Life cycle environmental analysis and life cycle costing of high wear-resistant rubber hoses

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Introduction

Rubber products are widely used in various applications, and rubber hoses are a category of rubber products that are widely adopted for conveying ready-mixed concrete on construction site. Abrasion resisting performance is the key parameter to determine the service life of rubber hose. In this study, we analyze the environmental and economic impacts of four types of rubber hoses with the inner layer made of different rubber composites to resist abrasion, i.e., Baseline, S-I, S-II and S-III.

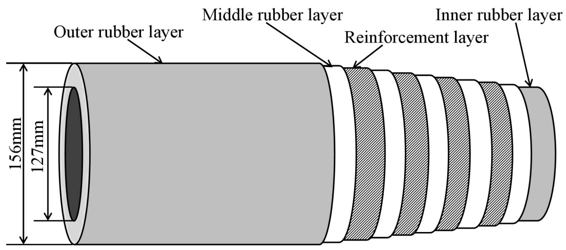


Fig.1 Schematic illustration of the rubber hose composition

The service life of four hose models are pumping 14,500 m^3 concrete(baseline scenario), 16,000 m^3 concrete(S-I), 17,000 m^3 concrete(S-II) and 20,000 m^3 concrete(S-III) respectively.

Research questions

- Will the improvement of rubber abrasion resisting performance also bring environmental and economic savings?
- What is the hotspots of materials and processes during the whole life cycle of rubber hoses?

Methods

Life cycle assessment (LCA)
+
Life cycle costing analysis (LCC)

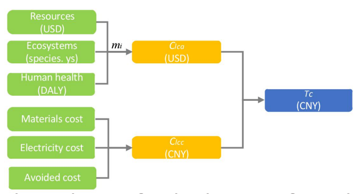


Fig.2 Flow chart of calculation of total cost

- System boundary: the entire life cycle stages of a rubber hose, including production, transportation, use and the end-of-life (EoL) recycling.

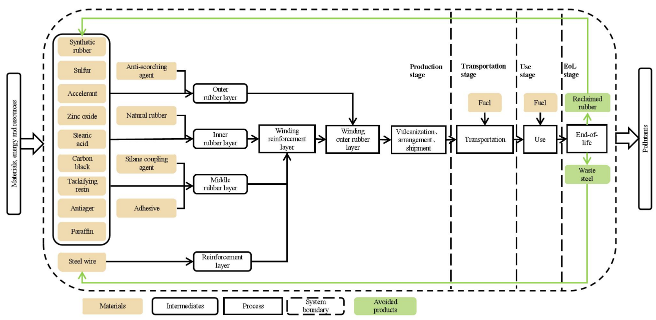


Fig.3 System boundary of the LCA and LCC models

- Functional unit (FU): “conveying 1 cubic meter of concrete” and “one rubber hose ”

Results & discussion

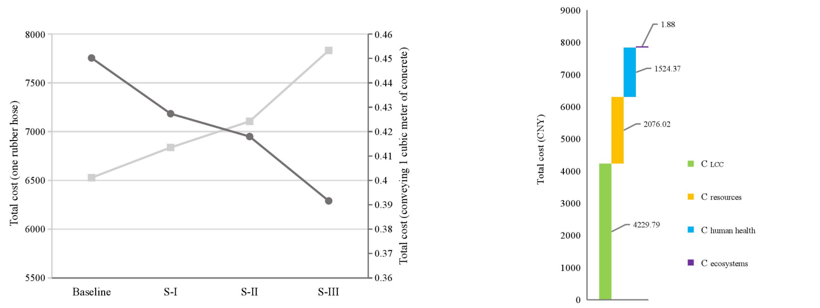
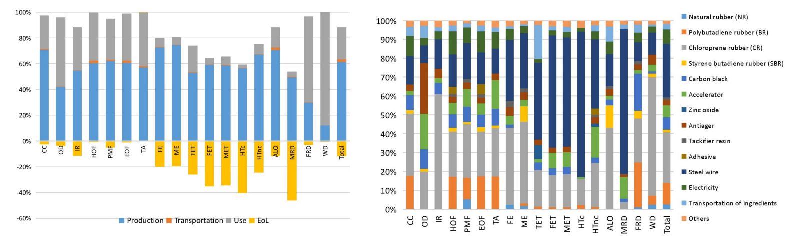


Fig.4 (a)Integrated analysis results of four rubber hoses;
(b)Contribution analysis of total cost of S-III

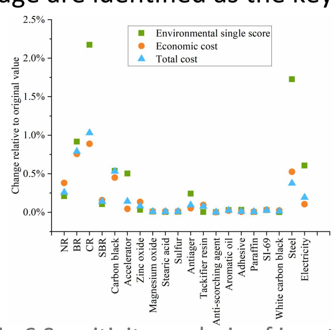
- When considering “one rubber” as FU, S-III has the highest economic and environmental burdens, which is 7,832 CNY (Chinese Yuan). But when another FU is selected, the results is completely opposite.
- Take the total cost of S-III as an example, environmental costs account for 46% and the life cycle costs account for 54%.



Note: “total” indicates environmental single score; “others” in figure (b) refer to raw materials with contributions less than 1%.

Fig.5 Contribution analysis of the high wear resistant rubber hose (S-III). (a) contributions of life cycle stages; and (b) contributions of materials and processes in the production stage.

- The single score of S-III is shown as the example for the contribution analysis. Production stage is the largest contributor(61%), followed by use stage (25%), EoL accounts for -12%, while transportation stage only occupies 2%.
- CR, BR, steel wire and electricity consumption during the production stage are identified as the key contributors.



- The economic cost is less sensitive to CR, steel wire, BR, electricity, accelerator, and antiager, whereas the environmental impacts is more sensitive to these parameters.

Fig.6 Sensitivity analysis of inputs in the production stage of S-III to environmental cost, economic cost and total cost (with 10% increase of the input).

Acknowledgments

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