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Sustainable Work Environment with Lean Production in Textile and Clothing Industry

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Abstract

The objective of this paper is to discuss Lean Production (LP) as a work organizational model that fosters a sustainable work environment in the companies. This is achievable through some Lean tools and initiatives that, when applied to the work environment reduces the energy, water consumption, environmental waste and raw-materials consumption and improves leanness and agility. This paper focuses the Textile and Clothing Industry (TCI) and brings up proposals, initiatives and/or projects that are related with Lean Production aims. Traditionally, TCI had been greatly dependent on natural resources: natural fibers, dyes, water, energy among others and a high consumer of water and energy, especially in dyeing and finishing processes. At the same time, these processes have a water and soil pollution problem. In this manner, reduce the consumption of these resources and reduce pollutants should be a major concern for companies and individuals to achieve a sustainable development. In this paper, the authors also present some proposals of how companies may engage in such projects.

Key words: Lean Production; Sustainability; Eco-efficiency, Textile and Clothing Industry.

1. INTRODUCTION

Lean Production (LP) [1] is a model of organization focused on waste elimination to reduce costs, delivering on time quality products, materials and information and respecting people and the environment. Wastes, from the point of view of customer, are activities that add no value to the products. This designation comes from the key idea of “doing more with less” where less implies less space occupied, less transports, less inventories, and most important, less human effort and less natural resources.

One of the paper objectives is to review some of the Lean tools and initiatives that are totally aligned with sustainable development and eco-efficiency concept. A further objective is to describe and discuss some identified projects and standards that are applied/developed for the Portuguese Textile and Clothing Industry (TCI). The presented proposals were integrated and classified according to their objective that could be the reduction of: energy and water consumption; environmental waste; raw materials consumption; and/or the improvement of leanness and agility.

This research is based on literature review gathered from different sources (local, internet…) and of projects related with the reduction of wastes, in all kinds.

The paper is structured in five sections. This first section introduces the theme and objectives. The second section presents the context study and motivation. The third presents a brief literature review about Lean Production, sustainable development and eco-efficiency concepts and the synergy between these issues. The fourth presents the results of the search of projects in TCI and explore the different proposals attending to their objectives. The fifth, last section, presents some concluding remarks.

2. CONTEXT STUDY AND MOTIVATION

This study focuses the Portuguese TCI that has a large representation in the Portuguese industry and it always had an important role in national economy. Although suffering transformation due to delocalization and closure of companies, this industry continues to be one of the most important Portuguese manufacturing industries.

This industry comprises two important sectors: the textile sector, which includes fiber production, spinning, weaving, knitting and finishing (dyeing, printing and finishing) and the garment sector, which includes manufacture of clothing and accessories. This industry has been very dynamic and competitive, investing in technology, modernization and changing the strategy and performance of companies operating in the sector, developing a culture of quality and innovation, fast response, and right distribution channels. From the territorial point of view, this industry is spread all over the national territory, although there are two main regions: North of Portugal (cotton companies) and Beira Interior (wool companies), representing 85% of the companies. The TCI is composed approximately by 4000 companies (excluding clothing) and some 11000 garment companies, which together represent about 19% of all production units of the manufacturing industry and 1.4% of companies operating in Portugal. It represents 10% of national exports (in nineties this value was 30%), 22% of employment, 8% of turnover and 10.7% of Gross Value Added of manufacturing industry [2].

However, Portuguese TCI presents many problems such as: (a) stocks accumulated everywhere due to a production of wrong product; or to an anticipated production; or to large lots (overproduction); (b) discouragement of operators and high absenteeism, (c) high level of accidents, (d) operator's specialization, (e) high energy and water consumption, (f) high raw materials consumption and disposal, (g) high pollution of rivers, soil and air, among others.

Despite some drawbacks, TCI continue to be an industry that it is worthwhile continuing to invest. This investment does not mean that a high capital investment has to be done. Often, changing to a better production organization permits achieve amazing improvements. The Lean Production (LP) could help in the production organization leading to sustainable and efficient production work environment.

3. A BRIEF LITERATURE REVIEW

This section briefly reviews Lean Production models, sustainable development and relationship between them.

3.1. Lean production

Lean Production is a model of organization focused on the customer and delivery of on time quality products, materials and information without any wastes, i.e., activities that add no value to the products. LP do this with the involvement of all people in the company in a way that not injuries the environment. Lean Production means "doing more with less" where less implies less space occupied, less transports, less inventories, and most important, less human effort and less natural resources. LP had its roots in Toyota company that designed, after the Second Great War, a production system, Toyota Production System (TPS) [3] and [4], which employed some pillars, like JIT production and autonomation concepts and some tools (standardized work, kaizen, heijunka,…) to reduce lead times and the cost of products (Figure 1).

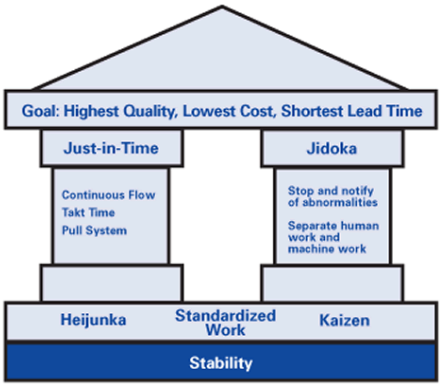

Figure 1. TPS house [5]

It was the book "The Machine That Changed the World"- written by James P. Womack, Daniel T. Jones and Daniel Roos [1] that gave the popularity to the Toyota Production System (TPS). Meanwhile, same authors proposed a new book presenting LP as a philosophy of thinking called Lean Thinking (LT) [6]. The basic principles of LT are: 1. Value, 2. Value Stream, 3. Continuous flow, 4. Pull System; and 5. Pursuit perfection.

These principles imply the dedication of all people, being the last one, pursuit perfection (principle 5), the one that implies the strongest and continuously commitment of people in order to improve all the processes and activities in companies, through the waste elimination. There are seven deadly wastes: overproduction, transports, movements, waits, over-processing, defects and inventories. Additionally, other authors [7], [8] add more wastes to this list: making the wrong product efficiently; untapped human potential; inappropriate systems; wasted energy, water and natural resources.

Nowadays, Lean Thinking principles are implemented in all sorts of industries [9-11] and services companies [12] and [13], to manufacturing operations or processes [14] inside a company.

3.2. Sustainable development and eco-efficiency

According to Brundtland report called "Our Common Future", sustainable development is: "*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" [15]. Sustainable development is based on three pillars (Figure 2): economic; environmental and social responsibility. Economically, companies must grow without compromising their integrity; socially, human rights must be respect, with social equity and social investment; environmentally, companies must worry with environment. Exposing these relationships, it is possible to notice that sustainable development was a concept with a strong connection to the companies or business, but also involving intensely the government and civil society partnerships to concretize this concept.

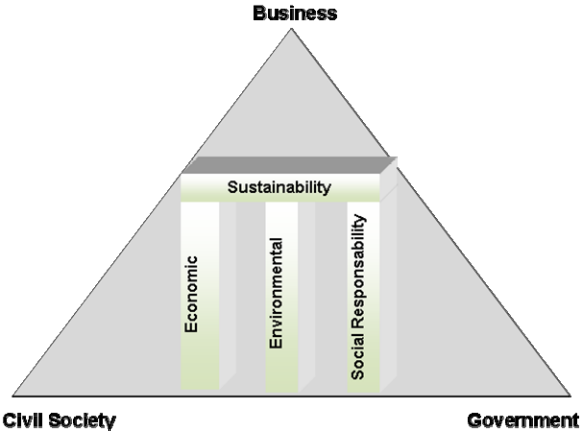

Figure 2. Pillars of sustainable development and partnerships involved

According to Holliday et al. [16] "The prices of goods *must reflect all the costs – financial, environmental and social – involved in making them, using them, disposing of them or recycling them.*". This is also applied to the services. Companies exist to satisfy their clients and to have profit, without compromise the nature and the future of the planet, working at any price. It is important to have a compromise between the business and sustainability. The companies must have economic viability, environment respect and social equity of people to have a sustainable business. Achieving full-cost pricing by being cleaner and more efficient, by producing with less and by supplying the customers with the wanted goods and services, makes happy leadership companies [16].

In the book *"Walking the talk: the business case for sustainable development"* [16], the authors describes ten building blocks of sustainable progress: 1) the market, 2) the right framework, 3) eco-efficiency, 4) corporate social responsibility, 5) learning to change, 6) from dialogue to partnerships, 7) informing and providing consumer choice, 8) innovation, 9) reflecting the worth of earth, and 10) making markets work for all. Enrolling in these steps and with the cooperation of business, government and civil society could create a market that maximizes the opportunity for all. The authors presented also 67 case studies revealing the opportunities and problems faced by them in the path of sustainable progress. Some of these case studies are developed in well-known companies like Shell, General Motors, BASF, Sony, DuPont, Toyota or Nestlé.

Of the ten building blocks identified, it should be stressed the eco-efficiency concept. This concept links sustainable development to business agenda. According to Business Council for Sustainable Development (BCSD), eco-efficiency is "*The delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impact and resource intensity throughout the life cycle, to a level at least in line with the Earth's estimated carrying capacity."* [17]. Eco-efficiency concept translates the simple idea of *"creating more with less"* by: (i) reducing materials intensity; (ii) minimizing energy intensity in both products and services; (iii) reducing the quantity and the dispersion of toxic substances and decreasing the level of toxicity of such substances; (iv) promoting recycling and the use of renewable energy; (v) extending the durability of products, and; (vi) increasing service intensity.

3.3 Lean Production and sustainable development

To satisfy the clients, companies consume energy, water and raw materials (natural resources). At the same time, they must be careful not to be a larger-than-life consumption because not only it is expensive but also natural resources are limited. So, it is necessary to optimize the processes and prevent wastes of resources in a reasonable "doing more with less". The relationship between Lean Production and sustainable development is evident, sharing the same key idea of "creating or doing more with less". Some organizations benefit from this relationship, almost, two decades now. As Kidwell [18] explained *"Lean strategies coincidentally benefit the environment, without the need for special "environmental" toolkits or a separate focus on environmental considerations".* Moreira et al. [19] reviewed the papers about this relationship and created a cause-effect diagram showing the evidence between the seven wastes and the impact (effect) on the environmental performance (Figure 3). The seven wastes that are identified by LP to be eliminated are: 1) overproduction (overburdening of employees); 2) inventory; 3) unnecessary transportation (and actions of employees); 4) defects; 5) waiting; 6) over-processing motion; and 7) motion.

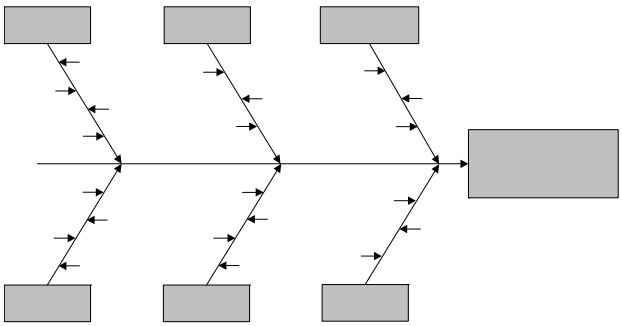

Figure 3. Production wastes as causes of weak environmental performance [19]

Lean Production carries a dramatic reduction to all kinds of wastes being a whole-system thinking [20] and it is totally akin with a socially responsible strategy. The U. S. Environment Protection Agency (US-EPA) discovered this way of thinking more than two decades ago and they are adopting the Lean Thinking principles and adapting Lean tools like VSM, 5S, JIT production or others to assess the use of hazardous materials, the energy and water consumption, the pollution, and so on. US-EPA had created guidebooks, toolkits and reports to be used by the companies (Table 1).

Others authors have proposed different alternatives such as toolbox using 5S and *poka-yoke* tools to help to address the environmental management system (EMS), [32], [33].

Table 1. US-EPA guidebooks, toolkits or reports and case studies

Ref#	Guidebooks, toolkits or reports	Case studies
[21]	The Lean and Green Supply Chain: A Practical Guide for Materials Managers and Supply Chain Managers to Reduce Costs and Improve Environmental Performance	GM, Commonwealth Edison, Andersen Corporation, Public Service Electric and Gas Company
[22]	Pursuing Perfection: Case Studies Examining Lean Manufacturing Strategies, Pollution Prevention, and Environmental Regulatory Management Implications	Boeing Everett and Boeing Auburn Machine Fabrication
[23]	Lean manufacturing and the environment: research on advanced manufacturing systems and the environment and recommendations for leveraging better environmental performance	Apollo Hardwoods, General Motors, Goodrich Corporation, Warner Robins U.S. Air Force Base
[24]	Findings and Recommendations on Lean Production and Environmental Management Systems in the Shipbuilding and Ship Repair Sector	Bath Iron Works, Bender Shipbuilding and Repair, Northrop Grumman, Southwest Marine Inc., Todd Pacific
[25]	The Lean and Environment Toolkit	
[26]	Working Smart for Environmental Protection: improving State Agency Processes with Lean and Six Sigma	Delaware, Iowa, Michigan, Minnesota, and Nebraska agencies
[27]	Lean in Government Starter Kit: a Practical Guide to Implementing Successful Lean Initiatives at Environmental Agencies	
[28]	The Lean and Chemicals Toolkit	Canyon Creek Cabinet, Goodrich Aerostructures, Lockheed Martin
[29]	The Environmental Professional's Guide to Lean & Six Sigma	
[30]	Lean, energy & climate toolkit: Achieving Process Excellence Through Energy Efficiency and Greenhouse Gas Reduction	Baxter International, General Electric, Toyota Motor Manufacturing North America, Cummins, Inc.
[31]	Lean & water toolkit: achieving Process Excellence Through Water Efficiency	IBM, GE, DTE energy

The EMS have been applied and adapted to improve the production systems [34]. Benefits of this application are the reduction of disposal costs by establishing a reusable container program with its suppliers, more effective resource utilization implying financial benefits, savings in avoiding product obsolescence and disposal [21]. Additionally, by applying this, space, cost, energy needs, air emissions, solid waste are reduced [23].

4. ACHIEVING SUSTAINABLE WORK ENVIRONMENT WITH LEAN PRODUCTION

From the previous section, companies could also decrease the energy consumption in reducing wastes by using LP principles, particularly, SME companies [35]. This section will, mainly, unveil proposals, some available, others in development, to reduce the water and energy consumption, environmental wastes and raw materials in manufacturing phase. Additionally, proposals to improve leanness and agility are summarized.

4.1 Proposals for the reduction of energy and water consumption

According to US-EPA [31] the apparel (garment) industry uses high volumes of water in raw material production but in the manufacturing phase this also happen. The manufacturing phase of the textile industry involves different technological process: spinning, weaving, textile ennoblement (dyeing and finishing), knitting and sewing. From all the processes, dyeing and finishing, are the one that consume more energy and water: it is impossible to dye and finishing without water and some processes have several washes, so, high water consumption and energy to heat the water.

According to ATP [36] the volume of water annually consumed varies between 90000 m^3 and 800000 m^3. In Table 2, it is possible to see the water consumption by treatments (operations), substrate and machine used.

From the available data, it is possible to perceive that the type of substrate, machine and process used, influence the water consumption. Understanding this influence, the companies would take the right decision in order to reduce the water and, consequently, the energy consumptions. Today, technological advances should concern on how to reduce the water and energy involved in the transformation process. Currently, there are research projects in progress that investigate the possibility of replacing the water by CO_2 in the dyeing of synthetic fibers. Others related projects are using enzymes to optimize the dying process (less time, less energy and less water) and some performance indicators involving various stakeholders are been developed to help companies visualizing the economic benefits of these projects [37]. Though, there are other challenges for the environment that are necessary to be aware, like the use of nanotechnologies and its impact in the environment [38].

Table 2. Influence in water consumption according type of substrate, machine and process used

Treatments	Substrate type	Machine	Water consumption (l/Kg)
Desizing, bleaching, dyeing, rinsing, soaping, softening	cotton fabrics and their mixes	washing machines off	25-50
Washing wool fabrics and their blends	wool fabrics and their mixes	washing machines off	50-100
Bleaching, dyeing, rinsing, soaping, softening	knitted cotton mixes	Jet	100-150
Bleaching, dyeing, rinsing, soaping, softening	yarn and cotton mixes	Autoclave	120-200
Washing, dyeing and rinsing, softening	wool knitwear mixes	Jet, Barca	100-150
Washing, dyeing, rinsing, soaping, softening	yarn and mixes	Autoclave	50-100

In International Exhibition of Textile Machinery (ITMA) held in Barcelona in September 2011, the main message given was to build machinery more efficient, with less water and energy consuming.
In the same direction, the US-EPA developed a toolkit to help companies to improve machine efficiency by water and energy reduction [31]. This toolkit is based on Lean principles and applies some tools such as root cause analysis, 5Why, fishbone diagram, 5S, Kaizen events, value stream mapping (VSM) and Visual management as practical strategies and techniques to identify problems sources and improving common Lean results related to time, cost and quality, reducing water use, costs, and risk. In this toolkit is also divulgated a spreadsheet developed by Global Environment Management Initiative (GEMI), to help the creation of a water balance for a facility, available at: www.gemi.org/waterplanner/calc-waterbalance.asp.

The US-EPA of Lean, energy & climate [30] is another toolkit to address the energy efficiency and climate pledging a reduction of greenhouse gas emissions, costs and risk. The delivery of value to customers continues assured through the products quality. The tools employed in this toolkit are VSM, Six Sigma, standard work, visual controls, employee engagement and mistake-proofing, Kaizen events, Total Productive Maintenance (TPM) and plant layout reconfiguration.

4.2 Proposals for the reduction of environmental waste

Environmental waste is an unnecessary or excess use of resources or a substance released to the air, water, or land that could harm human health or the environment. Environmental wastes can occur when companies use resources to provide products or services to customers, and/or when customers use and dispose of products [25].

During the industrial process, companies produce pollutants substances, materials wastes, air emissions, wastewater discharges and hazardous and solid wastes (trash or discarded scrap). The hazardous substances can affect the workers during the industrial process and the consumer when they are present in the product. Dyeing and finishing use chemical products and dyes that, when discharged directly into rivers, could be prejudicial. That kind of effluents must be processed before discharged into the river, otherwise will contaminate the rivers, killing the fish and wildlife. Better it would be to eliminate the need of using these products or their replacement by others with less pollutant. This is not always possible, since products quality will decrease. The registers or labels on products should be checked, as well an estimation of the level of pollution that it causes.

In Portugal, environmental concerns have increased and, in the textile industry, some important work is been done. In respect to the Environmental Management, textile companies are managed according to NP ISO 14001:2004 and some companies also by regulation (EC) Nº 1221/2009 of the European Parliament and the Council of 25 November 2009 [39]. Nowadays, few Portuguese textile companies are registered under Eco-Management and Audit Scheme III (EMAS III), according to the Portuguese Environment Agency (PEA). Under the NP ISO 14001:2004, International Standards relating to environmental management are intended to provide organizations with the elements of an environmental management system (EMS), which can be integrated with other management requirements helping these organizations to achieve environmental and economic objectives [40].

The European Union (EU) eco-label (Figure 4) for textile products ensure that certain substances are not used because they are prohibited or, if can be used limits the amount, according to environmental standards to be fulfilled.

Figure 4. EU Eco-label [41]

Another label is the Öeko-Tex® Standard 100 (Figure 5) applied to a textile or accessories, ensuring textile that products are not harmful substances to human health. This label is based on a norm prohibiting or restricting the presence of certain substances in textile products.

Figure 5. Oeko-Tex Standard 100 and 1000 [42]

The products are classified in four categories according to the use and contact with the skin: 1) baby products, 2) products in contact with the skin (interior clothes, bed sheets), 3) products which are not in direct contact with skin (coats, …) and 4) decorative material. A company with their products or the entire supply chain of these products, certified according to Oeko-Tex® Standard 100 could obtain the Oeko-Tex Standard 1000 certification. That is, the Oeko-Tex Standard 1000 complements the Oeko-Tex® Standard 100. The Oeko-Tex® Standard 100, the companies have their products certified and, with the Oeko-Tex Standard 1000 certification, the companies with the certified products are audited and certified which respect to the environment throughout the entire textile supply chain. To obtain a certification according this standard, companies must fulfill a certain criteria relating to production process that respect the environment and prove that, at least 30% of total production is already certified to Oeko-Tex® Standard 100. Without exception, this standard shows that these products are

safe in terms of human ecology and environmental criteria. Unfortunately, Portugal has very few companies certified by Oeko-Tex® Standard 1000. There are others certifications to ensure environmental responsibility, namely Global Organic Textile Standard (GOTS) [43].

The environmental concern allows companies to reduce costs by reducing energy consumption, water, and products and so on; increased sales for the valuation of services; improving the image; opening new markets. It is important to notice that the technological advances should concern about the reduction of greenhouse gas emissions or the reduction of the use of chemicals, without changing the quality of textile products.

US-EPA, once again, provide companies with some toolkits to achieve this reducing environmental wastes [25] and enhancing environmental performance related to all aspects of chemical manufacturing, management and use [28]. Tools used for achieving this are VSM, Six Sigma, 6S (5S + safety), standard work, visual controls, employee engagement and mistake-proofing, Kaizen events, Total Productive Maintenance (TPM). Time, cost and quality of products are, in this way, assured to the client.

An environmental management system is based on the Plan-Do-Check-Act (PDCA) cycle and its main objectives are: eliminate or minimize the environmental impact of an organization, establish and comply with the environmental policy; periodically check the objective and systematic management system implemented, to achieve continuous improvement in environmental performance [40].

Other efforts intended to apply a continuous application of an integrated preventive environmental strategy (processes, products and services) to reduce risks to humans and to the environment come from organizations like United Nations Environment Program (UNEP) that had been developing cleaner production programs [44]. WBSCD and UNEP recognize that, eco-efficiency and cleaner production program are complementary, reinforcing the same goal of sustainable development [45]. A recent report from the same organization, [46] addresses some challenges for decoupling natural resource use and environmental impacts from economic growth, identifying driving factors, both technological and economic from countries where decoupling is already taking place.

Another project in this area and from two Portuguese universities is the use of corn fibbers, soy and bamboo textiles in an outdoor advertising biodegradable. Biodegradable textiles are "slightly more expensive" than synthetics, but the cost difference in their production, has dimmed over the past few years, as new tissues are being improved [47].

A concept applied to “things” design is the Cradle to Cradle (C2C) concept that leads people to think in the way the “things” are made. In C2C model, all materials (metals, fibers or dyes), are classified in technical or biological nutrients. Employing these kinds of materials, they can be used several times and do not constitute residues [48].

4.3 Proposals for reduction of raw materials consumption

Textile industry have been strongly dependent on raw materials consumption, like cotton, natural fibers, silk, wool, dyes, among others. So, it is fundamental to assure a biodiversity of species and take care for its continuity. The economics of ecosystems depends on that. This is the reason why UNEP hosted studies like The Economics of Ecosystems and Biodiversity, TEEB [49], reporting that the economic values of biodiversity and ecosystem services must be considered in the decision-making processes.

This has been the concern of many important companies (Diesel, O&M agency, …) that launched campaigns to prevent the killing of animals for their skin [50]. Research on alternatives materials could be one solution to natural materials. As an example, the green textiles are more promoted than before. Materials like biological cotton or use of more friendly fibers such as polyester or hemp are real alternatives to the existent and were promoted in the last textile forum organized in Portugal [51].

Recycling materials are also an alternative to satisfy demands instead of exploring the existent ones. For example, use of clothes from recycled materials such as PET products. An interesting project is the transformation of old clothes in paper sheets for weddings invitations or paper bags for shopping.

Lean Production, promoting the urgent need to reduce/eliminate the seven wastes, particularly overproduction, defects and over-processing, will avoid, the extraction of raw materials to produce unneeded products among other effects [19]. Tools to reduce these wastes like JIT production, leveling, standard work, mistake-proofing mechanisms, will reduce the raw materials depletion. Adopting a Lean consumption [52], instead of a mass consumption behavior, by an adequate culture will also contribute to this reduction. The provider and the consumer will be aligned, with the first (provider) supplying exactly what the second (consumer) want, where and when he/she want without waste his/her time by solving his/her problem permanently.

4.4 Proposals to improve leanness and agility

It is worth to mention that in The Millennium Project [53], sustainable development and climate change are the first of the 15 Global Challenges facing humanity and its accomplishment will improve enormously the life for all in the planet. Due to global warming, causing by climate changes and the disappearance of well-defined seasons, the textile companies had to change their business strategies as a way to satisfy the market because some winter days are warm as well as others during the summer are cold. Therefore, the demand for certain items, such as finer knitwear during the winter and even tops compel companies to rethink their management strategies.

The traditional seasonal demand and the way of working are changing and companies must be flexible

in order to respond quickly to their customers following Lean strategies producing only what is needed, on the right quantity and on the right time (JIT production). By doing this, large lots of the same product provoking overproduction will be avoided. Other Lean tools already referred are necessary to implement the JIT production, being the most important tool, the engagement and motivation of people. This engagement is possible through continuously Kaizen workshops as showed in Štefanić et al. [54]. With engaged and thinking people the company will have the agility for adapting to changes that are occurring [55].

5. CONCLUDING REMARKS

This paper showed that Lean Production and Sustainable development are totally aligned and share the same purpose. It is worth to notice that all stakeholders are trying to reduce water, energy, raw materials and environmental wastes, in a trend which satisfy all. Lean principles and tools like VSM, 5S, Kaizen, TPM, poka-yoke mechanisms or others, are used to achieve this trend by diagnosing, measuring, improving and supporting the sustainability of production systems. Furthermore, using the principles, a Lean culture is developed permitting engage people in a continuous improvement.

Textile industries are also trying “walking the talk” and are doing some changes to the conventional processes. This was exposed through a significant number of projects already in progress allowing to the companies walk on the right way. Some proposals were presented in this paper showing that some efforts are been done in order to sustainable development but much more has to be done. LP could help achieve this sustainable development and help to aware for the biggest barrier to sustainable development that is resistance to change.

This paper presented some proposals of what can be done in Textile and Clothing Industry; nevertheless these can be applied to all industries and services. With this review, it was possible to identify the need of a proper methodology (on-going by the authors) that will link all these “loose ties”, showing that all important topics are connected.

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Održivo radno okruženje sa LEAN proizvodnjom u industriji tekstila i odeće

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Rezime

Cilj ovog rada je da se posmatra lean proizvodnja (LP) kao radni organizacioni model koji podstiče održivo radno okruženje u kompanijama. To se postiže pomoću lean alata i inicijativa koje, kada se primene na radno okruženje, smanjuju energiju, konzumiranje vode, otpad i konzumiranje sirovina, i poboljšavaju rad s manje ulaganja i agilnosti. Ovaj rad se fokusira na industriju tekstila i odeće i donosi predloge, inicijative i/ili projekte koji su vezani za ciljeve lean proizvodnje. Tradicionalno, ova industrija je u velikoj meri zavisna od prirodnih izvora: prirodnih vlakana, boja, vode i energije, između ostalog, i veliki je potrošač vode i energije, posebno kod bojenja i završnih radova. U isto vreme, ovi procesi imaju problem zagađenja vode i zemlje. Na taj način, smanjenje konzumacije ovih resursa i smanjenje zagađivača trebalo bi da bude glavna briga kompanija i pojedinaca kako bi postigli održivi razvoj. U ovom radu, autori takođe predstavljaju neke predloge kako kompanije mogu da se uključe u ovakve projekte.

Ključne reči: *Lean proizvodnja; održivost; ekološka efikasnost, industrija tekstila i odeće*