TOOTH BENDING STRESS AND TOOTH IMPACT STRESS OF THIN-RIMMED SPUR GEAR

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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

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ABSTRAK

Kelebihan utama gear taji rim nipis (*thin-rimmed spur gear*) adalah pengurangan berat suatu gear dan ia digunakan dalam pelbagai aplikasi. Mempunyai sistem gear yang ringan dan cekap dapat meningkatkan kecekapan enjin secara keseluruhan. Penggunaan gear rim nipis adalah lazim dalam kebanyakan aplikasi yang melibatkan penggunaan gear. Kajian ini bertujuan untuk menyiasat kesan ketebalan rim, ketebalan web dan pengaturan web pada kekuatan lenturan gigi gear taji rim nipis menggunakan kaedah Analisis Unsur Terhingga (FEA); dan untuk menentukan tenaga hentaman, kekuatan hentaman pada keliatan gigi gear dan anjakan gigi gear taji rim nipis menggunakan pelantar ujian hentaman. Persamaan asas dari *American Gear Manufactures Association* (AGMA) telah digunakan dalam kajian ini untuk meramalkan tegasan pada akar gigi gear, yang kemudiannya dibandingkan dengan analisis unsur terhingga. Set gear taji rim nipis dengan ketebalan rim dan ketebalan web yang berbeza telah disimulasikan dalam perisian Abaqus 6.14 sebagai model unsur terhingga (FE) untuk dianalisis. Tegasan akar gigi gear taji rim nipis yang digunakan dalam FEA adalah berdasarkan dua jenis aturan web iaitu aturan web simetri dan aturan web tidak semetri. Nilai tegasan *von Mises* telah diekstrak dari sisi tegangan (*tensile side*) di bahagian kritikal *Hofer*, pada gigi gear kedua yang bersentuhan. Daripada dapatan kajian, terdapat peningkatan nilai tegasan pada akar gigi gear direkodkan apabila ketebalan rim dikurangkan. Dapatan FEA menunjukkan bacaan maksimum tegasan *von Mises* pada akar gigi gear berlaku di tengah-tengah pada bahagian kritikal Hofer bagi gear taji padu. Kedua-dua jenis aturan web mempunyai tegasan *von Mises* maksimum yang lebih tinggi berbanding model gear taji padu. Sebagai perbandingan, model tidak simetri adalah 13% lebih tinggi berbanding model simetri pada nisbah kenaikan tekanan *von Mises* tertinggi. Seterusnya, bagi mencapai objektif kedua, sebuah alat ujian hentaman dibangunkan untuk mengkaji kekuatan hentaman pada gigi gear taji rim nipis. Alat perakam data digunakan untuk mendapatkan bacaan terikan pada tolok terikan yang dipasang di bahagian kritikal *Hofer* pada satu gigi gear yang diuji. Data menunjukkan anjakan pengukuran span mencapai anjakan terbesar apabila beban yang lebih tinggi dikenakan pada gigi gear. Sebagai perbandingan, anjakan terbesar bahagian tidak simetri TA4 adalah 5% lebih besar berbanding bahagian simetri TS4. Bahagian TA4 dan TS4 mempunyai nilai anjakan pengukuran span terbesar kerana kedua-duanya mempunyai ketebalan rim dan ketebalan web yang nipis. Dapat disimpulkan bahawa aturan web tidak simetri mempunyai nilai tegasan akar gigi gear yang lebih tinggi daripada aturan web simetri serta aturan web tidak simetri mempunyai anjakan pengukuran span yang lebih besar berbanding dengan aturan web simetri.

ABSTRACT

The main advantages of the thin-rimmed spur gear are its reduction in gear's weight and the wide usage in various application. The efficiency of an engine can be improved by possessing a lightweight and efficient gear system. Thus, the use of thin-rimmed gears is prevalent in most applications involving gear usage. This study aimed to evaluate the effects of rim thickness, web thickness, and web arrangements, on tooth bending strength of thin-rimmed spur gears using the Finite Element Method; and to analyse impact energy, impact strength on tooth toughness, and tooth displacement of thin-rimmed spur gears using an impact test rig. The basic American Gear Manufacturers Association (AGMA) equation was utilised in this investigation to forecast gear tooth root stresses, which were then compared to finite element analysis. For further analysis, sets of thin-rimmed spur gear with various rim and web thicknesses were simulated in Abaqus 6.14 software as a finite element (FE) model. The FEA was based on symmetric and asymmetric web arrangements. von Mises stress values were extracted at Hofer's critical section on the tensile side of the second tooth in contact. Resultantly, the root stress values increased constantly upon reducing the applied rim thickness. The FEA results revealed the maximum von Mises Stress at the middle of Hofer's critical section of the solid spur gear. Both type of web arrangements has higher maximum von Mises stress compared to solid model. As comparison, asymmetric model was 13% higher compared to symmetric model at the highest von Mises stress increment ratio. To achieve the second objective, an impact test mechanism was developed to determine the tooth impact strength on the thin-rimmed spur gear tooth. A data logger used to obtain strain readings on a strain gauge installed at Hofer's critical section on a single gear tooth tested. A positive relationship detected between the height of load drop and impact energy values. Data from the impact test experiment revealed the span measurement achieved largest displacement as a higher load applied to the gear tooth. As comparison, asymmetric part TA4 was 5% higher compared to symmetric part TS4 at the largest displacement. Part TA4 and TS4 hit the largest displacement value as both have the thinnest rim and web thickness. Conclusively, asymmetric web arrangement has a higher tooth root stress value and a largest displacement of span measurement compared to symmetric web arrangement.

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