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A Study to Identify the Elements of World-Class Lean Production Applicable to the Manufacture of Agricultural Tractor Transmissions and Axles

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Abstract

The purpose of this investigation was to provide a primer-style delineation of the principles and operational characteristics of lean production.

A STUDY TO IDENTIFY THE ELEMENTS OF WORLD-CLASS LEAN PRODUCTION APPLICABLE TO THE MANUFACTURE OF AGRICULTURAL TRACTOR TRANSMISSIONS AND AXLES

A Research Paper for Presentation
to the Graduate Faculty
of the
Department of Industrial Technology
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In Partial Fulfillment of the Requirements for
the Non-Thesis Masters of Arts Degree

by

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Fall, 1991

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FORWARD

Changes in the style of Western management and manufacturing are essential if we are to avoid being smothered by other parts of the world. For many years following World War II American products were in heavy demand; everyone expected the good times to continue. They did not. Product markets such as televisions, semiconductors, steel, cameras, video recorders, and automobiles, once traditional strongholds, are now populated by high-quality, low-cost foreign producers. This story is retold time and time again across America.

We need new paradigms. We must create a new culture within American manufacturing and service companies. This culture must cause two essential things to happen: 1) the transfer of the maximum number of tasks and responsibilities to the workers adding value, and 2) the creation of a system for detecting defects that quickly traces every problem to its ultimate cause. This investigation intends to identify the actions needed to cause this cultural change.

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INTRODUCTION

The Problem Setting

Many American manufacturers continue to use mass-production techniques developed by Henry Ford. These techniques are simply not competitive with the "world-class" lean production system pioneered by Japanese automotive companies.

Lean and mass production systems share the same objectives i.e. products that meet customer expectations for function, quality, and price. They differ, most times dramatically, in their execution. There is no single, simple definition of lean production (also referred to as Just-In-Time Manufacturing, Toyota Production System, and synchronous manufacturing). Definition is best accomplished by comparison to mass-production. For example, lean production develops new products in substantially less time; is able to produce many more products with the same amount of engineering effort; reaps substantially more benefits from long-term meaningful partnering with suppliers and; generates a higher degree of continuous improvement through empowered multi-disciplined teams. In addition, lean production produces few errors, transfers the maximum number of tasks and responsibilities to the workers adding value, has a system for detecting defects that quickly traces every problem to its ultimate cause, and fosters a continuing relationship with the customer.

Manufacturers unwilling to adopt Lean production methods will surely remain non-competitive in the global marketplace--assuming they survive at all. It is imperative that American manufacturers implement lean production. Maximum infusion of lean production will occur when all employees, not just managers, understand it's principles and adopt it's methodologies as part of a new culture.

Statement of the Problem

Too few white and blue collar non-managers in American agricultural equipment manufacturing industry are properly educated about lean production.

The Purpose of this Investigation

The purpose of this investigation was to provide a primer-style delineation of the principles and operational characteristics of lean production.

Research Question

What are the most important principles and operational characteristics of the lean production system?

Assumptions

The assumptions used in the pursuit of this investigation were:

1. Most blue and white collar non-managers in American industry do not fully understand the principles, operational characteristics, and implementation methodologies of lean production.

2. Most blue and white collar non-managers in American industry

have an interest in learning more about lean production.

Statement of Procedure

This investigation began with a wide-ranging review of literature. A histogram was then prepared to document the frequency at which individual lean production principles and/or characteristics were discussed in the literature. In addition, the Researcher visited several companies noted for their lean production system. Lastly, interviews were conducted with several (John) Deere and Company experts.

Definition of Terms

The following terms were identified to clarify their use in the context of the study:

Core competency

Those manufacturing operations a lean producer finds more cost effective to perform than purchase (C. S. Battles, personal communication, November 12, 1991).

Homogeneous build schedule

Fabrication of components and/or assemblies in a mixed-size, mixed-model sequence i.e. not batched (Dilworth, 1991).

Kanban

A term coined by Toyota to describe its card-based materials management system. Kanbans, in configurations such as simple paper cards, FAX documents, all types of material containers, metal tags, and electronic communiques are used to signal the need to perform a manufacturing operation or the transportation of work in process (Fallon, 1986).

Trigger production control

A methodology for consumption-driven shop floor production control. Essentially the same as Kanban. (Langill, 1991)

Value added

Those operations performed that change the physical configuration or properties of the product (Womack, Jones, and Roos, 1990).

World class

In possession of the principles, and able to execute most of lean/JIT production procedures (Womack, Jones, and Roos, 1990).

REVIEW OF RELATED LITERATURE

A wide-ranging review of related literature indicated many manufacturing professionals affirm the need to have lean/JIT production methodologies well-understood and implemented.

Bowman (1991) references surveys that prove there remains, even after a decade of industry focus, much confusion about what JIT manufacturing is and how to implement it. As a result of their involvement in a 5-year, 5-million-dollar study of the world's automotive industry, Womack, Jones, and Roos (1990) believe:

> Lean production is the superior way for humans to make things. It provides better products in wider variety at lower cost. Equally important, it provides more challenging and fulfilling work for employees at every level, from factory to headquarters. It follows that the whole world should adopt lean production, and as quickly as possible. (p. 225)

Ohno (1988), developer of the Toyota production system and many times referred to as the "founding father" of Just-In-Time manufacturing concepts states:

> Manufacturers can no longer base production on desk-top planning alone and then distribute, or *push*, them onto the market. It has become a matter of course for customers, or users, each with a different value system to stand in the frontline of the marketplace and, so to speak, *pull* the goods they need, in the amount and at the time they need them. (p. xiv)

American manufacturers face very skilled competitors in nearly all markets. Product markets such as televisions, semiconductors, steel, cameras, video recorders, and automobiles, once traditional strongholds, are now populated by high-quality, low-cost foreign producers. "Faced with a choice to enter an improvement spiral or to sink into the disaster of a competitive tailspin, companies are making serious efforts to improve their competitiveness" (Dilworth, 1991, p. 44). Lean production is a "broad philosophy of seeking excellence and eliminating waste throughout a company" (Dilworth, 1991, p. 44).

In a recent article discussing JIT manufacturing Ken Gottesman (1991), a consultant with Ernst & Whinney stated "few truly understand the meaning and scope of this manufacturing philosophy" (pg. 19). Crawford and Cox (1991) share Gottesman's opinion of the general understanding about lean/JIT philosophies. They believe however that it (JIT) "is recognized by many practitioners, researchers, and consultants as an effective method of improving manufacturing operations and maintaining or regaining competitive positions" (pg. 33).

Fallon (1986) believes lean/JIT production is so important that goals must be communicated to all employees. In addition he states "Make sure workers understand their changing roles" (pg. 77).

RESULTS AND DISCUSSION

So, what do experts, researchers, and practitioners hold to be the most important aspects of lean manufacturing? Two are profound.

One: Womack, Jones, and Roos (1990) found lean producers assigning the maximum number of tasks and responsibilities (empowerment) to the workers adding value to the product--roles, responsibilities, and authority are thoroughly defined for all jobs. They stated, "a key objective of lean production is to push responsibility far down the organizational ladder" (pg. 14).

Two: lean producers have a system that quickly traces every mistake/defect to its ultimate/root cause--there is relentless attention to problem resolution, defect prevention, continuous improvement, and waste elimination (e.g. Bowman, 1991; Crawford & Cox, 1991; Dilworth, 1991; Fallon, 1986; Gottesman, 1991; Heiko, 1989; Womack, Jones & Roos, 1990).

Other principles and operating characteristics are grouped in five broad categories--Culture, Quality Tools and Procedures, Product Development, Supply Management, and Manufacturing as indicated in Figures 1 and 2.

Figure 1. Histogram showing number of in-literature occurances as a function of the lean production characteristic.

	Number of Occurances
Cultural	
Eliminate waste (incl inventory), simplify	Bu Di Go He Fa Wo Cr
Continuous institutionalized improvement	Bu Di Go Cr Fa Wo
Employee involvement, empowerment	Fa Wo Di He Sc Yo
Total quality commitment, fanatitcism	Di Go Cr He Wo
Long-term emphasis/strategy	Bu Di Cr Fa Wo
Human resources a major asset, respect	Bu Di Wo Yo
Root cause problem solution	Di Go Wo
Work together for common good. Team play.	Yo Sc Wo
Customer focus, internal and external	Sc Wo
Attention to detail	Di Wo
Quality Tools and Procedures	
Total quality mngt/commitment	Sc
SPC	He
Mistake proofing	He
Product Development	
Integrated product development process	Wo
Shorten product introduction time	Ga Wo
Quick customization of products	Ga Wo
Supply Management	
Early, long-term supplier involvement	Cr Fa Wo
Fewer supplier	Fa Wo
Pay suppliers fairly	Fa Wo
Educate suppliers	Fa Wo
Steady delivery schedule for suppliers	Fa Wo
Supplier certification	He Wo

Bo=Bowman
Bu=Buck
Cr=Crawford & Cox
Di=Dilworth
Fa=Fallon
Ga=Garwood
Go=Gottesman
He=Heiko
Sc=Scholtes
Wo=Womack, Jones, & Roos
Yo=Yoshino

Figure 2. Histogram showing number of in-literature occurances as a function of the lean production characteristic.

	Number of Occurances
Manufacturing	
Setup reduction	Di Go Cr He Fa Wo
Cosumption driven production control (Kanban)	Di Go Cr He Fa Wo
Increased floor space density	Di Go Cr He Wo
Product-focused cellular mfr, worker flex	Di Go Cr Fa Wo
Lot size reduction	Cr He Fa Wo
Reduce material handling	Go He Fa Wo
Reduce inspection	Go He Fa Wo
Self-directed teams/work groups	Di Go Cr Wo
Reduced avg process/lead time (throughput)	Cr He Fa Wo
Reduce rework	Go He Wo
Preventive/predictive maintenance	Go Cr Wo
Employee training basis for improvement	Di Go Wo
Build to customer order	Fa Wo
Level schedule	Cr Wo
Reduced layers of management	Di Wo
Apropriate use of automation/technology	Fa Wo
Point of use material delivery	He Wo
Visual management	Di Wo
Homogeneous assembly	Di Wo
Clean, litter free	Cr
Rapid response to shifts in product mix vols.	Ga

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Culture

Truly successful practitioners of lean production possess a much different culture than mass-producers. All employees are selected based on their adaptability to the culture. All employees receive ongoing cultural coaching and counseling. Lean producer's beliefs and values include those described below.

Customer focus.

Scholtes (1988) found that employees recognize the need to give lasting value to the customer. They are deeply committed to external customers--those that purchase and use their products and services, and internal customers--fellow employees whose work depends on the work that precedes them.

Total quality commitment.

Each person is obsessed with quality. Quality is relentlessly pursued through products and services that delight the customer. Procedures, methods, and systems of execution are efficient and effective (e.g. Crawford & Cox, 1991; Dilworth, 1991; Gottesman, 1991; Heiko, 1989; Womack, Jones & Roos, 1990).

Waste is not tolerated.

Failure of management-controlled systems is recognized to be 85% of "the problem." There is continual effort to streamline and simplify methods, procedures, tools, and systems. People demonstrate meticulous attention to detail (e.g. Bowman, 1991; Crawford & Cox, 1991; Dilworth, 1991; Fallon, 1986; Gottesman, 1991; Heiko, 1989; Scholtes, 1988; Womack, Jones & Roos, 1990).

Employees work together for the common good.

The environment nurtures total commitment from all employees. There is a unity of purpose. Employees accept ownership, take responsibility--they learn all of the skills in their work group then additional skills outside their work group--they swap jobs. They think proactively.
Rewards go beyond benefits and salaries to the belief "we are family" and "we do excellent work." People have pride in their products and the company. Morale is high (e.g. Scholtes, 1988; Yoshino, 1991).

Employee involvement.

Dynamic work teams are the heart of the lean enterprise. There is a vital sense of meaningful employee involvement. Partnering is not a pretense. There are common struggles for the customer, not separate struggles for power. All transactions and relationships are conducted with fairness, honesty and consistency. People strive first for understanding and then to be understood--they negotiate for win/win (e.g. Dilworth, 1991; Heiko, 1989; Scholtes, 1988; Womack, Jones & Roos, 1990; Yoshino, 1991).

During a 1991 tour of Toyota Motor Manufacturing, U.S.A., Inc. (manufacturer of the Camry automobile), the General Manager of the Power Train Plant (engines) indicated that lean producers such as Toyota are very selective about the people they bring into their organization--they hire only well educated, technically talented, highly skilled problem solvers with good team-play skills. Potential employees must be adaptable to the culture (R. Scaffede, personal communication, October 8, 1991).

Self-improvement.

Everyone is constantly learning. All employees have a desire for improvement of their technical and professional expertise. People gain an ever greater mastery of their jobs and learn to broaden their capabilities.

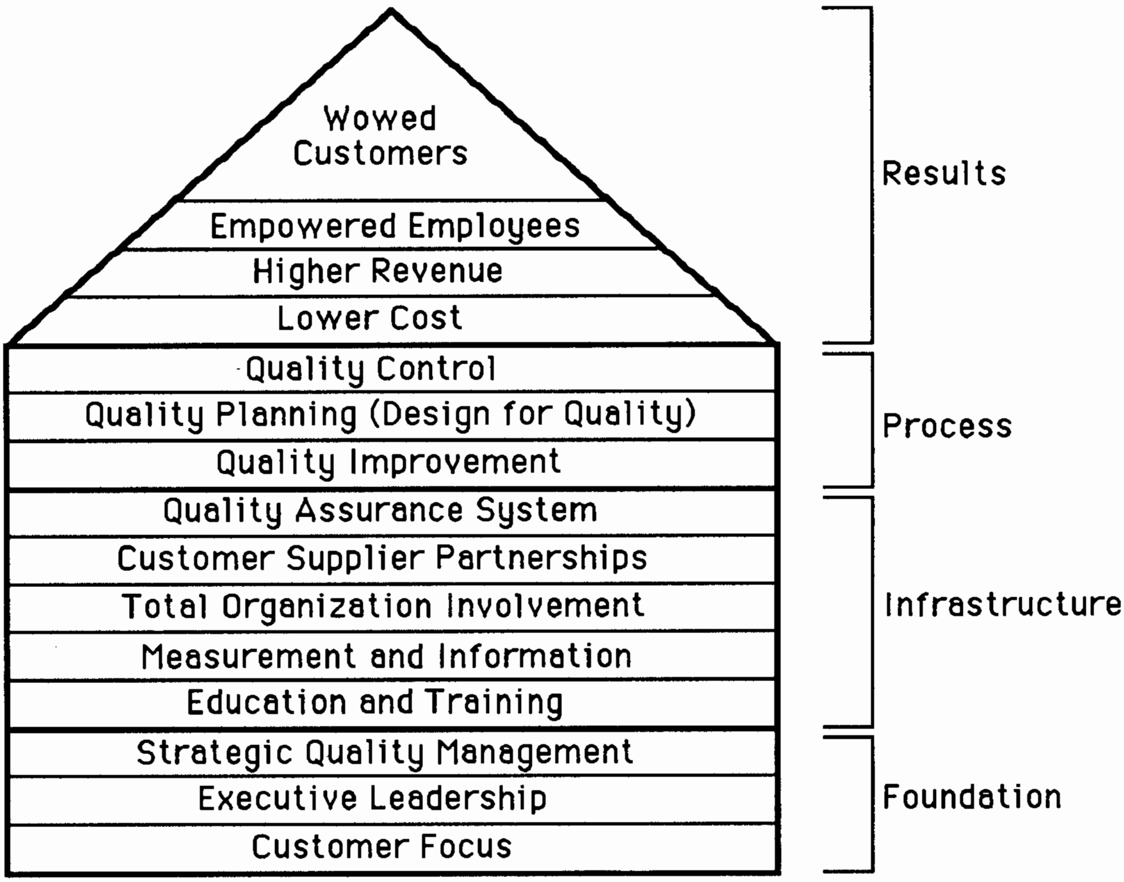
Respect.

Every person is important; every person is respected; every person is honored for their contribution (e.g. Buck, 1991; Dilworth, 1991; Womack, Jones & Roos, 1990; Yoshino, 1991).

Quality Tools and Procedures

Lean producers have systems, procedures, and tools that assure quality in all they do. They generally refer to their Total Quality Management (TQM) System or House of Quality. Some structure their system around the teachings of a well-known expert such as Juran, Deming, Crosby, Feigenbaum, or Ishikawa. For example, during a November 1991 visit to Allison Transmission (automatic transmissions for over-the-road, off-road, and military vehicles), the Plant Manager, World Transmission, described how the Deming principles are part and parcel of the Allison culture (W. K. Sutton Jr., personal communication, November 6, 1991). Others choose to adopt an approach consistent with the Malcolm Baldridge National Quality Award. Still others choose a hybrid. Regardless of the system, all have an intent focus on quality in all they do. Figure 3 shows a typical Total Quality Management system as suggested by Juran.

Figure 3. Elements of a Total Quality Management System.



Foundation.

The foundation of the system is a long-term commitment to the external and internal customer--a commitment to provide the customer with something of lasting value. Executives have a strategic vision and lead by example--they "walk the talk".

Infrastructure.

All employees receive comprehensive training in in how to use the many available problem identification (flow charts, check sheets, brainstorming, nominal group technique) and problem solving tools (histogram, scatter diagram, control chart, process capability, force field analysis).

Metrics exists that continually reflect the status and overall condition of the TQM system. These data/information are shared with all employees. Total Quality results when everyone in the organization understands their role and responsibilities--they are truly involved.

All complex products contain purchased components--those parts the producer chooses not to manufacture. The quality of these purchased components is as important as those the producer manufacturers. World class producers recognize that high quality, on time delivery, and competitive prices result when they enter into long-term relationships with their suppliers. They always work closely with their suppliers to help the supplier exhibit lean manufacturing characteristics.

Quality is assured through the methodical use of a set of procedures and "tools".

Process.

Continuous improvement of quality is one of the most important components of the lean producers culture. There is an ongoing planning effort focused on quality-related actions; a control mechanism exists.

Results.

The end results of a well-executed Total Quality Management system are lower costs, higher revenues, empowered/excited employees, and totally delighted--or if you will-- "wowed" customers.

Product Delivery

All large companies face the same basic problems in developing a new product. A number of functional departments--marketing, product engineering, manufacturing engineering, quality assurance, purchasing, and manufacturing--must collaborate intensively over an extended period of time. The question is how. Womack, Jones, and Roos (1990) and Garwood (1990) learned lean manufacturers demonstrate an ability to design and introduce a wider variety of products in a shorter time frame, with fewer errors, and for less expense than mass-producers. They generally use a process called Integrated Product Delivery. It contains the following procedural phases and administrative characteristics as described by one of (John) Deere and Company's experts (D. Allbaugh, personal communication, September 18, 1991).

Procedural Phases.

The object of the first phase, the Strategic Business Plan phase, is to define the marketplace, establish the need for the new product, project the potential market size, and identify strategic business opportunities. The deliverable from this phase is the "global business plan".

Completion of Phase 2, Program Definition, results in a definition of the product consistent with the business plan. Product usage and performance profile, target price, cost and capital targets, financial analysis, and the strategic marketing plan are example deliverables from this phase.

Phase 3 is the Concept Evaluation and Selection phase. This phase intends to evaluate product concepts in an effort to arrive at the program specification. Activities in this phase include: confirmation of customer needs, life cycle planning, serviceability goal setting, financial resource planning, quality strategy development, product safety planning, part count and weight estimating, patent and legal research, and prototype build planning.

Some of the deliverables from the Program Development phase, Phase 4 include: customer evaluation of the product, the product support strategy, a cost and capital tracking tool, the appropriation for expenditure, execution of the quality and product safety plans, detailed product specifications, tool procurement plans, and fabrication of prototypes in the factory.

Phase 5 is the Program Verification and Implementation phase. The object of this phase is to verify the adequacy of the product and the manufacturing processes prior to full production.

Phase 6 is the Production and Continuous Improvement phase. During this phase, full production is achieved and procedures established to allow ongoing/continuous improvement.

Administrative characteristics.

Womack, Jones, and Roos (1990) learned, during their five year study of the global automobile industry, that the activities of the various disciplines receive work direction from a project leader with great power. This is a most-coveted position. At Honda, for example, a new car program carries the name of the project leader.

Teamwork is of paramount importance. The lean product development team members come from all required disciplines; they are assigned to the project for it's life. They retain ties to their functional department, but for the life of the project they are clearly under the control of the project leader. There is a deep commitment by all members to the project and process. There is very little turnover.

Effective communications are mandatory. Critical design trade-offs are resolved very early in the project--team members sign formal pledges to do exactly what everyone has agreed upon as a group.

There is an early, intense, and ongoing collaboration of design, manufacturing and supply resources. This is generally referred to as simultaneous engineering. Products are designed for manufacturability and part proliferation is minimal.

Supply Management

Mass producer generally wait until engineering designs are well along before involving suppliers. Once involved, suppliers have little freedom to do anything other than provide a quote on the part(s). Price, quality, delivery reliability, and contract length become the elements of the customer-supplier relationship. "Cost comes first" is well understood. There is a counter-productive incentive for the supplier to "low ball" the quote in hopes to secure the follow-on business. Once the business is secured, then annual cost adjustments can be passed to the customer. Lean producers have a better way as described by one of (John) Deere and Company's experts on supply chain management (B. Dumolien, personal communication, November 25, 1991).

Reduced supplier base.

At the onset of the new product program the development team selects the few necessary suppliers with whom they will collaborate throughout the duration of the project and the lifetime of the product. They are selected on the basis of past relationships and proven performance. First-tier suppliers become members of the team (e.g. Fallon, 1986; Womack, Jones & Roos, 1990).

Partnering.

Lean producers view and treat their first-tier suppliers as extensions of their business. During a 1991 visit to Rockwell International Suspension Systems Company in Chatham, Ontario, Canada the Plant Manager stressed the importance of the Customer- Supplier relationship. He believes his company's performance now approaches world-class since recognizing the importance and logistics of the long-term relationship with Honda, one of their major customers (J. L. E. Parent, personal communication, October 15, 1991).

Long-term relationships.

There is an effort to create long-term relationship. Extended-duration relationships reduced the business uncertainty for the supplier. This provides an incentive for the supplier to enter into meaningful collaboration on cost reduction, quality and delivery improvement. Many times there is a sharing of proprietary data.

Early supplier involvement.

With all certainty, the early involvement of selected suppliers in the new product deliver process is critical. World class, lean producers leverage the knowledge and skills of their suppliers from the onset of a new product program. They choose not to do design on many components. Instead they give a functional specification to the supplier, asking the supplier to provide the detailed design. This assures those most knowledgeable (the supplier) about a component do the design work.

Manufacturing

All aspects of manufacturing are more efficient in the lean factory. Manufacturing processes, support facilities, and people are generally organized into product focused factories (also referred to as strategic business units). This organizational approach is called vertical integration.

Vertically integrated producers start with raw material, then perform all needed operations to produce a totally finished product. The intent of vertical integration is to place the maximum number of manufacturing operations under the direct control of the producer. Or, stated another way, minimize the number of purchased components and manufacturing operations. It was observed during a November 1991 visit that the Honda automobile and motorcycle engine manufacturing facility in Anna, Ohio has a high degree of vertical integration. An aluminum foundry on one end of the factory and a gray iron foundry on the other provide castings for the machining operations. Fully-machined components, such as engine blocks, transmission cases, and cylinder liners are then sub and final assembled, tested, painted, and shipped.

Nearly all producers choose not to include the maximum number of manufacturing operations under their direct control. They prefer to focus on their core competencies, finding this to be more cost effective. Henry Ford tried to achieve the maximum. He actually owned plantations to produce the rubber for the tires he needed. He owned iron ore mines and smelters to produce the steel he needed.

Vertically integrated modules exhibit the characteristics described below.

Employee safety.

Lean producers provide a healthy, safe work environment all employees.

Cellular operations.

Machines and processes needed to complete all operations on a collection (family) of parts with similar geometric configuration are physically grouped together in "cells". Machines in the cell are dedicated to the the part family--no cross routing occurs. Low volume (such as non-current service parts) and low-value-added components are generally not included in the high volume, current production cells. Final assembly cells are generally designed to accommodate a homogeneous build schedule (e.g. Crawford & Cox, 1991; Dilworth, 1991; Fallon, 1986; Gottesman, 1991; Womack, Jones & Roos, 1990).

Excellent space utilization.

Space between machines is minimized. Material handling distances are short, resulting in little unnecessary inventory, improved communication between workers, and an environment where the supervisor can more easily manage "visually." Very little space is allocated for material queues. Literally, there is a place for everything and everything is in its place (e.g. Crawford & Cox, 1991; Dilworth, 1991; Gottesman, 1991; Heiko, 1989; Womack, Jones & Roos, 1990).

Optimum flow of materials.

The arrangement of processes and cells is such that there is little backtracking of material, few alternate process routes, and minimum material handling (e.g. Gottesman, 1991; Fallon, 1986; Heiko, 1989; Womack, Jones & Roos, 1990).

Velocity of throughput is high.

Parts are processed on demand, no more, no less. In 1981, Monden stated "the idea of producing units in the necessary quantities at the necessary time is appropriately described by the short term 'Just-in-Time' " (pg. 38). The ultimate is goal is to produce in a lot size of one. Consumption driven, trigger-type, Kanban production control that "pull" rather than "push" product through the factory are used. Production schedule stability is a high priority. Although throughput is a primary focus, quality is never sacrificed. Assemblers are empowered to stop the assembly line if a critical mistake is detected (e.g. Crawford & Cox, 1991; Dilworth, 1991; Gottesman, 1991; Heiko, 1989; Womack, Jones & Roos, 1990).

Point of use deliveries.

Cells are designed to accommodate delivery of material to the point of use. Considerable reductions in material handling costs are achieved by eliminating bulk storage areas. (You will not find "high rise" storage systems in the lean factory). The objective is to deliver all material directly to where it is needed, in the correct quantity, in the preferred container (e.g. Heiko, 1989; Womack, Jones & Roos, 1990).

Quick job changeover.

Process changeover time is short. Lengthy setup time results in increased velocity of throughput and reduction of the evil of all evils--unneeded inventory. The lean producer uses many simple methods to streamline process changeover time. The secret, in part, is to recognize the importance of preparatory activities (e.g. Crawford & Cox, 1991; Dilworth, 1991; Fallon, 1986; Gottesman, 1991; Heiko, 1989; Womack, Jones & Roos, 1990).

Predictive/preventative maintenance.

Machine maintenance cost in a complex factory is high. Control of this cost is best accomplished through well-executed predictive and preventive maintenance. Preventive maintenance occurs on a regular and periodic schedule resulting from the analysis of historical data. Predictive maintenance schedules are constructed from projections of future machine degradation characteristics (e.g. Crawford & Cox, 1991; Gottesman, 1991; Womack, Jones & Roos, 1990).

Job classifications.

Few job classifications exist. This allows flexibility in job assignments and rotation. Few complicated work rules exist.

Effective/appropriate use of automation.

Although automation exists, it is applied on a very selective basis. Waste is never automated. Process and procedure simplification comes before high-tech process automation.

Systematic benchmarking.

Lean producers assess their overall effectiveness via regular and periodic benchmarking. Benchmarking is a comprehensive process that looks well beyond product design and manufacturing processes. Benchmarks many times come from companies in a totally different type business.

Performance measures.

Measures of performance are customer-oriented, bottom-line focused, accurate, simple, easy-to-understand and appropriate. Many are real time and visual such as the Japanese andon boards (lighted electronic displays) observed during a 1991 visit to the Toyota Motor Manufacturing (Camry automobile) facility in Georgetown, Kentucky.

Organizational hierarchy.

The organizational structure is simple and effective. It is designed to compliment the operation of the focused factory. Typically, the lean producer has fewer layers of management than the typical mass-producer. This reduces period (fixed) overhead.

Wage worker compensation.

Compensation for wage is fair, equitable, and consistent with the employee involvement and continuous improvement principles. Many lean producers do not have incentive pay systems--they pay their wage employees an hourly rate. Many have bonus payments based on predetermined measures that allow sharing of profits.

Salaried worker compensation.

Compensation for salaried staff is fair, equitable, and consistent with the employee involvement and continuous improvement principles. Some have a pay-for-performance type system with profit sharing.

Rewards and recognition.

One of the reasons lean producers are so successful is because they have meaningful rewards and recognition for all employees. Many, such as Toyota Motor Manufacturing, have streamlined suggestion systems that stress the quantity of self-implemented continuous improvement ideas. Some recognize perfect attendance with special parties and gifts. Employee-of-the-month programs are frequently observed.

Training.

People are the lean producer's most important asset. Therefore, ongoing training receives considerable attention. Many companies sponsor classes that require the employee to commit personal time.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

World-class lean production is multi-faceted. It's strengths, as compared to mass-production, lie in it's ability to to produce many more products with the same amount of engineering effort and in substantially less time. Lean production also reaps substantially more cost savings benefits from long-term meaningful partnering with suppliers and a higher degree of continuous improvement through empowered multi-disciplined teams. In addition, lean operations produce fewer errors, the workers adding value are tasked with more authority, and there is a system for that quickly traces every defect to its ultimate cause. There is a continuing relationship with the customer.

Conclusion

Lean production is superior to the mass-production techniques. It will ultimately replace mass-production in all manufacturing facilities producing for a world-wide market.

Recommendations

American manufacturer must learn, adopt, and implement lean production techniques as quickly as possible if they are to be a competitive force in the global marketplace. Survival can not be guaranteed otherwise.

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