PREDICTION OF THERMAL CONDUCTIVITY OF NATURAL RUBBER COMPOUND FILLED WITH CARBON BLACK AND GRAPHITE

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DECLARATION

I declare that this is my own work and this thesis dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or institute of higher learning and to the best of my knowledge and belief. In addition, it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Signature: Date:28/02/2020

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The above candidate has carried out research for the Master's thesis dissertation under my supervision

Name of the supervisor

Dr. Olga Gunapala

Signature of the supervisor: Date: 28/02/2020

DEDICATION

I would like to dedicate this thesis to my ever loving my family members, my father, mother, little sister, my wife, and my beloved son who lives among the stars right now.

Your loving kindness and unconditional support made me the best I can be! .

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Finally, my country, Sri Lanka, Thank you!

ABSTRACT

Rubbers and rubber composites are a vital materials category that has been used in multiple applications in the present day. Improving their characteristics, properties can make rubber material much more versatile in their performance at economically.

Improving the thermal conductivity (TC) of rubber composite is relevant to many aspects. Heat dissipation, heat build-up, curing, manufacturing, and product performance is directly and indirectly affected by the TC of a compound. In this research work, time – temperature data obtained by transient plane source (TPS) method was analysed to obtain TC of natural rubber (NR) and carbon black (CB) rubber compounds with added graphite. TCs were also obtained by two emphirical models Lewis – Nielson model and Hashin – Shtrikman model for the same samples.

Four rubber samples were used with varying graphite content from 0 phr (control), 5 phr, 10 phr and 15 phr. From the empirical modelling, modified Lewis-Nielson model (LN model) resulted thermal conductivities of ($Wm^{-1}K^{-1}$) 0.1618, 0.1736, 0.1858 and 0.1983 and Hashin-Shtrikman model (HS model) resulted 0.1619, 0.1655, 0.1688 and 0.1718 for 0 phr (control), 5 phr, 10 phr and 15 phr graphite added samples. For the same respective samples, TPS analysis TCs were obtained as ($Wm^{-1}K^{-1}$) of 0.1462, 0.1495, 0.1545 and 0.1725. All graphite added rubber samples demonstrated an increase in TC over the control sample (0 phr Gr sample).

In order to further minimise the difference between the TPS results and the empirically model values, a mulplier correction factor was introduced to each model. Minimise the sum of the squared of the errors were set to zero and the multiplier correction factors were obtained for each model as $\boldsymbol{\lambda}_{HS}$ = 0.932 and $\boldsymbol{\lambda}_{LN}$ = 0.864 for HS model and LN model respectively. Predicted TC values from both optimised LN model and HS model reduced its percentage difference between TPS analysed values to less than 5% except the 15 phr Gr sample'sTC resulted from HS model which had a 7.10% difference after optimisation.

In order to increase the accuracy of the complex calculations and to improve the sensitivity it is recommended to use powerful mathematical software programs.

Further improvement of the thermal conductivity can be potentially achieved by functionalisation of the graphite particles, decreasing the particle size and its distribution, which gives further future aspects for research. In depth, optimisation and detailed handling of parameters would be beneficial for the accuracy but at the same time this would compromise the time consumption and the simplicity of the computation method followed.

Using the optimised empirical models proposed in this study, TC can be reasonably estimated for NR and CB rubber compounds with added graphite. This understanding would definitely benefit the solid rubber industry

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LIST OF ABBREVIATIONS

1. NR – Natural rubber
2. CB – Carbon black
3. TC – Thermal conductivity
4. Gr – Graphite
5. phr – Parts per 100 rubber parts
6. GRG – General rubber goods
7. ETC – Effective thermal conductivity
8. TPS – Transient plane source

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