Assessment of human health impact based on life cycle assessment: A case study of Thai retread tire

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Abstract. The sustainable production of tire supply chain has been recently highlighted to reduce the environmental and human health impacts. The main environment problem of tire supply chain is waste treatment. When the tires reach the end of their working life, they are recycled (obtaining raw materials and other components for certain manufacturing processes) or burned (obtaining energy). During the exploitation, a tire with worn tread can be processed in a certain way to allow its reuse. The retreated tire should be accepted for further treatment. Hence, this study conducted the human health impacts of retreated tire using life cycle assessment. The recipe2016 technique and Sigmaoro 9.0 software were used as the method of human health assessment. The result showed that the total value of human health impact assessment for retreated tire production were 4.3E-06 Daly. The hotspot of human health impact for retreated tire production was tire material and electricity consumption. From this finding will help designers or managers recommend the installation scenario of retreated tire production by considering human health impacts.

1. Introduction

Due to the phenomenal growth in the transport sector as a part of rapid urbanization, especially in the countries where transportation of goods and people are essentially done through the existing road associated with production of tires and to identify the grey areas in which enough networks, tire industries have seen a rapid growth [1]. When the tires reach the end of their working life, they are recycled (obtaining raw materials and other components for certain manufacturing processes) or burned (obtaining energy). During the exploitation, a tire with worn tread can be processed in a certain way to allow its reuse. In the past few decades, the emphasis has been on its further use. If during the exploitation, a tire suffers the damages which can be fixed, it is planned for retreading [2]. In 2018, over six thousand retreading tires are manufactured annually in Thailand [3].

In order to be retreaded a tire must undergo a control realized in two basic steps before being accepted for further treatment. The first step consists of a visual control of tire treads or other damages. The second step consists of an X-ray of the interior of the tire. After retreading, within a final control, each retreaded tire is once again subject of a detailed visual check, before being returned.
Shanbag and Manjare [1] reported that there is a significant impact on the environment due to emissions from the generation of electrical energy and steam in the plant under study along with emissions due to various operations in the tire production process.

One of the effective environmental assessment tools for products is based on life cycle perspective. Called life cycle assessment (LCA), it is employed to assess environmental impacts of product throughout its life cycle, from raw material extraction to production processes, transportation, use, and disposal [4]. The information on LCA studies of tire industry is very scanty. A sustainable issue of natural rubber industry has been studied thorough LCA approach [5].

Generally, many LCA methods quantify single environmental consequences (e.g. IPCC Global Warming Potentials (GWP) and other LCIA methods aggregate many environmental consequences into one or more endpoint value(s). One of these endpoint values is measured as Disability Adjusted Life Years (DALYs), which quantifies the damage to human health as a consequence of aggregated environmental impacts. In addition to human health damage also damages ecosystems through, for example, adverse effects on climate change, water use, eco-toxicity, land use, eutrophication, and biodiversity loss [6]. Hence, the objectives of this study were to assess the human health impacts of Thai retread tire industry. A cradle-to-grave was used to compare the influence of different the resources and material consumption on its life cycle environmental impacts.

2. Material and Methods

The International Standards, ISO 14040 and ISO 14044 [7-8] were used to conduct the LCA study of retread tire industry for analyzing the human impact. The more detail of methodology, data and the assumptions are the following:

2.1. Goal and scope definition

2.1.1. The is the reprocess of the use tire with the good of casing. The retreading rubber can be the reduction the process on 30 – 50 percent of the new tire. Hence, the health impact assessment of the retreading rubber process consisted of the cool and hot processes including tire checker, repairing, buffing, rubber cementing, building, molding or envelope and curing (Shown in Figure 1). The cradle-to-gate approach was used in this study, was from raw material extraction through product manufacturing only and only related to product manufacturing [1]. The human health impact of the retreading rubber process was calculated by life cycle assessment approach.

2.1.2. The data from a one company of the retreading rubber process in the central parts of Thailand was collected in this study. The primary data of all process use was conducted by the input and output of mass balance.

2.1.3. The functional unit of this study was the 1 kg of retreading rubber product. The data inventory analysis was studied and calculated by the resources consumption, energy consumption and waste production or pollution generation among retreading rubber process. The input and output of process was collected according to the boundary scope of each unit. Secondary data for environmental impact assessment was obtained from the related study or report with strong in the academic reference. The database used for impact assessment was the ReCiPe2016.

2.2. Life cycle impact assessment

ISO 14044 [8] was used to the impact assessment includes the selection of impact categories, classification, and characterization. Two main orientations or classifications, namely midpoint methods and endpoint methods. In this study, endpoint is supportive for the decision-makers, while midpoint, is helpful when specific environmental concerns are targeted [9]. The allocation methods were chosen such that, where a market is already established, economic allocation was used, whereas in other cases system expansion was applied. Data storage and modelling were performed using the SimaPro 8.5.2.0.
3. Result and Discussion

3.1 Life cycle inventory of retreading tire

From the data collection from a case study of Thai retreading rubber tire process, the Input of the production process consisted of used tire, repair tire, electricity, chemical and water consumptions. The result shown in Table 1, the average consumptions from 2014-2016 of used tire, waste tire, electricity, chemical and water consumptions per functional unit (1 kg of retreading rubber tire) were 0.850 kg, 0.250 kg, 3.957 kWh, 0.230 kg and 0.001 kg, respectively.

Table. 1 Life cycle inventory of retreading tire

| Items                | Value (kg) / 1 kg tire/year | Average Value |
|----------------------|-----------------------------|---------------|
| 2014                 | 2015 | 2016 |                   |               |
| Used tire            | 0.850 | 0.900 | 0.800 | 0.850 |
| Raw tire material    | 0.250 | 0.300 | 0.200 | 0.250 |
| Electric consumption | 3.750 | 4.320 | 3.800 | 3.957 |
| Chemical consumption | 0.2083 | 0.2600 | 0.2207 | 0.230 |
| Water consumption    | 0.0009 | 0.0014 | 0.0011 | 0.001 |

3.2 Human health assessment

Figure 2 showed that the caparison of human impact based on the characterization for retreading rubber tire. The result indentified that electricity consumption was the majority impact on human health in all categories. Over 58 percents of human impact for retreading rubber tire were found in the human carcinogenic and non-carcinogenic toxicities.
Figure 2. Identification of impact categories on human health for retreading rubber tire process.

For damage and normalization impact found that the main human impacts of retreading rubber tire were raw material (used tire) and electricity consumption (Figure 3 and 4). Then, the reduction approach of electricity consumption for retreading rubber tire industry should be proposed for decreasing the human health for the end point impact. Shanbag and Manjare [1] identified that the significant reduction in environmental impact due to tyre production is possible if the source of electricity is non-conventional.

Figure 3. Identification of human health damage for retreading rubber tire process.

Figure 4. Identification of human health normalization for retreading rubber tire process.

4. Conclusion
This objective of this study was to identify the human health impacts of retread tire using life cycle assessment. Therecipe2016 technique and Sigmaoro 9.0 software were used as the method of human health assessment. The result indentified that electricity consumption was the majority impact on human health in all categories. Over 58 percents of human impact for retreading rubber tire were found in the human carcinogenic and non-carcinogenic toxicities. The hotspot of human health impact for retreaded tire production was electricity consumption. Then, the reduction approach of electricity consumption for retreading rubber tire industry should be proposed for decreasing the human health for the end point impact

5. References
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