These universities should not only be recognized as providers of education and training for innovators, but also as engines of economic growth, without diminishing their primary mission of education. There is no argument that achieving success in the emerging global knowledge economy requires: creating a highly educated and skilled workforce, an environment supporting innovation and entrepreneurial behavior, and a public and private commitment to purpose, policy, and investment. It is critical that industries and universities, in the US, form an effective, sustaining, collaborative partnership creating a system for clearly defining industry R&D needs then integrating successful R&D results into education, workforce training, and industry product / process design improvements.

The US strategic plan for success in the global knowledge economy (especially manufacturing) should center on our universities placing far greater emphasis on building alliances to focus on unique core competencies and becoming more engaged in regional and statewide economic development activities. Participation by faculty in start up and spin off high-tech companies should be encouraged while intellectual property policies should be simplified. Universities should even consider investing some of their own assets in high potential state and region based venture capital activities.

Recommendations and Observations

The United States is in a severe economic crisis which is in part the result of losing a world leadership role in manufacturing. A suggested pathway out of this crisis has been presented here as a ***framework*** for global competitiveness in manufacturing. The operational concept for the framework is quite simple: create 50 Silicon Valleys (US50SV), one in each state of the US. Terman's concept was to "effectively" apply advanced technologies in the electronics area. The idea here is to "effectively" distribute and apply advanced mechanics and computational methods integrated with modern business strategies in the manufacturing area throughout the US. The host architecture for this integrated system is MSBDM. Each US50SV will be funded at ~ $ 2 M / year from the federal government with a $ 2 M / year match coming from private industry, state and local governments (only in exceptional cases should US50SV funds be used for new construction). Each US50SV will be lead by Co-Directors, evenly split between industry and academia. ***Selecting Co-Directors will not follow the standard procedure of appointing someone to assume an additional university assignment nor other-duties-as-assigned to some less than enthusiastic industry executive. There are exceptionally gifted individuals in both academia and industry who are innovative, and will demonstrate a passion and constancy of purpose to make the US50SV concept successful.*** The US50SVs will report to a joint committee consisting of the President's Council of Advisors on Science and Technology (PCAST) and a select committee recommended by leaders from America's Fortune 500 (PC-F5). ***Selecting members of PC-F5 will follow similar guidelines to those defined for the Co-Directors. There is a wealth of exceptionally gifted individuals on PCAST and in the Fortune 500 group.*** Each US50SV will have one or more manufacturing core technology focus areas such as casting, extrusion, welding, machining, stamping, tool & die, business and financial management, etc. In many cases there will be constructive / competitive duplication of certain key technology areas from state to state. A simple clear strategic plan for the operation, goals, and objectives of each US50SV will be submitted to PC-F5 by each state's governing body for institutions of higher learning (Boards of Trustees, Boards of Regents, etc.). Locations for the US50SV (Headquarters), within a state should rotate every ~ two years among that state's major universities (public and private). The intent here is not to develop another (million dollar) funding mechanism for centers of excellence conducting R&D which is published in peer reviewed journals, it is to develop innovative value added technologies (million dollar ideas) which can be quickly transferred and integrated into industry product / process design improvements. When a particular university is selected as a host site for a US50SV, this does not mean that that university receives a $ 4 M R&D grant. Awarding R$D $'s will be based on competitive proposals from all universities and industry partners throughout the particular state.

The US50SV concept is based on collaboration, initiative, synergism, and shared information and the primary measures of success (annual performance ratings) for US50SV's are in the areas of innovation, effective R&D collaborations with other universities & industry, value added technology transfers to industry, and a clearly identified increase in jobs. Each US50SV is located in an individual state and if its annual performance is not satisfactory its headquarters location should be changed. A cost effective and efficient method for the technical, business, and financial management of the US50SV program will be developed and implemented by PC-F5.

Innovative ideas in product design and process improvement often require thinking outside the box, across organizational boundaries and including professional and non-professional groups. The best solution to a manufacturing process problem can, and often does, come from a production line technician. Again, management must create and sustain an environment (a learning organization from top to bottom) which encourages and facilitates innovative outside the box thinking, focused on continuous product / process improvement.

Proactive collaboration is the key point, just as Terman took the trouble to meet with design engineers of different companies to determine industry needs, academic leaders must go to the plant to see first hand what the actual situation is on the plant floor. Also, industry leaders must go to the universities to see first hand what the actual situation is inside the ivy covered walls of academia.

The first of Deming's 14 Points for management transformation is: "Create constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs". Elaborating on this point he further states, "Constantly improve design of product and service. This obligation never ceases".

The use of effective multi-scale material models in a robust simulation based design framework (MSBDM) can enable US manufacturers to approach design optimization in terms of minimum weight, safety, and lifecycle performance. Effectively integrating these advanced technologies in business and manufacturing strategies like Six Sigma, Kaizen, Lean, etc. will result in a reduction in both material and long term warranty costs and an increase in product safety, customer satisfaction, and company bottom lines.

Epilogue

When Sam Walton was asked to what he credited his amazing success in the business world, he answered, "good decisions". When he was further asked how he developed the ability for making so many "good decisions", he answered; "experience". Finally, asked how he attained this "experience", he responded; "bad decisions".

It's time for some good decisions related to manufacturing in the US.

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