

## Potential applications, limitations and future perspectives of cleaner production for sustainable manufacturing processes in Sri Lanka - A review.

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**Abstract - Industrial sector performs a vital role in economic development of any country by providing different benefits such as earning foreign exchange, creating employment opportunities and developing regional infrastructures. After termination of thirty years of war, Sri Lanka achieved high GDP growth and manufacturing sector is contributed to 32% of total GDP. Subsequent, industrial sector growth caused detrimental environmental issues which are generated by inappropriate manufacturing and maintenance practices. Raw material, labor hour and by products can be wasted during manufacturing processes which caused financial losses to the industry. Cleaner production concept is implemented as a technique which can be used for reducing any wastage and undesired conditions of manufacturing processes. It helps to maintain high productivity, appropriate functions in industries and high economic benefits for all stakeholders. Also, waste reduction helps to decrease environmental impacts, conserve limited natural resources and maintain the sustainability. Sri Lankan manufacturing sector has a high potential to apply cleaner production concept and it can be apply for any type of manufacturing processes from small scale to large scale. Sri Lanka has own cleaner production center which facilitate for auditing and other services with skilled resource persons. Some limitations are accounted on applicability of cleaner production in Sri Lankan manufacturing sector and future developments are needed. The present study examines a comprehensive review on (i) cleaner production concept, (ii) its potential applications for manufacturing sector in Sri Lanka, (iii) limitations and (iv) future perspectives for developing this concept to achieve sustainability.**

**Keywords - Cleaner production, sustainable development, sustainable manufacturing process, waste reduction.**

### I. INTRODUCTION

Sri Lanka is a low middle income country which has per capita income of over US\$ 3000 in 2013<sup>[10]</sup>. Different economic sectors have contributed to Sri Lankan gross domestic production (GDP) and manufacturing sector plays a significant role in economy. After termination the war which lasted for 30 years, Sri Lanka achieved high economic growth (annual average of 7.5%)<sup>[10]</sup>. Specially, manufacturing sector achieved high growth rate and contributed nearly 32% of GDP in 2012 (in 1970s manufacturing sector contributed to 16% of GDP)<sup>[15]</sup>. Furthermore, Sri Lankan economy has changed in a favourable way for manufacturing sector and it continuously employs approximately 25% of the labour force<sup>[2]</sup>.

Continual expansion of manufacturing sector caused detrimental environmental issues<sup>[14]</sup>. Higher levels of energy and material consumption, high waste generation, usage of high amount of chemical materials and hazardous by product generation have resulted local and global level environmental problems such as air pollution, water pollution, raw material depletion, global warming, etc.<sup>[12]</sup>.

### II. SUSTAINABLE MANUFACTURING PRACTISES

Sustainable manufacturing practices are very much important to reduce negative impacts by monitoring the material use, increasing the energy efficiency and managing the material flows. Sustainable manufacturing is a manufacturing practice that does not harm the environment or human during the life cycle of manufacturing process<sup>[4]</sup>. It includes recycling, conservation, waste management, water supply, environmental protection, regulatory compliance, pollution control and a variety of other related issues<sup>[13]</sup>. Cleaner production is considered as one of major techniques which used for maintain the sustainability in manufacturing process in any type of industry.

### III. CLEANER PRODUCTION

Cleaner production (CP) is a pollution preventative, waste reduction integrated strategy and it can be used for reducing costly end-of-pipe treatment methods throughout the entire production cycle. It promotes efficient use of raw materials, energy and water<sup>[3]</sup>. According to the United Nations Environmental program (UNEP), cleaner production (CP) is defined as 'the continuous application of an integrated preventative environmental strategy to processes, products and services to increase overall efficiency and reduce the risk to humans and the environment'<sup>[3,4]</sup>. CP technique provides many benefits to the organization such as increase the productivity, reduce the production cost, optimize the resource consumption, produce safer and better products, reduce the level of pollution risk and comply with environmental management systems. National cleaner production centers (NCPC) are promoting CP in their countries and it helps to add valuable investments in CP<sup>[5]</sup>. CP policies focused on environmental management, integration of ISO14001, waste management and voluntary initiatives from the private sector<sup>[5,7]</sup>.

### IV. CLEANER PRODUCTION ASSESSMENT

A cleaner production assessment (CPA) is a systematic procedure which involves to identify inefficient resource consumption and poor waste management in the manufacturing processes<sup>[3]</sup>. CPA is a problem solving strategy to identify wastes in the manufacturing processes, suggest solutions and implement the best practises to reduce the<sup>[4]</sup>. The ultimate goal of cleaner

production is to achieve a closed loop operation in which all excess materials are recycled back into the process. The four elements of cleaner production are the precautionary approach, preventive approach, democratic control and integrated and holistic approach [5]. Integrated approach of CPA is shown in Figure 1.



Fig 1. Integrated approach of Cleaner Production [5]

### V. APPLICABILITY OF CP IN INDUSTRIES

Manufacturing sector is increasing their growth rate and many industrial bureaus are developed in Sri Lanka. Industrial sectors are generating different types of wastes such as, glass, plastics, paper, food waste, wood, metals, textiles and hazardous waste [17]. Central environmental authority of Sri Lanka stated that the increment of solid waste generation is about 5% each year [9]. Further, a highest portion of the solid waste generated in the Koggala Export Processing Zone is fabric waste, comprising 56% of the total waste, followed by food waste (28 %), and paper and cartons (5 %) [9]. Sustainable manufacturing process is very much important to Sri Lanka for reducing the waste generation. CP approach can be applied to minimize or eliminate the waste in manufacturing sector. As a fundamental step, Sri Lankan cleaner production center was established in 2002 with the support of UNIDO. They provide the guidance and promote the CP technique within Sri Lankan manufacturing sector to achieve sustainable development [16].

#### CP practices

Different CP practises are used to increase the productivity in industries. As examples, good housekeeping, input substitution, better process control, equipment modification, technology change, product modification, onsite recovery and reuse, waste to product and energy efficiency practices can be used for reduce the wastes generation in the manufacturing sector [1]. Good housekeeping practices help to prevent leakages and spills by taking managerial and operational actions. Proper maintenance practices, regularly checking equipment and proper working procedures can be used to reduce wastes [5]. Inputs can be substituted by less expensive, less hazardous and more efficient input materials. Also, management can take action to change working procedure, machine instructions and record keeping strategy to maintain a better process control. Equipment can be modified to increase the product quality and reduce the wastage [1]. Furthermore, existing technology

can be replaced and order of the manufacturing process can be changed to improve the efficiency of the process. Management should make decisions to change the characteristics of the product if there are unavoidable waste and losses [5]. Waste materials can be captured and reused onsite to prevent and minimize the waste [8]. Also, market demand for the waste materials or by product can be identified and new product can be developed by using these materials. It would be a new income to the organization and financial losses due to the waste generation can be reduced through it [5]. In addition, organization should focus on efficient energy usage and any type of change can be taken place to reduce the energy consumption in the industry. Economic, environmental and social benefits can be achieved through implementing CP techniques in any manufacturing industry in Sri Lanka [1]. It is essential to promote the CP concept in industrial sector to reduce the negative impacts and improve the product quality using an environmental friendly manner.

### VI. CHALLENGES FOR IMPLEMENTING CP TECHNIQUE IN SRI LANKA.

There are numerous challenges in Sri Lanka to overcome for promoting and implementing the CP technique. Many manufacturing industries are not following this technique because of the less awareness and fear to unknown of new concepts [8]. Stake holders and general public are not well aware about of waste generation, environmental problems and sustainable manufacturing techniques. Environmental policies are not much supportive to the CP technique. Lack of government support and political barriers are other major problems to promote this technique in the country [11]. Market conditions and buyers are always focusing on the low-cost products and owners are considering on the cost reduction. Extra amount of money can be spent when implementing the CP in the organization and it reduces the interest of the managers to implement CP technique [5]. Lack of time, staff, resources, finance, knowledge and technical skill for investigation and implementation CP technique are other major challenges [6]. Furthermore, management did not have any skill to understand problems by their selves and they did not aware about better process/ product designs. Many industries are resistant to take risks and make investments on the novel concepts. Many challenges have been accounted for implementing the CP technique in Sri Lankan condition and the country should be focused to overcome these challenges [6]. Government support, public awareness, training programme and awareness for all stakeholders of the manufacturing industry are major requirement to promote CP technique in Sri Lanka. Sri Lankan manufacturing sector can reduce their wastage and improve the product quality by implementing the CP concept.

### VII. CONCLUSION

Sri Lankan manufacturing sector is in a fast growing stage and it contributes to 32% of GDP in the country. With the increment of manufacturing sector many environmental issues have been taken place. Specially, waste generation is increasing at a rate of 5% per year and people are more concerning on the sustainable manufacturing processes.

Cleaner production is one of a major technique which promotes sustainable manufacturing by reducing wastes and improving the product quality. CP technique can be implemented in any type of manufacturing industry and different CP practises can be used to reduce the wastage. Many challenges and barriers such as lack of awareness, fear for the unknown, lack of government support, lack of skilled peoples and etc. are accounted on CP technique implement in Sri Lankan conditions. Sri Lanka can overcome these challenges through government support, public awareness and stakeholder awareness to promote CP in the country and to improve the sustainable manufacturing sector.

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