THE FORMULATION OF LUBRICATING GREASE FROM WASTE TRANSFORMER OIL

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MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG

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We hereby declare that we have checked this thesis and, in our 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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STUDENT'S DECLARATION

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

Trend formulasi minyak telah beralih kepada alternatif yang lebih hijau. Penjanaan minyak buangan terus meningkat akibat perindustrian dan urbanisasi. Penyelidikan telah menunjukkan bahawa minyak buangan boleh digunakan semula sebagai minyak asas gris tetapi, kepelbagaian komposisi minyak buangan pada setiap koleksi - terutamanya minyak buangan daripada industri automotive, akan menyumbang kepada kualiti gris yang tidak konsisten apabila dimasukkan dalam formulasi gris. Walau bagaimanapun, masalah ini tidak jelas bagi minyak buangan daripada industri kuasa seperti minyak pengubah buangan (WTO). Dalam usaha untuk mengatasi masalah tersebut, kajian ini bertujuan untuk merumuskan dan menghasilkan gris dengan menggunakan WTO sebagai minyak asas untuk mengetahui kebolehgunaan WTO sebagai minyak asas gris kerana belum ada penyelidikan berkaitan gris–WTO telah dilakukan. Rawatan dan analisis WTO diramalkan berkait dengan kebolehgunaan WTO sebagai minyak asas gris. Analisis WTO dijalankan untuk mengetahui keadaan WTO berdasarkan sifat bendalir WTO, tahap kontaminasi, dan kandungan logam di dalam WTO. Gris sodium dan FS berasakan WTO kemudian dirumuskan, dihasilkan, dan dicirikan secara fizikal dan kimia menggunakan kaedah ujian standard dan tidak standard yang telah dipilih berdasarkan peralatan yang ada. Additif MoS_2 juga ditambah ke dalam perumusan bagi memerhatikan bagaimana ia mempengaruhi struktur dan sifat gris. Rawatan WTO secara pengenapan, penapisan, dan penyejatan didapati cukup untuk mengurangkan kepekatan bahan cemar di dalam WTO kepada had yang dibenarkan dan analisis WTO menunjukkan bahawa WTO yang sudah dirawat mempunyai ciri-ciri yang setanding dengan kebanyakan minyak asas gris dan telah membuktikan kebolehgunaan WTO sebagai minyak asas gris. Analisis gris menunjukkan bahawa kandungan WTO berkadar terus dengan *oil bleeding* dan *oil separation* dan berkadar songsang dengan konsistensi dan *dropping point* gris. Penambahan additif MoS_2 ke dalam rumusan didapati hanya sedikit mempengaruhi sifat gris. Gris sodium dan FS dengan ciri-ciri yang diinginkan telah berjaya dirumuskan dan dihasilkan menggunakan 70 % dan 92 % kandungan WTO. Walau bagaimanapun, WTO dan gris berasaskan WTO mempunyai *anti-wear properties* semula jadi yang tidak baik. Atas dasar ini, kajian telah mendapati bahawa WTO boleh digunakan sebagai minyak asas gris dan telah berjaya merumus dan menghasilkan gris berasaskan WTO tetapi, kajian lanjut diperlukan untuk memperbaiki kerja-kerja perumusan gris dan menambah baik lagi kualiti gris yang dihasilkan.

ABSTRACT

Grease formulation trends were shifting towards greener alternatives. Waste oil generation continues to rise due to industrialization and urbanization. Researches has shown that waste oil can be reused as grease base oil but, the variability of waste oil compositions upon every collection – especially for waste oil generated from automotive industries will contribute to inconsistent grease quality when incorporated in grease formulation. This problem, however, is not apparent for waste oil from the power industry such as waste transformer oil (WTO). In pursuance to overcome the aforementioned problem, this study aims to formulate and produce grease using WTO as a base oil to address the viability of WTO as grease base oil as no grease-WTO-related research had been done. WTO treatment and analysis were predicted significantly associated with the viability of WTO as grease base oil. WTO analysis is carried out to investigate the WTO condition based on its fluid properties, contamination level, and wear metal content. WTO-based sodium and FS greases then formulated, produced, and characterized physically and chemically using standard and non-standard test methods, chosen based on the available equipment. Additive MoS_2 is also added into the formulation as to observed how it affect the grease structure and properties. The WTO treatment of settling, filtration, and evaporation are adequate to reduce WTO contaminant concentration to allowable limit and the WTO analysis show that the WTO has good characteristics comparable to most grease base oil and has proved the WTO viability as grease base oil. Grease characterization shows that the WTO content is directly proportional to grease oil bleeding and separation and inversely proportional to the grease consistency and dropping point. Addition of additive MoS_2 was found to only slightly affecting the grease properties. WTO-based Sodium and FS grease with desirable properties were successfully formulated and produced using 70% and 92 % WTO content, respectively. The WTO and WTO-based greases however, has poor natural anti-wear properties. On this basis, this study found that WTO can be used as grease base oil and managed to formulate and produce greases using WTO but, further research is needed to improve the grease formulation work and the produced grease quality.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

%Diff	Percent different
%Error	Percent error
wt%	Weight percentage
R^2	Coefficient of determination

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
BL	Boundary lubrication regime
COF	Coefficient of friction
FG	Fumed silica grease (no additive)
FGM	Fumed silica grease (with MoS_2)
FL	Full-fluid lubrication regime
FS	Fumed silica
FTIR	Fourier transform infrared spectroscopy
ICP-MS	Inductively coupled plasma mass spectrometry
ITO	Industrial grade transformer oil
ML	Mixed lubrication regime
MoS_2	Molybdenum disulfide
NLGI	National Lubricating Grease Institute
PAG	Poly(ethylene glycol-ran- propylene glycol) monobutyl ether
PAO	Polyalphaolefin
PEG	Poly(ethylene glycol)
PTFE	Polytetrafluoroethylene
SG	Sodium Grease (no additive)
SGM	Sodium Grease (with MoS_2)
TEM	Tunneling Electron Microscopy.
VI	Viscosity index
WSD	Wear scar diameter
WTO	Waste transformer oil

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