SIMULATION BASED SUSTAINABLE MANUFACTURING SYSTEM DESIGN WITH COST REDUCTION ACHIEVEMENTS

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ABSTRACT

In this study was proposed to adopt the eco-friendly design principles to minimize the environmental impact and reduce the costs of manufacturing and assembly to identify and analyzing the application of the eco-friendly design to the redesign of a nozzle component by focusing in the textile and other manufacturing industry. In product aspects, there is a requirement to move beyond the traditional approach. Life cycle analysis concept consists of a need to model and attain optimized technological developments and improve process planning to minimise energy and resource utilizations, without reducing the product quality or the manufacturing capacity. Product life cycle analysis is a systematic approach and integration of environmental aspects during the early stages of product development that can be considered very important in order to improve overall environmental performance of the product. It enables to understand the total product life-cycle results, including inventive techniques for products, processes and systems required in production. The merits and demerits of the factors, which influencing the application of eco friendly design were also examined. The nozzle manufacturing organisation developed a longitudinal case study on eco- friendly design. The procedures of eco-friendly design, the application and usage of eco-design recommendations considered during the component redesign were discussed in detail. A cost of production was reduced to a greater extent in relation to the use of copper, varying materials and ABS in its composition. Hazardous materials were systematically avoided and minimized consumption of energy was also reveled under the process of the die casting, injection moulding and additive manufacturing processes. Eco-friendly design establishes to investigate further in the combined discussion of technical viability and market feasibility in a redesign work and the necessity to gain managerial support for a redesign work are the main impact of this study.

***Keywords*: Eco-friendly design, nozzle, energy consumption, environmental impact**

1. INTRODUCTION

Eco-friendly design is a method of development of components and products with environmental concerns that could transform in the ecological assignment. Consistent sustainable development and for the minimization of the ecological effect of new products, this procedure is becoming a basic for the creative technical invention of environmental concerns; its options are being viewed as important for the warranty of the product (Deo, 2001). Thus, Eco-friendly design has its potential effectiveness in the innovation of new ideologies and in the emerging of new consumer behavior. To assist the social requirements without burdening the commitments of the present and future generation, the sustainable product development integrates the ecological concerns in the manufacturing design, the necessity for the environmental conservation, acceptance of the society, the perception and

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view of the new generation for protecting the environmental aspects (Turra Dilce T, 2002).

To assist the corporate and global economy towards sustainable ecological impacts establishing a positive environmental approach to develop efficient eco-friendly and green products (Albino, V, 2009). This type of ideologies depends on the concept of eco-friendliness. The eco-effectiveness and eco-efficiency concept has been initiated in various aspects. It was proposed several distinct traditional definitions for eco-efficiency (Cote.R, 2006). Eco-efficiency is enumerated generally as the profitable value addition by a company with regard to its consolidated environmental impact (Dyllick, T, 2002). The primary objective of eco-design is to minimize the environmental impact of a product throughout the product life cycle, that consist of raw materials, manufacturing, marketing, utilization and end of the destination which defined as a set of manufacturing processes based on the innovation of eco-efficient components and manufacturing procedures, eco-design has as its concentration [6]. The development of new components and, along with Life Cycle Analysis (LCA), encourages a new scrutiny of design methods and a production technology incorporates ecological concerns in eco-design (Fiksel, J., 2006, Luttropp, 2006, Byggeth, E, Bhander .G, 2003). Prominently required in eco-design stages are tools for multi factor evaluation and achieving the standard in which reveals eco-design tools are lacking in the early phases of design. Eco-design tools addressing these requirements, integrate with sensible changes recognized in the design procedures, may assist eco-design model. Improving the availability of eco-efficient components and minimizing the environmental impact are the important concerns on environmental sustainability of the product or service which allows the study to relate the functions (Manzini, E, 2005, Peuportier, B, 2013) Apart from the positive environmental impact output from the eco-design, additional advantages comprises of cost reduction through improved competitiveness on quality, launching new products in new markets (Knight, 2008). The primary focus of this study is to examine the implementation of eco-design ideologies in the redesign of a product of nozzle from the textile industry, arriving at the conclusion as an eco-design, adopted on the redesign of a product of nozzle in textile industry product, provide to reducing environmental impacts and in the mean time minimizing the manufacturing costs and assembly and the indicators that dominates the usage of eco-design.

2. METHODOLOGY

Present eco-design tools could not consider the standardization of design, product development; product redesign and new product innovation based on a rupture and new product development system, happens when new inventions in the manufacturing system is required was pointed out by (Knight, P, 2008). The materials selection is an important factor to arrive the result for reduced environmental impact; the packaging and distribution; the energy consumption, water, air and other materials as in the manufacturing process in the final product lifecycle, reuse, remanufacturing and the recycling of the full products are fundamental for a sustainable development eco-design system. The selection of raw material will have direct impact of environment as well as the cost of production, functions of production

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process and the quality of product. The health factor of the consumers was also contributed by the selection of materials (Ahmad T. Mayyas, 2013). This study is an investigation based case documentation of information pertaining to a nozzle manufacturer that practices eco-friendly design is intend to be beneficial in future studies, on the basis of primary data collected in the sector.

3. TRADITIONAL MANUFACTURING PROCESS

3.1 SAND CASTING PROCESS

Sand casting is an energy intensive manufacturing process because it requires the melting and shaping of significant quantities of metal. According to EIA results (EIA, 2001). Foundry industries in developing countries suffer from poor quality and productivity due to involvement of number of process parameters in casting process. Sand casting process is high energy and resources required are material and energy inputs and outputs for mold and metal preparation, casting and sub processes explained by Bovea, M.D, 2012). In the Figure-1 shows the procedure and real processing for producing sand cast metal. Experiments were performed in a medium scale ferrous foundry producing

Figure - 1 Photographical image of nozzle component

4. EXPERIMENTAL WORK AND PROCEDURES

4.1 Injection molding process

The Injection molded die parts shown in Figure - 2 are widely used in consumer products and industrial equipments. Injection molding is a manufacturing process that includes pulverized plastic material injecting it in a molten state forced into a mould passage in a required shape. The injection molding process consists of melting raw polymer granules, also referred to as

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plasticating (Plasticating, 2014) and injecting the molten polymer into a mold. Once the material injected cools, solidifies and ejects by another mechanism, the piece within the mould produced as the required component. After the injected molten polymer is solidified, the mold, which includes of two halves, is opened, cooled and the solidified component is ejected out by an external force (Osswald. T, 2008). This method of manufacturing is commonly used for a wide range of products and has a very high quality surface.

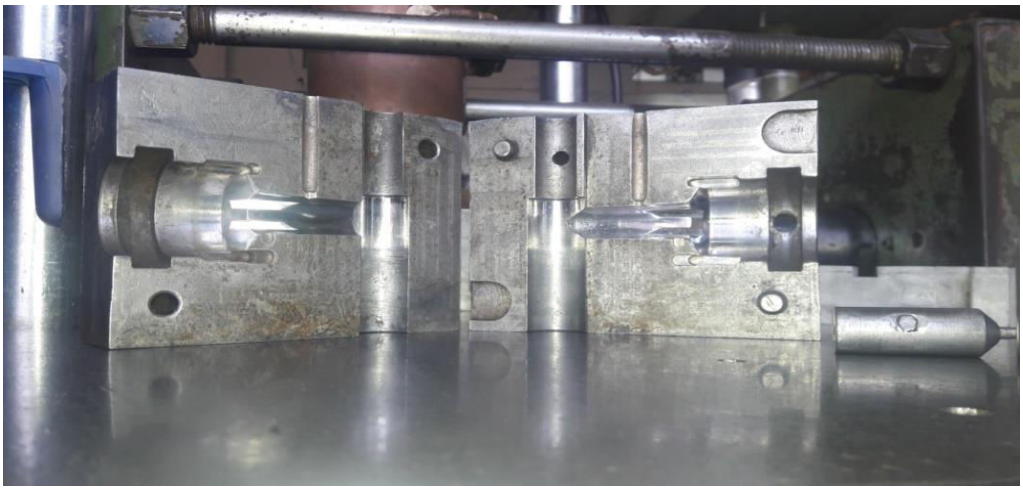

Figure - 2 Photographical images of Tool and Die for the Nozzle component

The quantum of investment required for installing injection molding machineries is often very high and this method of manufacturing is not suitable for small scale industries. The designing and fabrication of dies and tools is costly compared to other advanced manufacturing processes. Also each and every components required design and production of separate dies and tools leads to high capital costs. The nozzle component manufactured using two different manufacturing methods such as injection moulding and extrusion process is deployed in the textile industry. The nozzle was chosen for the eco-design application due to higher in sophistication in the production process. The usage of nozzle in Moulding Machine and in Textile Industries is for different purposes. Nozzle was widely used for: cool the air in the blue room, humidify and dehumidify the HVAC system and clean the air particles.

4.2 The integration of eco-design

In the manufacturing industries the utilization of eco-design product development processes were analyzed in detailed before redesign. Cost evaluation and importance to legal compliances are the vital factors considered by the nozzle manufacturer while selecting the supply network. The elements stated above could be changed because of the external market constraints for the manufacturing industry. The ability of the R&D team for the innovative inventions and using appropriate techniques, the capability for improving the motivation among experts applying eco-friendly design and proper structure of sustainable product development process to assist the eco-design utility were the internal factors of a manufacturing industry. The

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aesthetics and performance elements of the nozzle redesign enables the manufacturing industry for cost reduction and to enlighten the ecological benefits to face the global market competition. Only if the redesign process reduces the cost of production and gives economic gains which could influence the buyer in placing orders for nozzle. Application of eco-friendly design process in the product and the market evaluation are the two important stages conducted side by side for the redesign of nozzle.

4.3 Sustainable products

A product which has minimum environmental impact during its life cycle is a sustainable product. The sustainable elements of components consist of raw material extraction, manufacturing, usage and end of degradation (Halada K, 2003).

Figure – 3 *Components produced by Injection molding process*

A few assessment factors should be taken into account in selection of materials for sustainable production process. Mechanical properties, process and cost evaluation were considered in the conventional material selection process. Environmental concerns should also be considered in addition for new sustainable product development. The traditional factor of mechanical property consists of density, strength, hardness, toughness, stiffness and creep resistance. This should be fulfilling the fundamental requirements of sustainable product design. The cost effectiveness is the primary factor for all the industrial manufacturing companies in sustainable product design and selection of materials. The raw material procurement cost, the production process cost, the distribution logistics cost and the cost of disposal of the waste products are the four factors considered as the economic property (Chan Joseph WK, 2007). The nozzle component shown in Figure – 3 is produced with a thermoplastic polymer, such as polycarbonate (PC) and ABS materials for original processes these nozzles were designated as conventional method nozzle and for redesign processes these were known as redesigned nozzle. An injection molding process includes six stages namely mold closing, filling, packing and holding, cooling, mold opening/ejection and plasticating.

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4.4 THE PROCESS OF THE IMPLEMENTATION OF ECO-DESIGN

The Eco Audit Tool applies Granta's is an add-on tool to helps address such objectives. It draws on Granta's environmental data to quantify the eco impact of key life-phases of a CAD model indicates Figure - 4, helping to identify the most significant environmental costs and thus focus attention on the areas which can lead to the biggest improvements. Perform a quick audit during early-stage design. Further reduce cost of interpreter for customers by applying eco material selection strategies to minimize in-use energy consumption.

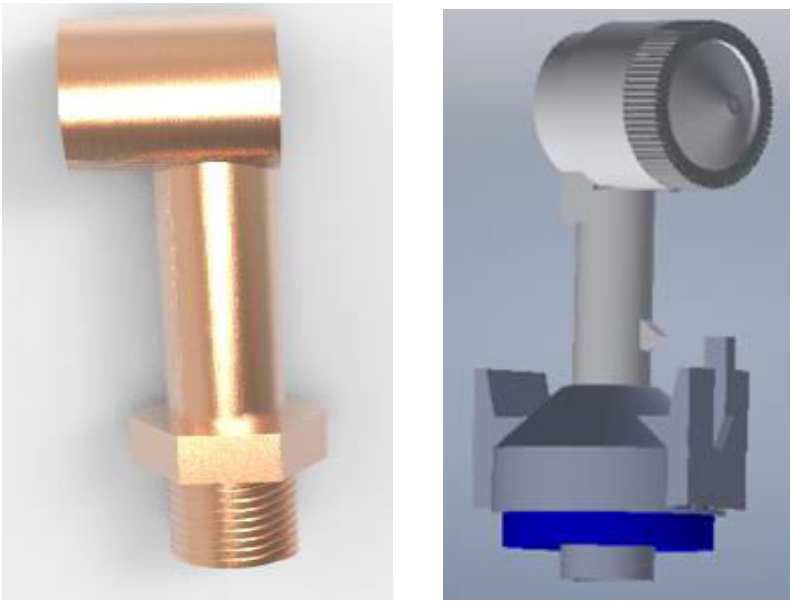

Figure – 4Existing and *Proposed Nozzle Cad Model*

Unlike LCA assessment, which focuses on detailed environmental reports for finished products, the Eco Audit Tool informs decisions during the early stages of design, where changes cost least, but matter most. Knowing which phases are likely to make the most significant contribution to environmental impact helps to guide design strategies to minimize that impact. The selection of right materials and processes for design is essential. Environmental impacts are increasingly important in engineering and design. To limit the carbon footprint of product, reduce its energy usage, cut wastes and emissions, or specify the manner of its disposal. To do this, for need rapid estimates of the CO_2 emissions and energy uses for each life-phase. The Eco Audit Tool draws on Granta's environmental data to quantify the eco impact of key life-phases of a material, helping to identify the most significant environmental costs and thus focus attention on the areas which can lead to the biggest improvements.

5. DISCUSSION AND RESULTS

Normally in textile industry, the benefits are anticipated to be based on the cost effectiveness in procurement and manufacturing processes as well

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as in problems related to the law of the land, on the basis of avoiding of debarred articles like unhealthy raw materials.

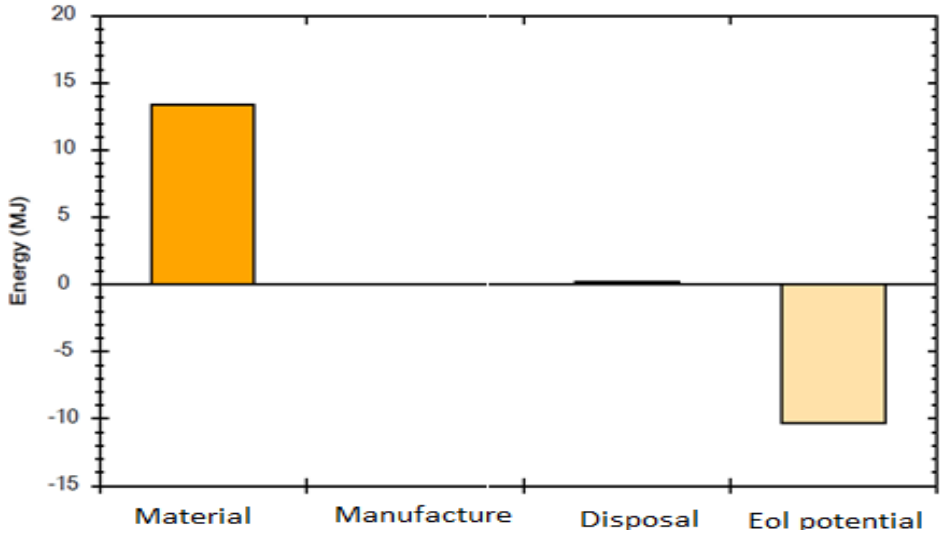

Figure – 5 *Energy usages summary of existing model*

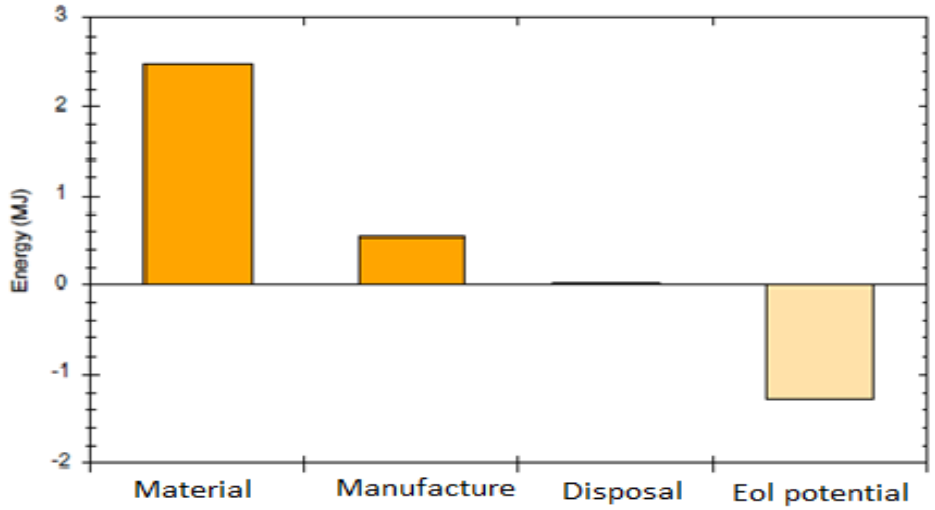

Figure – 6 *Energy usages summary of proposed model*

In this study discussed about the few benefits generated out of the socio-economic and environmental conservation. The major effects of energy usages and carbon foot factors are shown in Figure – 5 to 8, for the efficient In environmental sustainability manufacturing process cost effectiveness has utmost priority. The major environmental impact generated less temperature needed by the injection moulding equipment, with the application of thermoplastic polymer material. parameter which assist in the dissemination of eco-friendly design of nozzle.

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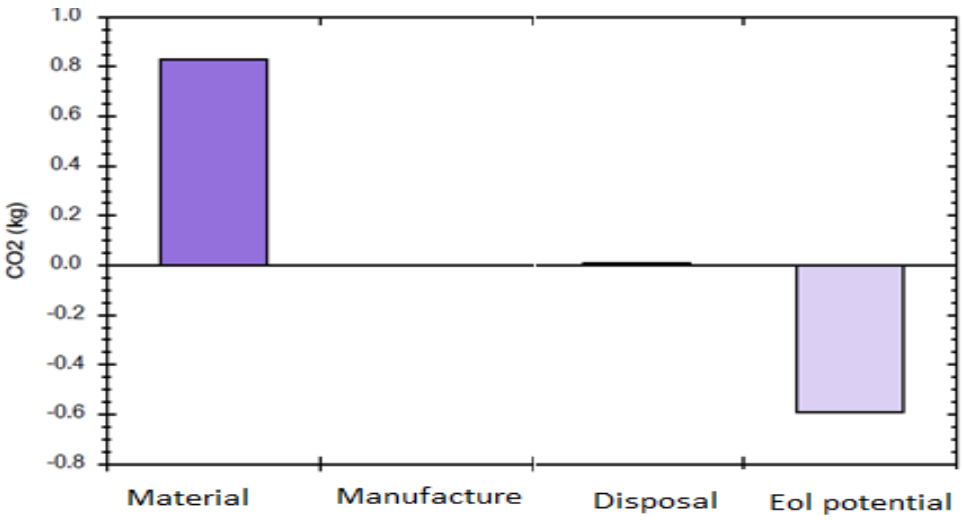

Figure – 7 *Carbon foot print of existing mode*

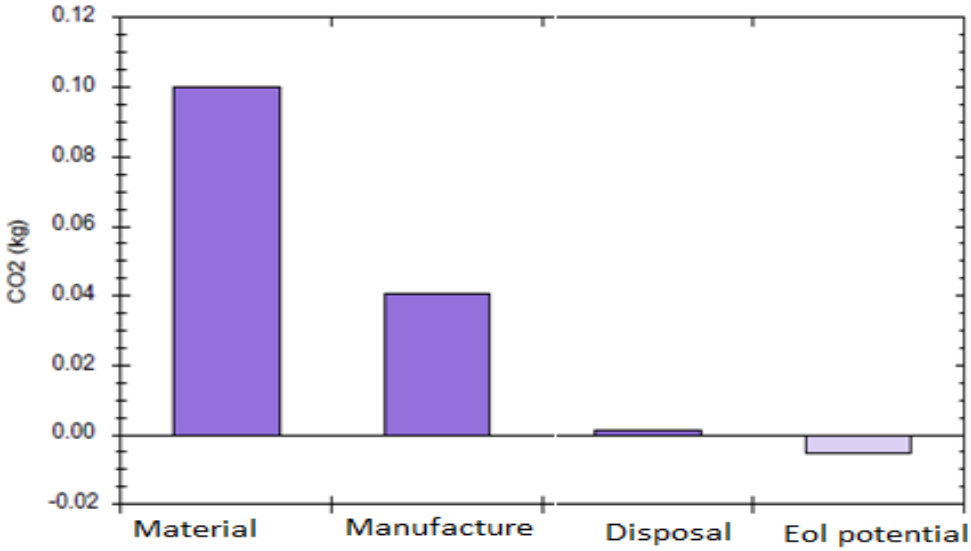

Figure – 8 *Carbon foot print of proposed model*

Further, this raw material is simpler to reuse and recycle than the original components. The practices to be conducted and the results which can be expected in the utilization of eco-friendly design to existing components and suggested for the proposed component were discussed in this study. The overall eco-friendly design usage has the prospects to increase awareness about eco-friendly design, establishing the procedures, anticipated issues to be faced in the application of accessible existing and proposed eco-design in the product development process. The cost and mass reduced by a redesigned nozzle shown in Table- 1 and 2. The industry wish to develop the nozzle market share is highly essential. To improve the credibility of the industry, anyone will strategically give importance for environmental sustainability. The benefits derived out of the application of eco-design, guidelines for eco-friendly design practices, the operational forms of eco-design, the variables determining the application of eco-design were the factors evaluated in this study.

Table – 1 Material cost breakdown by existing model

Part Name	Material	Total Mass (kg)	Cost (USD)
Part1	Copper	0.068	0.68
Part2	Copper	0.068	0.68
Part3	Copper	0.044	0.44

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Part4	Copper	0.023	023
Part5	Copper	0.022	022
	Total	**0.22**	**2.3**

Table – 2 Material cost breakdown by proposed model

Part Name	Material	Total Mass (kg)	Cost (USD)
Part1	ABS	0.0079	0.025
Part2	ABS	0.0079	0.025
Part3	ABS	0.0051	0.016
Part4	ABS	0.0027	0.0086
Part5	ABS	0.0026	0.0082
	Total	**0.026**	**0.084**

Further, this raw material is simpler to reuse and recycle than the original components. As per the perception of the industry, the benefits of cost effectiveness and environmental impacts were explained in detail. The technological advancements were not managed properly in the product development process applying the eco-design in a structured process. Even though the factors like cost effectiveness and legal compliances are prioritized in the market, the environmental considerations should be focused for the sustainable manufacturing process applying eco-friendly design. Only the cost effectiveness and legal compliances are influencing the application of an eco-friendly design in an industry. In this discussion suggests that the evaluation should be done about the inevitable internal parameters and the prospective component to be developed through eco-design handles risks, anticipated technical issues, and management and motivation factors. Identification and deployment of appropriate technical experts in eco-friendly design, environmental management and waste reduction techniques is very critical because of lack of qualified persons. The benefits generated like cost reduction motivates the industry to identify and deploy qualified human resources for adopting eco-design practices.

6. CONCLUSION

The sustainable manufacturing product development projects, the objective of sustainability incorporating socio-economic, cultural impacts and is linked within an ecological approach. The benefits of eco-design such as cost effectiveness motivates the chances for a redesign for a product applying eco-design practices in the available component manufacturing assists to go further to manufacture the sustainable component which leads to the sustainability of the corporate itself. Without considering the component manufacturing traditional procedure applied in the industry, adopting systematic guidelines for eco-design manufacturing procedures is possible. The design experts must evaluate the chances of applying the overall requirements for the future component development practice to integrate eco-friendly design tools efficiently. Apart from this, the knowledge of which eco-friendly design processes are usable in the product design happens in the procedures of eco-design execution

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