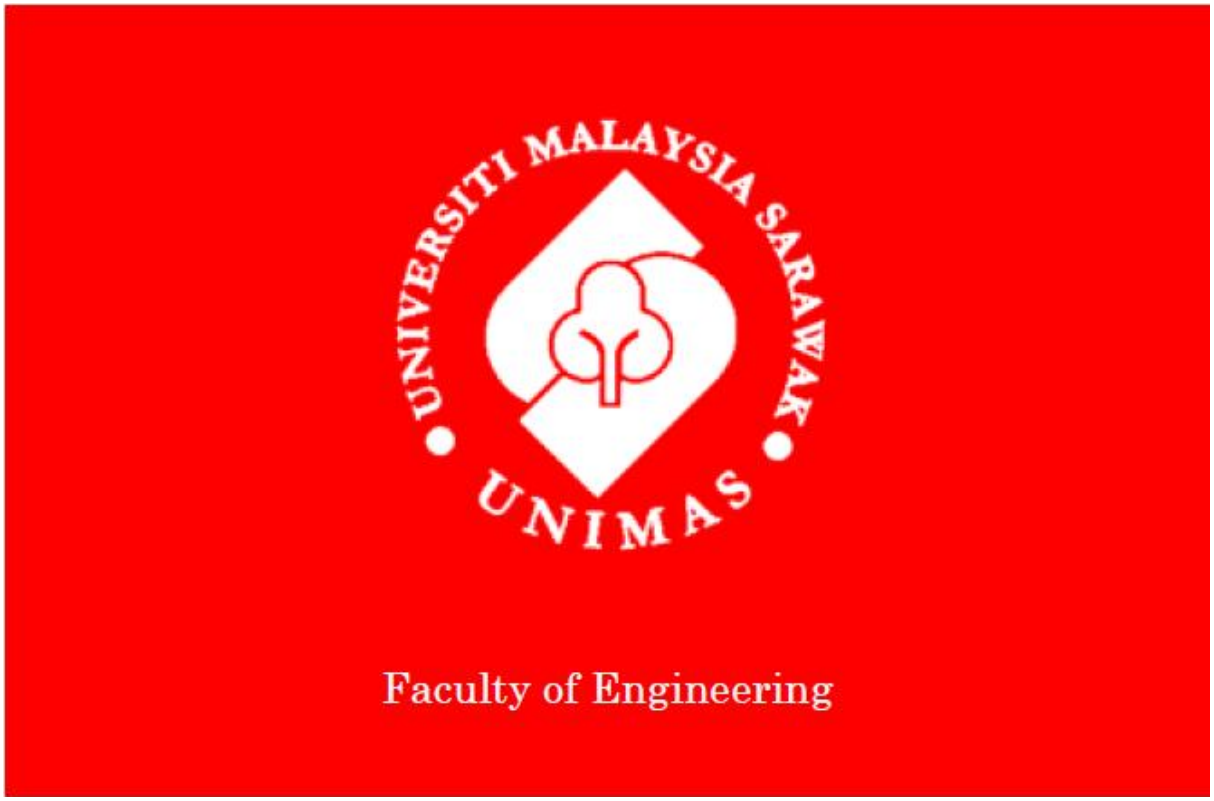

EVALUATION OF PEAT SOIL AS AN ALTERNATIVE FUEL

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Bachelor of Engineering with Honours

(Mechanical and Manufacturing Engineering)

2010

UNIVERSITI MALAYSIA SARAWAK

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EVALUATION OF PEAT SOIL AS AN ALTERNATIVE FUEL

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This subject is submitted in partial fulfillment of

the requirements for the Degree of Bachelor of Engineering with

Honours (Mechanical and Manufacturing Engineering)

2010

To my beloved family and friends

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ABSTRAK

Kepupusan bahan api fosil telah menjadi salah satu masalah di dunia masa kini. Semakin hari, semakin banyak bahan api fosil digunakan manusia untuk mencapai kemajuan dalam kehidupan harian mereka. Daripada perniagaan kecil sehinggalah perusahaan besar, kesediaan tenaga untuk jangka masa panjang adalah paling penting untuk pertumbuhan dan pembangunan dunia . Batu arang juga ialah bahan api fosil yang paling cepat berkembang pada tahun 2003 hingga 2008. Walau bagaimanapun, batu arang yang dikategorikan sebagai bahan api fosil akan pupus tidak lama lagi jika kadar penggunaan terus meningkat. Lantarannya, penyelidikan telah dibuat di serata dunia untuk menggantikan penggunaan bahan api fosil dengan bahan api alternatif. Dalam projek ini, potensi tanah gambut sebagai bahan api alternatif bagi menggantikan batu arang akan dinilaikan. Ciri-ciri pelbagai adunan dan saiz-saiz pelet berbeza berbanding dengan nilai kalori, dikaji di dalam projek ini. Daripada keputusan eksperimen, pelet gambut tulen didapati mempunyai nilai kalori kasar sebanyak 13.3 MJ/kg pada kadar kelembapan 20%. Sebaliknya, adunan pelet tanah gambut dengan habuk kayu mengandungi 3% nilai kalori kasar lebih tinggi berbanding dengan adunan pelet tanah gambut dengan tebu pada jumlah kandungan abu yang sama. Diameter pelet10mm jenis adunan juga menjanjikan potensi yang lebih baik berbanding dengan diameter pelet 8mm . Kesimpulannya, tanah gambut mempunyai potensi untuk menggantikan batu arang sebagai bahan api pepejal dalam masa terdekat. Kerja peningkatan boleh dilakukan pada tanah gambut untuk meningkatkan lagi ciri-ciri bahan api tanah.

ABSTRACT

Fossil fuel depletion is one of the major concerns of everyone in the world right now. As time passes by, more and more fossil fuels are consumed each day as people progress in their daily lives. From small businesses to large economies, the long-term availability of energy worldwide is paramount to growth and development. Coal was the fastest growing fossil fuel in the year 2003 to 2008. However, coal which is categorized as fossil fuel will deplete soon if the rate of consumption keeps on rising. Therefore, research is done in many parts of the world to replace the usage of fossil fuel with alternative fuel. In this project, the potential of peat soil as an alternative solid fuel to replace coal is evaluated. The behavior of various admixtures and sizes of pellets to the calorific value of peat pellets are studied in this project. From the experimental result, pure peat pellet has a gross calorific value of 13.3 MJ/kg at operating moisture content of 20%. On the other hand, pellet of peat soil with saw dust admixtures has 3% higher gross calorific value compared to pellet of peat soil with sugar cane admixture at the same amount of ash content. The 10mm diameter pellet of admixtures also promises a better potential as compared to the 8mm diameter pellet. As a conclusion, peat soil has the potential to replace coal as solid fuel in the near future. Improvements can be done to peat soil to further improve the fuel properties of the soil.

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LIST OF ABBREVIATIONS AND NOTATIONS

ASTM	-	American Society for Testing and Materials
BD	-	Non – specific bulk density
C	-	Carbon
ESB	-	Electricity Supply Board
G_s	-	Specific gravity of soil
H	-	Organic Content
M	-	Mass of wet soil sample
MARDI	-	Malaysian Agriculture Research and Development Institute
N	-	Nitrogen
N	-	Ignition loss
SD	-	Specific bulk density
TPS	-	Total pore space
USDA	-	U.S. Department of Agriculture
V	-	Volume of Soil Sample
V_s	-	Volume of solid
W_s	-	Weight of soil
γ_w	-	Unit weight of water, 9.81 kN/m^3

CHAPTER 1

INTRODUCTION

1.1 General

The purpose of this project is to investigate the potential of peat soil as an alternative fuel. Scientist has predicted the depletion of fossil fuels like coal, oil and natural gas in the coming years. The world energy consumption is increasing rapidly each day and thus will accelerate the depletion of fossil fuels. This study is mainly on the fuel properties of the peat soil with different admixtures in a combustion process. The admixtures that are going to be used in the experiment are saw dust and sugar cane fiber. Experiments are conducted in laboratory to test out the effect of the peat with different types of admixtures. The size of the peat is also manipulated in the experiment.

1.2 Background

Peat is a geologically young coal, a precursor to the formation of lignite. It is an accumulation of plant remains in various stages of decomposition. It is thousands of years old, rather than millions of years old as coal are (Gates, 1981). Peat is an organic soil which consists more than 70% of organic matters. Peat deposits are found where conditions are favorable for their formation. Peat in strict definition usually refers to the

accumulation of a purely one hundred percent organic material and the distinction between soil and vegetative accumulation is not clear. Over the years, 'peat' has been alternately referred to as 'organic soils' and Histosols. Peat as organic soils on the basis of mass composition i.e. soils that contain at least 65% organic matter or conversely, less than 35% mineral content (Mohamed et al, 2002). Peat soil is an accumulation of the partially decomposed remaining of dead plant material which is completely organic. Peat also is of low density and is black or dark brown in colour (Nurdiana, 2007).

Organic soil or Histosols can be identified using Soil Taxonomy. Soil taxonomy differentiates between mineral soils and organic soils. Soil material that contains more than the amounts of organic carbon described above for mineral soil material is considered organic soil material. Soil colors (hue, value, and chroma) are used in many of the criteria that follow. Soil colors typically change value and some change hue and chroma, depending on the water state (Soil Survey Staff, 2003). There are few types of peatswamps which is commonly referred as wetlands. But a wetlands classification is not the same as peatswamps classification.

- Wetlands - Large or small bodies of open water surrounded by wet mineral soils as well as peatland.
- Moor - A boggy area of waste land, usually peaty and dominated by grasses and sedges.

- Bog - Wet spongy ground, poorly drained, rich in plant residues, having a specific flora such as sedges, heaths and sphagnum.
- Marsh - A tract of soft land usually characterized by monocotyledons.
- Mire - A marsh or bog.
- Fen - Low land partly or wholly covered with water.

It is clear from these definitions that all these wetlands could include peat, and to a wider degree organic soil (Andriesse, 1988).

Andriesse (1988) also stated three basic kinds of the organic material that referred to peat soil, namely; fibric, hemic and sapric. Figure 1.1 shows the profile of morphology of drain organic soils such as fibric, hemic and sapric. They are indicated based on the degree of composition (humification) of the original plant material. Fibric peat material mostly is less than 0.1 g/cm³ of bulk density, two – third of volume before rubbing fiber content and three – forth of volume after rubbing. The saturated water content varies from about 850 % to over 3000 % of weight oven dry material. It is light yellowish brown or reddish brown in colour. Hemic is an intermediate in degree of humification that the bulk density is about 0.07 g/cm³ to 0.18 g/cm³. Fiber content is around one – third and two – third of volume before rubbing. While the water content is about 450 % to 850 % when saturated and the colour of hemic is commonly dark greyish brown to dark reddish brown. Sapric is the most highly decomposed. The bulk density is equal or more than 0.02 g/cm³. The fibre content average is less than one - third of volume before rubbing. The maximum water content, when saturated is less

than 450 % on the oven – dry material. The colour is very dark grey to black (Andriesse, 1988).

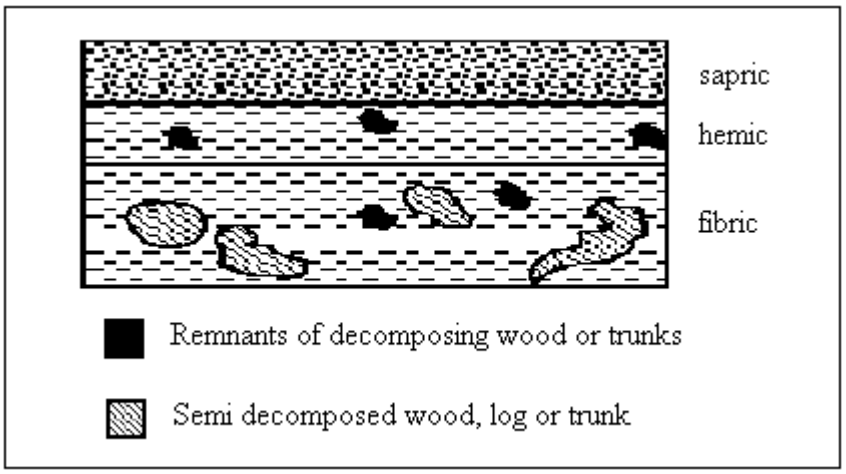

Figure 1.1 Profile of morphology of drain organic soils. (Mohamed et al, 2002)

Peat deposits are found in many places around the world. Peatlands represent over half of the world's wetland area and they cover a total of around 3% of global land mass or 3,850,000 to 4,100,000 square kilometers. Around 80% of peatlands is found in high latitudes with approximately 60% of the world's wetlands are peat. There are approximately 150 million hectares of peat worldwide. In Malaysia, the percentage of peatland coverage is 18% of the land which amounting to 2.7 million hectares (Norliza, 2006). Sarawak as the largest state in Malaysia has the biggest reserve of peat land. There are about 1.5 million hectares of peat land in Sarawak, which are relatively under developed. They are located in low-lying coastal depressing areas which are shown in Figure 1.2 (Jaya, 2002).

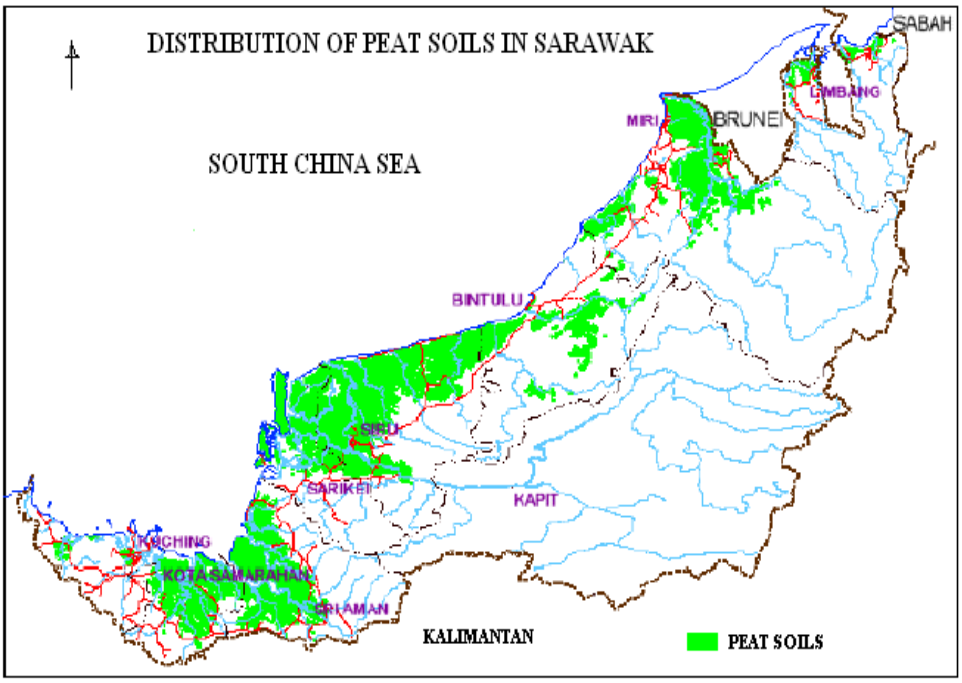

Figure 1.2 Distribution of peat soils in Sarawak (Jaya, 2002).

Figure 1.3 Peat swamp forests in Sarawak (Singh et al, 2003).

1.3 Scope of Study

This study focused on the potential of peat soils as alternative fuels. Therefore there are a few objectives that are covered in the study. First of all, geotechnical properties of peat soil are to be studied. Next, analysis of the combustion properties of peat soil is made. Lastly, the author is to evaluate the potential of peat soil as an alternative solid fuel.

In order to achieve the objectives mentioned above, the author will manipulate the composition of the peat soil and admixtures. The effect of different sizes of pellet to the energy is also evaluated through experimental works. Different types of admixtures are also used in the experiment to observe the behavior of fuel properties when mix with peat soil.

CHAPTER 2

LITERATURE REVIEW

2.1 General

In this globalization era, we, human, are consuming more and more fossil fuels in order to progress in our daily lives. Fossil fuels such as petroleum, natural gas and coal are depleting each day and is predicted by many scientist that the resource is going to deplete very soon. Therefore, alternative for this fossil fuels is very much welcome now. In fact, every country in the world is now doing intensive research and development for new type of fuels to replace this fossil fuel. Many are looking for cheaper fuel alternatives as the current fossil fuel prices are sky rocketing over the years. Peat soils are unwanted soil type which is less valuable compared to other type of soil. Therefore it is cheap to get peat soil and study the potential of peat as a type of fuel.

This section briefly explains the characteristics of peat soil which cover the basic geotechnical properties, physical properties and the combustive properties of peat soils. According to Deboucha et al. (2008), peat soil basically has a few special characteristics such as low shear strength typically around 5 to 20 kPa. It also has high degree spatial variability and high natural moisture content which can reach up to 800%. Peat soil has

high compressibility including significant secondary and tertiary compression. It also has potential for further decomposition as a result of changing environment conditions.

2.2 Peat for Energy in Ireland

Peat soil is widely used in Ireland as a source of energy in the country. Ireland's energy requirements exceed 10 million tonnes of oil equivalent (TOE) and the national expenditure on energy exceeds £2.5 billion annually. Ireland's indigenous energy sources supply 12% of its total energy requirements. Total primary energy requirement is a measure of all energy consumed in the country. In Ireland, because of overall growth, primary energy requirement in 1993 was 24% higher than it was in 1980. In this period the contribution of peat to Ireland's energy requirement has remained fairly constant in terms of tonnage used per annum.

Before indigenous natural gas came on stream in 1979, peat was the most important indigenous energy resource. Peat has been used for electricity generation since the 1950s. Its contribution peaked in the mid 1960s when it provided just under 40% of Ireland's total power generation. In 1980, it contributed 21% of the fuels that went into generation while in 1995 this figure was 16%. Electricity demand has continued to grow over the decades but there has been no increase in the peat fired generating capacity of the ESB since the 1980's. Installed ESB generating capacity for peat is 420 MW in 5 stations. Peat is supplied by Bord na Móna to the peat fired power stations run by the ESB in Ferbane, Rhode, Lanesboro, Shannonbridge and Bellacorick (Bord Na Mona, 2001).