An MHIA White Paper

MATERIAL HANDLING INDUSTRY OF AMERICA®

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Integrated Lean Thinking & Ergonomics:

Utilizing Material Handling Assist Device Solutions for a Productive Workplace

INDUSTRIAL ENGINEERING
SOUTH DAKOTA SCHOOL OF MINES

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Introduction

Over the past several decades, “Just-In-Time” has become the battle cry in many American industries, as the Internet raises consumer expectations and mass customization requires an increasingly flexible production base. Consumers want their grocery stores to have the freshest produce available regardless of the local growing season. Automobile owners needing to repair their vehicles are no longer willing to wait an indefinite amount of time for their parts to arrive. Home remodelers expect to purchase a dishwasher today that exactly matches their cupboards and have it delivered tomorrow. Online shoppers assume whatever they order is sitting in a warehouse ready to be shipped.

At the same time companies are fielding requests for increasing flexibility and decreasing lead-time, the global marketplace is forcing companies to find new ways to decrease costs while maintaining (or increasing) their level of quality. While from a traditional mass-production perspective these demands seem to be in conflict with one another, shifting to lean systems unifies lead-time, cost, and quality as key performance indicators. Keeping people, and thus ergonomics, at the heart of the lean philosophy helps assure that the company is not removing waste in the process by creating new wastes of overburden on the workers.

Finding appropriate countermeasures involves a systematic consideration of the entire set of process. Unfortunately, all too often when a company decides to invest in material handling equipment, ergonomics and lean concepts are often not at the forefront of the thought process. This seems surprising considering that material movement is essential in lean concepts and is at the heart of ergonomics. More importantly, by strategically using material handling products and keeping the worker at the center of the process, companies can also experience improved quality along with ergonomic and lean benefits.

When contemplating the purchase of material handling equipment, keep in mind that the benefits outweigh the costs in the long run. Benefits to keep in mind include:

- Increased production,
- Decreased worker fatigue,
- Decreased workers’ compensation costs, and
- Increased worker morale.

To fully understand how lean manufacturing, ergonomics, and material handling interlink, one must understand lean and ergonomics as well as the intersection between the two. This paper will explain lean concepts and ergonomics and relate them to material handling. It will also provide specific situations in which companies have used material handling equipment to improve or support their lean initiatives and to help improve the ergonomics of their processes. Most importantly, the addition of material handling equipment to the given examples has ultimately improved the quality of the process and the end product.

Overview of Lean Thinking

Toyota has worked since the late 1940s to develop and hone an operations philosophy which cuts costs and lead time within their factories without sacrificing quality or customer service. Many manufacturing firms, envious of Toyota's quality, productivity, and profit margin [1-6] have attempted to implement the Toyota Production System, also called lean manufacturing or lean thinking, on their shop floors with varying levels of success [7, 8]. The primary goal of lean thinking is to increase profit by reducing cost and increasing productivity; this is achieved through the elimination of all the waste in the system [9]. Waste is "anything other than the minimum amount of equipment, materials, parts, space, and worker's time, which are absolutely essential to add value to the product [10]."

Credited to Taiichi Ohno, Toyota's chief of production in the post WWII period, the lean system was developed through the 1950's and 1960's to provide the best quality, lowest cost, and shortest lead time through the elimination of waste [11]. The Japanese term for what American companies usually categorize as waste is *muda* and was defined by Fujio Cho of Toyota as "Anything other than the minimum amount of equipment, space and worker's time, which are absolutely essential to add value to the product." [12] The *muda* variety of waste is often described as the set of seven categories shown in Table 1. The presence of all of these types of waste in a system has a negative impact on lead-time, cost, and quality. The waste of unnecessary motion is particularly related to ergonomics. Excess motion consists of bending, twisting, lifting, reaching and walking. These often become health and safety issues and should be dealt with as soon as they are recognized.

Table 1. The seven categories of *muda* waste.

Type of Waste	How to Avoid The Waste
Correction	Perform each operation without error. Build quality into every process.
Overproduction	Produce *only* the amount of goods necessary – not faster, sooner, or more.
Motion	Simplify standardized work sequence to eliminate unnecessary movements.
Material Movement	Minimize the distance between processes, and avoid temporary material locations.
Waiting	Assure machine availability. Perform preventative maintenance. Use man/machine charting to ensure optimization of operator's time.
Inventory	Provide material when needed by the customer and only in the quantity required.
Processing	Provide *only* the required amount of processing and effort for each operation.

Many practitioners and teachers of lean thinking add an eighth type of waste: the under-utilization of the workers. Eliminating this waste in the system means encouraging and making constructive use of the creativity and ingenuity of the people actually doing the work as well as assuring that the workers are adding value to the product rather than doing “make-work” activities. The importance of this is stressed by Ohno [13] and Shingo [14] in their seminal works on the Toyota Production System. In addition to *muda* waste, companies need to locate and remove *muri* waste, i.e. unreasonable mental or physical burden.

The lean philosophy of operations used to reduce or, ideally, eliminate these wastes is often described as a house. As shown in Figure 1, the roof of the house is the goal of the system – to produce the highest quality product with the lowest cost and shortest lead time. The cost decreases include reducing the money spent on poor quality products, reducing the money tied up in inventory, and decreasing dollars spent on workers’ compensation and other employee injury-related costs. It is important that companies keep their production goals in mind – lean thinking is not just about reducing costs, it is about adding value.

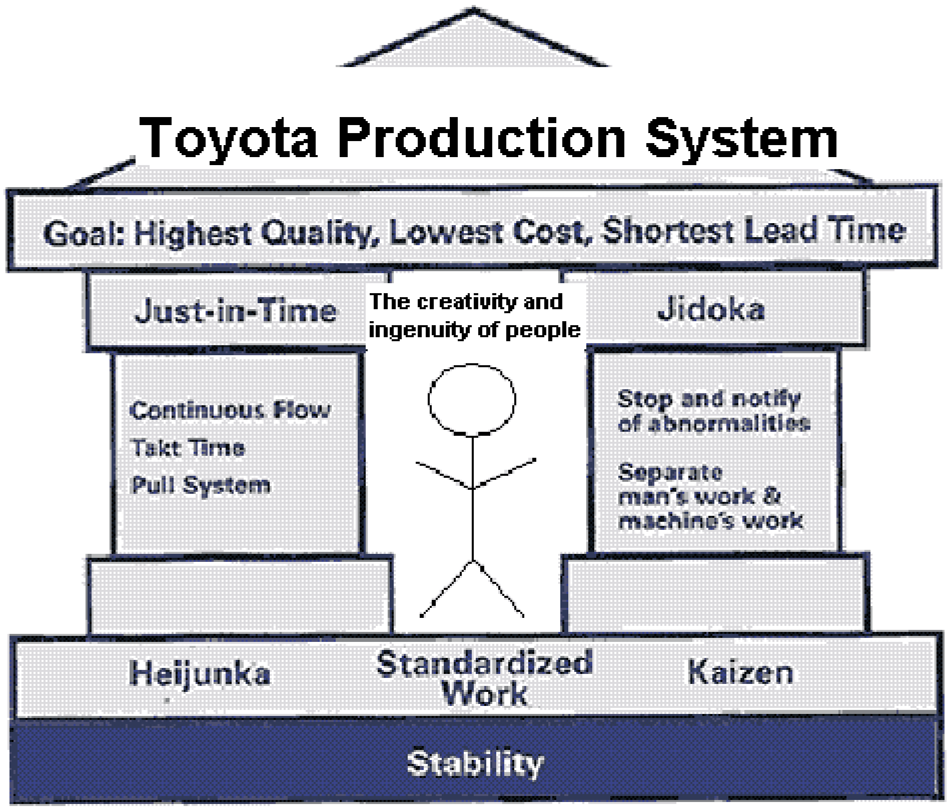

Figure 1 Toyota Production System House of Quality

The first of two pillars holding up the roof of the house is the ***just-in-time*** pillar and is a support tool for the system. Just-in-time relates to consumption on the production line based on demand, or sometimes called a “pull system.” The company receives deliveries “just-in-time” which creates the right products at the right time in the right quantity. The result is a short lead time and decreased costs.

The second pillar consists of ***Jidoka*** which means building in quality at the source. If a company waits until the end of the process to “inspect quality into the product,” it is often too late to quickly fix, much less find, the root cause of a quality problem. Additionally, any material produced from the point of the quality spill until the discovery of the problem at the final inspection often must be scrapped or reworked. Ideally, abnormalities will be prevented before they can occur (*poke*-yoke or error-proofing). When abnormalities do break through into the system, they are discovered through worker interaction with the product (*andon* systems) as well as machine programming (autonomation) and are immediately flagged and fixed. If necessary, the system is stopped in order to make sure the abnormality is removed.

The foundation for the lean thinking house consists of operational stability using ***heijunka*** and ***kaizen*** along with standard work. *Heijunka* simply means production smoothing and *kaizen* is translated as continuous improvement. Standard work means that every time a particular task is done, the task is performed the exact same way. These elements are like the foundation of a house: if done well, they rarely noticed by visitors, but harming the foundation significantly weakens the ability of the house to withstand its environment.

No matter how strong or beautiful a house is built, a house in which no one lives is a waste of resources. Thus, the most important aspect of the lean house is the people who make up the center. The human touch is necessary for most production processes as they can detect abnormalities that a machine is not programmed to do or simply cannot; the only processes in which the human touch should not be some part are those where the person would be unsafe. The combination of lean thinking and ergonomics results in a system where the worker is as efficient, safe, and comfortable as possible while trying to produce the best product possible. Material handling plays a significant roll in lean by keeping the worker at the center and ameliorating many of the ergonomic problems that would otherwise remove the person from the process. Transportation and unnecessary motion are two of the seven types of wastes that can be significantly reduced with the implementation of ergonomic assist systems and equipment. With the correct ergonomic assist product in place, waste can be removed from the system creating an increase in production, decreased costs, and an increase in quality.

Overview of Ergonomics Principles

The definition of ergonomics (or human engineering or human-centered design) simply refers to ***designing for human use*** [15]. Over the years, the objectives of the ergonomics field has grown to encompass the design of work systems (including equipment, materials, tools, interfaces, environment, etc.) within human capabilities so as to improve productivity and reduce injuries and fatigue [16, 17]. Concepts from the field of industrial engineering have had considerable influence within the field of ergonomics, particularly with regard to ***working smarter, not harder,*** elimination of waste, and maintaining a systems view, including the economic impacts [18].

Ergonomics principles and guidelines are useful in prevention of operator fatigue and stress leading to potential work-related musculoskeletal and neurovascular disorders (hereafter referred to as musculoskeletal disorders, or MSDs). Some of the key ergonomics principles for sound workplace design include [18]:

- Avoiding prolonged, static postures

- Promoting use of neutral joint postures
- Locating work, parts, tools, and controls at optimal anthropometric locations
- Providing adjustable workstations and a variety of tool sizes
- When appropriate, providing adjustable seating, arm rests, back rests, and foot rests
- Utilizing feet and legs, in addition to hands and arms
- Using gravity
- Conserving momentum in body motions
- Providing strategic location (in the ***power zone***, see Figure 2) for lifting, lowering, and releasing loads
- Accommodating for a broad variety of workers with respect to size, strength, and cognitive abilities

Many of these principles can be met by using techniques such as redesigning work, standardizing work, and reducing or eliminating risk factors for potential development of MSDs, especially the physical risk factors [18, 19]. Many types of assist devices can be utilized to adhere to ergonomics principles, including carts, lift devices (e.g., scissor lifts and lift tables), adjustable worker elevation platforms, tool balancers, manipulators, vacuum assist devices, workstation cranes, adjustable workstations and seating, conveyors, stackers, container tilters, and pallet invertors and rotators, and vibration dampening devices [20]. An excellent resource illustrating a wide variety of powered and non-powered material handling assist devices to reduce or eliminate MSD risk factors is the ***Ergonomic Guidelines for Manual Material Handling*** [19].

The three major risk factors for potential development of work-related MSDs are high force, awkward posture, and excessive repetition [18]. Other potential risk factors [21] can include vibration, cold stress, lack of rest, non-occupational factors (e.g., hobbies, sports, home chores, driving, and sleep issues), personal risk factors (e.g., gender, age, health history, and fitness level), and even psychosocial factors (e.g., organizational climate and culture, job attitude and satisfaction, personality traits, and personal problems [e.g., loss of a loved one, financial difficulties, etc.]).

Many of the occupational risk factors, especially the physical risk factors (high forces, awkward postures, excessive repetition, and vibration) can be reduced or eliminated altogether by adhering to proper workplace design principles and appropriate use of assist devices.

The ***power zone*** is the lifting region that is considered optimal by ergonomists. This area extends from approximately standing elbow height to standing knuckle height and as close to the body as possible (see Figure 2 [22]). For compliance, check the location of the third knuckle on each hand during the exertion with relation to the zone. The ***power zone*** optimizes worker strength and durability with the most comfort by providing the arms and back with maximum leverage. Often, workplace lifting and lowering occurs in locations that are out of the ***power zone***. The advantage of material handling assist devices is to bring objects into the power zone at critical points during the work task. By bringing material, especially heavy loads, into the power zone, material handling assist devices improve ergonomics and decrease the risk of MSDs.

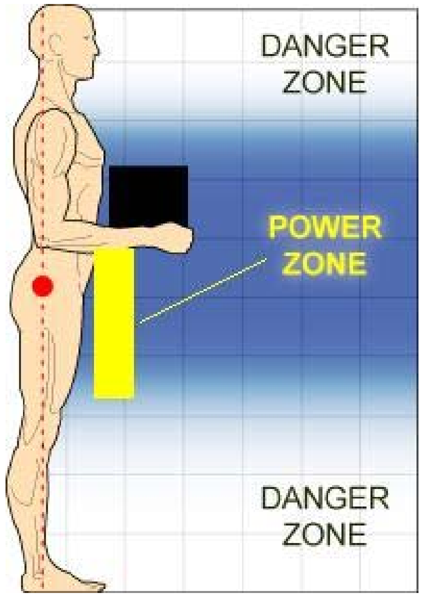

Figure 2 Power Zone [22]

MSDs typically account for about one-third of workplace reports of injury, but more importantly they often account for about three-fourths of costs. MSD claims requiring surgery can, in total, cost approximately $15K for a wrist disorder, $20K for a shoulder injury, and $40K for a back injury [23]. The cost of lost workdays of MSDs, based on lost earnings and workers' compensation, has been estimated at $13-20 billion annually and as high as $50 billion annually if indirect costs are included [24].

Cost savings through implementation of ergonomics principles and assist devices can be challenging to track accurately, but quite rewarding. It is not clear what or how many injuries have been prevented due to proper ergonomics or how many workers' compensation claims can be prevented each year. Where workers' compensation claim costs (direct costs) might be relatively easy to track, indirect costs may not be. How can you accurately track costs associated with indirect costs such as turnover, absenteeism, mistakes, restricted work duty, paperwork burdens, etc? Indirect costs have been estimated anywhere from 2:1 to 14:1 in contrast with direct costs. So conservatively use a 2:1 ratio, or in other words, triple your workers' compensation claim costs as an estimate of the cost of not addressing ergonomics-related issues [23].

The bottom line is that proper ergonomics has been shown to decrease fatigue, a symptom that is often a precursor to injury. Ergonomics also plays a significant role in achieving the goals of ***lean thinking*** by reducing costs and improving productivity through eliminating waste (e.g., unnecessary motions) and reducing mistakes (improving quality). By limiting the number of repetitions and excess motion, a company will save time and money. ***Ergonomics plays into lean as much as lean plays into ergonomics, a effective tool that links the two is material handling assist devices***, more specifically; ergonomic assist devices (e.g., carts, lift tables, tool balancers, etc).

When looking at the principles of ergonomics and lean, it becomes clear how the two interlink. To properly keep the worker at the center of the process, material handling assist devices become a link. More specifically, establishing the best lean process with the proper ergonomics can often be accomplished with material handling assist devices. They allow the worker to remain in the middle of the process while maximizing production and decreasing process waste. The following section contains examples of the benefits ergonomic assist devices can provide. They show some example applications companies have used to solve their lean and ergonomics challenges. They range from simple lifts to complex manipulators but all achieve the same goal; increased production, decreased worker fatigue, and an increase in quality.

Applications

This paper considers four applications in which lean thinking and ergonomic principles are crucial to creating effective, sustainable countermeasures. First, countermeasures are considered for *removing waste* within the context of adding value to the product and for the workers. Next the issue of maintaining *flexible processes* is discussed. This is followed by a section on the *impact of fatigue on productivity*. Finally, the paper explicitly addresses the needs of the office and the *service sector*.

Removing Waste

As discussed in the Overview of Lean Thinking section, waste is "Anything other than the minimum amount of equipment, space and worker's time, which are absolutely essential to add value to the product." [12] Removing waste from systems and processes has many benefits, including:

- Decreasing lead-time – removing waste shortens the supply chain as well as shortening the internal value added processes.
- Increasing quality – removing waste also removes excess steps and inventory waiting that may hide quality problems or hide the quality problem until it is too late to fix easily.
- Decreasing costs – removing waste decreases the inventory that must be held and may decrease costs of equipment, facilities, and people as well.
- Increasing productivity – removing waste removes unnecessary movement, inventory, and double handling, leaving the people and machines available to be more productive.

Additionally, removing the waste of unnecessary motion can have a significant positive impact on ergonomics and workers' compensation costs.

Often, work activities are placed into two categories: value added and everything else, where "everything else" is waste. There is a third category that should also be considered: incidental work. Incidental work is all activities that are transparent to the customer, but necessary to complete the value added tasks. For example, payroll and accounts receivable are incidental work for most organizations. While, like value added work, incidental work may have waste within it, the task itself is likely necessary to the overall operations of the organization.

In order to remove waste from the system, improvement processes should focus on simplification, combination, and elimination. Simplifying work includes creating standard work so that everyone knows, and does, the same work the same way every time. Error proofing a process also removes waste through simplification. Additionally, using workplace organization disciplines such as 5S, and techniques such as part orientation, location marking, and color coding, can simplify a process as well as remove waste and minimize safety hazards.

Combining steps of a process can also remove waste. For example, moving machines closer together to remove walking and material transportation between them removes waste. Combining steps in set-up and change-over processes reduces wasted time while the process is offline as well as reducing the amount of inventory that must be held to buffer against long production runs. Part ejectors and appropriately used mechanical handling devices can also reduce waste by reducing the steps the operator must perform in the value-added process.

Finally, some waste may be removed from the system through eliminating some work functions all together. For example, must adjustments be constantly performed on a given machine? If so, can they be automated? Or error-proofed? Might preventative maintenance be used instead? Other places to look for work activities that can be eliminated include additional handling and set-up time that forces the process to stop.

An example of simplification, combination, and elimination in the same process is the West Virginia National Guard hanger responsible for repairing Army Black Hawk helicopters. They installed a vertical lift module to use in their hanger to remove waste from their processes (see Figure 3). Currently, they have one unit installed and another being installed. They are using an industrial vertical carousel to store parts needed to fix the helicopters. The first unit had replaced several storage spaces and cabinets within the hanger. The second unit will replace approximately 15 cabinets that are five feet high each. These units included nuts and bolts and other small repair parts. By simplifying the process through standard part locations within the carousels, it is much easier for the repair technicians to locate the parts they need. By combining the many cabinets into two vertical carousels the West Virginia National Guard has removed unnecessary walking for the operators. Finally, eliminating the bending and twisting necessary to lift heavy parts off the ground has significantly improved their ergonomics. The parts are now in position to move the part onto the cart and cart the part the rest of the way. Additionally, the vertical carousels have a positive impact on the National Guard's security needs. These helicopters run about $17 million each and parts to fix them are expensive as well as critical to the helicopter operations. The parts must be secure and a vertical carousel equipped with a lockout system provides them with the necessary security. Overall, benefits that were most seen by the West Virginia National Guard in this example were safety and security, time savings, space savings and ergonomics related.

Figure 3 High-Capacity Industrial Vertical Lift Module

Flexible Processes

The history of business, sports, and politics all tell us one undeniable truth: "All competitive advantage is temporary. [25]" The next change in the environment, the next new idea, the next change in customer demand is always around the corner. Building organizational processes to be flexible significantly aids in the firm's ability to respond appropriately to these changes.

There are many techniques and thought processes that can add flexibility to a process. For example:

- *Set-up / Change-over* – Every time the color of the product, the size of the product, or other change is made in the production line, the set-up process must occur to account for the change. Single Minute Exchange of Die (SMED) is a systematic way of approaching and streamlining the set-up process. [14]
- *Machine choice* – Decisions must be made weighing the differences between a specialized machine that will complete one task very efficiently or a flexible machine that might not be as efficient, but will adjust with the needs of the product family over the long term.
- *Inventory controls* – Holding too much inventory "clouds the picture" of what the firm really has available for the customer and what capacities the firm really has to meet new expectations.
- *Linkages* – Since transporting material or storing material in a warehouse is not adding value to the material, it is, by definition, waste. Therefore, shortening the lead time in a logistics system removes waste from the system and makes the system more flexible.

It is important that these techniques and the many others that increase flexibility are used as part of the whole organization system. The creators of the Toyota Production System recognize that the value is in the implementation and discipline of the whole system rather than picking bits and pieces [13, 14].

Building flexibility into cell design is illustrated through the example of utilizing a workstation crane for a work cell (see Figure 4). This company was looking for a way to load and unload virtually any type of parts to any location within a work cell. Any combination of machines placed in this work cell can be serviced by this crane. Additionally the crane can provide versatile assistance for maintenance and tool/die changes. Parts can be quickly and easily be strategically delivered to the worker's **power zone** or strategically to or from any machine. Manually lifting is essentially eliminated. A single worker can essentially perform all tasks within the cell with the assistance of this type of crane. Various end-effectors could be mounted on the crane to accomplished specialized tasks. Cells of almost any size can be designed.

For example, Stone Co.[1], is a maker of fabricated stone products. This company was looking for a new way to load and unload large granite slabs through several machining processes. The process involved several employees working together to lift the slabs manually. They lifted the slabs by the corners which created a tremendous amount of pressure to the center, sometimes causing a break point. Each slab was also moved several times during the process which increased the possibility of injury to the workers

[1] Name has been changed.

as well as damage to the slabs. By installing overhead bridge cranes, the need for manual lifting of these 850 lbs slabs was eliminated.

Figure 4. Workstation crane for a work cell.

The cell is created through the combination of an overhead bridge crane as the supporting structure and a hoist attached to the bridge span that does the actual lifting, along with a vacuum end effector attached to the hoist that suctions the granite so it can be lifted by the hoist. This flexible cell can be placed in any position where the granite slabs need to be moved. Additionally, when the steps to process the granite change to meet changing needs of the customers, the slab moving cell can be easily moved to another position on the shop floor. Beyond the positive impact on flexibility, Stone Co. estimates a 25 percent increase in productivity because of the ease of movement of the entire system. Worker fatigue and the risk for personal injury were also reduced and the addition of the lifting and hoisting devices has created new opportunities for the ergonomists to work with the operators for further injury reduction. Quality was improved by eliminating damage, nicks or scratches, to the slabs as happened before the system was installed.

Impact of Fatigue on Productivity

Over two centuries ago, work was dominated by human labor with some assistance from simple machines and tools, ranging from raw physical labor to specialized work performed by skilled artisans. The work pace and output were certainly limited by human energy and work capability. In subsequent decades came the advent of interchangeable parts, mass production, industrialization, machines with increasing capabilities, computers, robots, an array of advanced sensors and controls, and systems with machine intelligence. At the extreme, the concept of the completely automated, lights-out facility was envisioned (but never fully realized) where humans served only as designers and maintenance technicians and the output would only be limited by machine capability. Contemporary work design seeks to utilize an optimal balance of human and machine capabilities. For the human side, it is key to understand and fully utilize both physical and mental capabilities in an optimal manner, sometimes described as ***working smarter, not harder***. When humans become overtaxed, either physically or mentally, they experience fatigue (physical or mental) and experience subsequent decreases in output, productivity, and quality.

Some of the risk factors for the potential development of MSDs, as presented in the ***Overview of Ergonomics Principles,*** have a direct impact on physical fatigue (e.g., high force, awkward posture, and excessive repetition). The goal of contemporary work design seeks to optimize the mutual strengths of humans and machines. Proper use of ergonomic assist devices can eliminate or reduce fatigue-related risk factors and thus allow the worker to stay both physically and mentally capable throughout the work shift.

Optimal stress suggests that workers' health and safety are not compromised, fatigue is not accumulated between shifts, and there is reasonable productivity [18]. Manipulators and reaction arms are a perfect fit for fatigue-reducing solutions. Allowing these devices to reduce or eliminate the forces required and to extend out or into a machine to perform work saves on fatigue and stress that would be experienced by the worker.

For example, an operator utilizing a reaction arm "reaches" into a frame to quickly, effectively, and safely position a 40 lb part for assembly (see Figure 5). While most people can easily lift and hold 40 lbs within their ***power zone***, few people could hold such a load with their arms extended and their back in a deeply flexed posture while completing the assembly task quickly and accurately. Before this manipulator was installed, most workers had to lay on the floor on their back to "bench press" the part into position, then attempt to hold it with one hand while fastening with the other. In this case the manipulator enhances quality, productivity, and safety, but it also eliminates worker fatigue throughout the duration of the work shift.

A key principle in reducing fatigue is reduction or elimination of "static work". Static work is essentially a muscle contraction without motion, such as lifting a box and holding it in position, or holding and supporting a part in one hand while performing an assembly with the other hand. Often static work can be eliminated by utilizing a stabilizing or holding device, such as a vice, fixture, manipulator, or an adjustable height work surface (such as lift). Not only do such devices support the part or load, but they free up a second hand or both hands for value-added work, all while reducing fatigue.

Figure 5 Manipulator in Assembly Operation at Large Vehicle Manufacturer. Operator can safely and effectively position an awkward 40 lb part. Previously the operator was forced to lie on the floor in a supine posture to position and affix this part.

Often parts are delivered to a work station on a pallet placed on the floor. The parts might be stacked on the pallet or in a large bin. The worker accesses the parts by combinations of bending, extended reaching and twisting to various locations on the pallet or within the bin causing excessive stress to the low back and shoulders, as well as contributing to fatigue. A simple, effective solution is to place the pallet or parts on an adjustable height (or self-leveling) lift thus bringing the parts into the ***power zone***. Such lift tables are powered with pneumatics or hydraulics, often with a scissors mechanism. This minimizes the reaching, and flexing and twisting of the low back. A turn table allows the pallet to rotate, thus always bringing the parts closer to the worker and again reducing reaching and back flexion (see Figure 6a). A tilting table tips a parts bin so that parts flow to the worker, thus reducing trunk flexion and reaching across the bin and providing easier access to the bottom of the bin (see Figure 6b). The combination of a table with easily adjustable lift (or self-leveling lift), turn, tilt, or up-ending features provides an extremely versatile environment for workers of all sizes. These features reduce or eliminate excessive stress due to lifting, reaching, and twisting, while reducing physical stress and contributing to improved quality and productivity. Lifts and related material handling devices can be used to strategically position parts, tools, and even workers.

	
(a) Lift table with turn feature.	(b) Lift table with tilt feature.

Figure 6. Lift tables with turn (a) and tilt (b) features bring the parts into the ***power zone***.

Service Sector

The name “lean manufacturing” often elicits images of smoothly operating Toyota facilities or other examples on a manufacturing floor. The majority of the books on lean thinking are about manufacturing situations. While these examples are important, lean thinking is not restrained to production operations. Fabrizio and Tapping point out that “While much attention and energy has been focused on machine effectiveness, shop floor efficiency, and just-in-time production, little attention has been focused on the role of office improvement…Every nook and cranny of your establishment must operate within the principles of lean [26]." This is true for true service sector industries, such as hotels, health care, and logistics/distribution; for the office functions of manufacturing industries, such as sales, accounting, and purchasing; and for service/production hybrid industries, such as retail stores, restaurants, cosmetics.

Fortunately, lean thinking is really a philosophy – a way of operating – rather than a discrete set of tools or techniques. Just as a company can create new tools to implement lean thinking on the shop floor, tools and techniques can be tweaked or created new to infuse lean thinking in the office and other service sector situations.

Standard work, for example, is the practice of doing the same thing the same way every time and by every person. In repetitive manufacturing environments, this is implemented through detailed work tables complete with time allowed for each task, time allowed for walking between stations, and a layout diagram. This level of detail is important for assuring quality and the ability to meet productivity goals in manufacturing. Sometimes, this level of detail works well in service situations. For example, the housekeeping department at a hotel may build this form of standard work. Often in service, however, standard work takes a broader, more flow-chart-like form. The series of questions that must be answered to schedule an expedited material pick-up or the process by which a marketing campaign goes from idea to full scale implementation are examples where a standard work umbrella may be very useful.

Production regulation is a key concept on the lean manufacturing floor. Composed of the ***just-in-time*** pillar of the ***lean house*** (see Figure 1), production regulation is the process by which consumption on the production line is based on customer demand. Every service sector company and every production facility office needs to consider who is their customer and how does that customer demonstrate demand. For example, the customer of an insurance claims office may be policy holders who need to make a claim; their demand is demonstrated through contacting the office with the initial claim information. The company can then use the same philosophy of production, or operations, regulation to remove waste and reduce lead-time while maintaining or improving the quality of the customer experience.

One of the supporting tools to just-in-time production on the manufacturing shop floor is assuring proper part orientation. This means not only placing the part at an appropriate ergonomic level and in a position that is easy for the operator to grasp, but also having the right part at the right place at the right time. This is also a significant concern in service industries. For example, pharmacies must be able to fill a prescription quickly and accurately while assuring both the safety of the workers and security of the pharmaceuticals. Like a growing number of hospitals around the country, Rapid City (SD) Regional Hospital, has reached outside of the traditional pharmaceutical technologies to address these needs. Although they are a relatively small facility, this hospital pharmacy has invested in a vertical carousel (see Figure 7).

Figure 7 Vertical Carousel Application in a Hospital Pharmacy

The vertical carousel has a positive impact on part orientation through:

- Bringing the needed drug to the operator at the press of a button.
- Positioning the needed drug in the operator's ***power zone***, as described in the ***Overview of Ergonomics Principles***.
- As long as the same drug is filled in the same bin and properly labeled, the accuracy of the prescription fill is improved. The machine will recognize the code and bring only that level of tray to the opening for picking.

In addition, this system uses much of the vertical space that otherwise would require employees to bend forward or reach over their heads. It also decreases the time spent looking up and down shelves for the correct drug.

Finally, the use of vertical carousels in hospitals and other similar facilities combines effective part orientation with customizable levels of security. The vertical carousel comes with locking doors that will shut while the carousel is in motion and only open once the tray's code that is to be accessed is in front of the doors. Limiting the number of people with access codes and/or the shelves in the carousel to which their codes apply increases security further.

Many creative applications are possible across the very broad spectrum of the service sector by focusing on strategic placement of parts, products, tools, equipment, and people to reduce human stress and injuries, while realizing improvements in quality and productivity of services and life.

Conclusion

Lean thinking, when implemented correctly, requires effective ergonomics. Effective ergonomics is a necessary part of any sustainable organization. Neither concept is really new, but the trend in most (if not all) industries has made the appropriate application of these ways of operating all the more vital to both short term and long term success. The successful implementation of lean thinking and ergonomics includes the redesign of work, standardizing work, and reduction or elimination of MSD risk factors. Successful implementation often includes utilization of material handling assist devices.

Removing waste from the system decreases lead-time and costs while increasing quality and productivity. Lean analysis helps make potential ergonomics challenges visible so that these issues may be corrected. Making processes more flexible allows the company to better position itself for competitive advantage. It also creates an environment where it is normal to make tweaks to the work, forming new opportunities to continuously find creative improvements. Worker fatigue, which has a negative impact on productivity, can be significantly reduced through application of sound ergonomics principles. All of these tools, techniques, and philosophies are just as useful in the office and the service sector as they are in the manufacturing environment in satisfying rising customer expectations.

For Further Reading

While there are enough books, papers, and web sites on lean and ergonomics to fill a library, the authors have suggested the following resources as a starting place for readers who wish to dig a little deeper:

Ergonomic Guidelines for Manual Material Handling (NIOSH 2007-131) available from the Material Handling Industry of America at www.mhia.org/ease

The Ergonomics Kit for General Industry 2nd Edition by Dan MacLeod

The Toyota Way by Jeffrey K. Liker

Lean Production Simplified by Pascal Dennis (Productivity Press)

5S for the Office by Thomas A. Fabrizio and Don Tapping

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