UNIVERSITI PUTRA MALAYSIA

EXPERIMENTAL DETERMINATION OF FATIGUE LIFE FOR INTERNATIONAL RUBBER HARDNESS DEGREE 60 ENGINE MOUNT RUBBER

MARYAM HOSSEINI

EXPERIMENTAL DETERMINATION OF FATIGUE LIFE FOR INTERNATIONAL RUBBER HARDNESS DEGREE 60 ENGINE MOUNT RUBBER

By

MARYAM HOSSEINI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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DEDICATION

To my beloved family for their love, support and encouragement

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman : Aidy Ali, PhD

Faculty : Engineering

In the new millennium era, rubber materials are vigorously used in many industries including automotive that cover a wide range of applications such as tires, seals, belts, bushes and engine mounts. Rubber is an ideal material for many applications because it can withstand very large strain with no permanent deformation or fracture.

The behavior of material under repeated loads differs from static loads. Elastomers fail at cyclic stress or strain amplitude much lower than static stress or strain. It is based on growth of cracks through the material. The fatigue analysis and its lifetime evaluation are very important in design procedure to assure the safety and reliability of the rubber components. Design of rubber against fatigue failure is one of the important topics to be focussed for checking the failures during its operation life.

Many mechanical and environmental factors could prolong the rubber fatigue life. The fatigue failure process of materials is explained by two approaches including crack initiation and crack propagation.

The present work deals with investigation of the fatigue behavior using rubber dumb-bell test specimens under uniaxial loading. The material used in this study is a vulcanized natural rubber with a typical engine mount formulation and the hardness of International Rubber Hardness Degree 60. Test specimens were designed based on type 2 of MS ISO 37 standard and used for tensile and fatigue tests, both in ambient temperature. Fatigue tests were conducted under the displacement controlled condition with a sine waveform of 0.1 Hz and the ratio of the minimum displacement to the maximum displacement was equal to zero. The experimental results were presented under strain controlled condition.

For investigation of the fatigue damage behavior, a theoretical equation was developed based on the continuum damage mechanics theory. The Ogden strain energy potential of first order was used for defining a constitutive relation of the natural rubber. The proposed theoretical formula was based on function of the strain range under cyclic loading to determine the fatigue life of elastomeric material. The ability of predicted fatigue life shows a reasonable agreement of 98% with experimental values. The experimental results and theoretical equation were validated with the previous experimental data which show a good agreement of 97% and 93% respectively.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENENTUAN JANGKA HAYAT LESU BAGI KEKERASAN GETAH DARJAH 60 PADA PENDAKAP ENJIN

Oleh

MARYAM HOSSEINI

Januari 2010

Pengerusi : Aidy Ali, PhD

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Dalam era alaf baru zaman kini, bahan seperti getah banyak digunakan di dalam industri, termasuklah di dalam industri automotif yang meliputi pelbagai aplikasi seperti tayar, kedap, talisawat, sesendal dan peredam enjin. Getah adalah bahan yang sesuai digunakan kerana ia boleh menahan terikan yang sangat tinggi tanpa perubahan bentuk yang kekal atau patah.

Perilaku sesuatu bahan dalam beban berulang adalah berbeza jika dibandingkan dengan beban statik. Elastomer akan mengalami kegagalan pada nilai tegasan atau terikan berkitar yang kurang berbanding nilai tegasan atau terikan dikenakan secara statik. Ini berlaku disebabkan oleh tumbesaran keretakan pada sesuatu bahan. Analisis kelesuan dan penentuan jangka hayat adalah amat penting semasa rekabentuk untuk memastikan keselamatan bagi komponen getah. Rekabentuk komponen getah dan kegagalan komponen disebabkan oleh kelesuan telah menjadi salah satu tajuk yang penting untuk difokuskan bagi mengenal pasti tahap kegagalan semasa dalam operasi.

Banyak faktor mekanikal dan persekitaran boleh mempengaruhi jangka hayat lesu bagi getah. Kegagalan komponen getah disebabkan oleh kelesuan dapat diterangkan melalui dua pendekatan, iaitu permulaan retak dan rambatan retak.

Kerja terkini melibatkan siasatan penentuan kelesuan menggunakan spesimen dumbel yang dikenakan beban pada satu arah. Getah yang digunakan ialah getah asli yang telah divulkankan dengan kekerasan International Rubber Hardness Degree 60, formulasi yang biasa digunakan di dalam komponen peredam enjin. Spesimen direka mengikut spefikasi berdasarkan MS ISO 37 jenis 2, dan digunakan dalam ujikaji regangan dan kelesuan dengan keadaan suhu persekitaran. Ujian kelesuan dijalankan dengan kawalan terikan menggunakan bentuk gelombang sin berfrekuensi 0.1 Hz dan nisbah terikan minimum dan terikan maksimum bersamaan dengan sifar. Keputusan ujikaji ditunjukkan dalam keadaan kawalan terikan.

Di dalam siasatan kerosakan disebabkan oleh kelesuan, satu persamaan teori telah dihasilkan berdasarkan teori kontinum mekanik kerosakan. Potensi tenaga terikan Ogden peringkat pertama digunakan untuk menentukan hubungan konstitutif bagi getah asli. Formula teori yang dicadangkan ialah berdasarkan fungsi antara julat terikan dengan bebanan berkitar untuk menentukan jangka hayat elastomer. Perbandingan keputusan eksperimen dan jangka hayat yang diramalkan mencapai persetujuan sebanyak 98%. Keputusan eksperimen dan teori disahkan oleh keputusan eksperimen yang telah dijalankan dahulu dan menunjukkan kesepakatan yang baik, iaitu masing-masing 97% dan 93%.

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I certify that a Thesis Examination Committee has met on 7 January 2010 to conduct the final examination of Maryam Hosseini on her thesis entitled "Experimental Determination of Fatigue Life for International Rubber Hardness Degree 60 Engine Mount Rubber" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Date: 8 April 2010

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

MARYAM HOSSEINI

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