UNIVERSITI PUTRA MALAYSIA

THERMAL PERFORMANCE OF PARABOLIC CONCENTRATORS UNDER MALAYSIAN CONDITIONS

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By

YAASEEN RAFEEU

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

January 2011

Dedicated to my parents Mohamed Ali, Zulaikha Yahuya and my Family

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: Mohd Zainal Abidin Ab Kadir, PhD

Faculty: Engineering

Renewable energy generation is becoming more prevalent on today's electric grid. The challenges of increasing the percentage of renewable energy will be dealing with the intermittent nature of renewable sources. This thesis outlines various existing solar technologies. The understanding of each technology and its associated challenges provide a suitable basis to recognize advantages and drawbacks, more importantly it gives the technological development of solar dish concentrator.

Three experimental models with various geometrical sizes and diameter of about 0.5m of solar dish concentrators are used to analyze the effect of geometry on a solar irradiation and temperature and in maximising the solar fraction under Malaysian environment. These models are used to analyze the performance of parabolic concentrating collector's parameters such as reflector materials, aperture diameter, depth of concentrator, size of focal point and temperature at the focal point with different solar irradiations to increase the thermal efficiency. There are 3 dishes involved which described as D_1, D_2 and D_3. D_1 is having depth of 5cm, focal point of 26.45cm and D_2 is having depth of 15cm, focal point 10.42cm. The reflective material of these 2 dishes are 3M aluminium films while D_3 having shiny stainless steel as a reflector with depth of 10cm and focal point of 12.66cm. The absorbers

were fabricated from 85cm length of copper tube of 4 mm in diameter spiralled and positioned at the focal point.

Components of the concentrated solar power technology such as reflectors and turbine/engines are quite mature in the market development. However, there is opportunity for improvements where new techniques can be adopted. Solar concentrator systems are among the alternatives that can be used to develop an improved and efficient renewable energy system. The enormous solar potentials in Malaysia could be used to bringing significant social and economic benefits in both rural and urban areas. At present there are many factors that would limit the implementation of renewable energy systems in Malaysia, particularly solar dish concentrators.

Thermal efficiency of the different dimensional dish concentrators are analysed using an absorber placed at the focal point. There is a significant variation in the efficiency of the concentrator with different reflective materials used. The efficiencies are calculated and results are conclusive. The 3M Silverlux aluminium films are much efficient than shiny stainless steel and increasing the area of the concentrator gives much more considerable variation in the results i.e. efficiency when comparing with the base. Overall, the efficiency of D_1 and D_2 is over 60% compared to D_3, which is 50% in many cases (by neglecting the losses).

Finally, the results conclude that concentrator D_3 is less efficient compared with other two concentrators. Although the results in this thesis could be used to develop efficient solar dish concentrators in Malaysia, there is still more research need to be done in improving current technology of dish concentrator systems, as the higher the efficiency of solar dish concentrators, the greater the role of renewable energy in the near future.

Sari tesis ini dipersembahkan kepada Senat Universiti Putra Malaysia di dalam memenuhi keperluan Master Sains

PRESTASI TERMAL PENUMPU PARABOLA DI BAWAH PERSEKITARAN MALAYSIA

Oleh

YAASEEN RAFEEU

Januari 2011

Pengerusi: Mohd Zainal Abidin Ab Kadir, PhD

Fakulti: Kejuruteraan

Penjanaan tenaga boleh diperbaharui menjadi lebih menonjol pada grid elektrik hari ini. Cabaran-cabaran peningkatan peratusan tenaga boleh diperbaharui akan berhadapan dengan sumber boleh diperbaharui yang sering terputus. Tesis ini menghuraikan pelbagai teknologi matahari yang ada. Pemahaman dari setiap teknologi dan cabaran yang berkaitan memberikan asas yang sesuai untuk mengenali kelebihan dan kekurangannya, lebih penting lagi memberikan perkembangan teknologi penumpu parabola suria. Tiga model ujikaji dengan saiz geometri yang berbeza (diameter sekitar 0.5 meter) dari penumpu parabola suria digunakan untuk menganalisis kesan geometri pada penyinaran suria dan suhu dalam memaksimumkan pecahan suria dalam persekitaran Malaysia. Model-model ini digunakan untuk menganalisa prestasi faktor pengumpul penumpuan parabola seperti bahan pemantul, diameter bukaan, kedalaman penumpu, saiz titik fokus dan suhu pada titik fokus dengan penyinaran suria yang berbeza untuk meningkatkan kecekapan termal.

Terdapat 3 parabola yang terlibat yang digambarkan sebagai D_1, D_2 dan D_3. D_1 mempunyai kedalaman 5cm dan titik fokus pada 26.45cm manakala D_2 mempunyai

kedalaman 15cm dan titik fokus pada 10.42cm. Bahan reflektif kedua-dua parabola ini ialah filem-filem aluminium 3M manakala D_3 mempunyai keluli tahan karat berkilat sebagai pemantul dengan kedalaman 10cm dan tumpuan utama 12.66cm. Penyerap-penyerap telah dibuat dari 85cm panjang tiub tembaga dengan 4mm diameter dilingkar dan ditempatkan di tumpuan utama.

Komponen teknologi tenaga suria tertumpu seperti pemantul, turbin /enjin-enjin agak matang dalam pembangunan pasaran. Namun, ada peluang untuk perbaikan di mana teknik baru dapat diterima pakai. Walau bagaimanapun, terdapat peluang bagi penambahbaikan di mana teknik-teknik baru dapat diambil. Sistem penumpu suria adalah salah satu alternatif yang boleh digunakan untuk membangunkan sistem tenaga boleh diperbaharui dipertingkatkan dan cekap. Potensi suria yang besar di Malaysia boleh digunakan untuk membawa manfaat sosial dan ekonomi yang ketara di kedua-dua kawasan luar bandar dan bandar. Ketika ini, terdapat banyak factor-faktor yang menghalang pelaksanaan sistem tenaga boleh diperbaharui di Malaysia, khususnya penumpu parabola suria.

Kecekapan termal dari penumpu parabola yang berbeza dimensi telah dianalisa dengan menggunakan penyerap yang ditempatkan pada titik fokus. Terdapat variasi yang ketara dalam kecekapan penumpu dengan penggunaan bahan-bahan pantulan yang berbeza. Kecekapan telah dikira dan hasilnya adalah pasti. Filem aluminium jenis 3M Silverlux jauh lebih cekap berbanding besi tahan karat berkilat dan penambahan kawasan penumpu memberikan lebih banyak variasi yang cukup besar dalam keputusan (kecekapan) bila dibandingkan dengan rujukan. Secara keseluruhan, kecekapan D_1 dan D_2 adalah lebih daripada 60% berbanding dengan D_3, yang 50% dalam banyak kes (dengan mengabaikan kehilangan).

Akhir sekali, keputusan menyimpulkan bahawa penumpu D_3 kurang cekap berbanding dengan dua penumpu lain. Walaupun keputusan-keputusan dalam tesis ini boleh digunakan untuk membangunkan penumpu parabola suria yang cekap di Malaysia, masih terdapat banyak kajian-kajian yang perlu dilakukan dalam menambahbaik teknologi semasa sistem penumpu parabola, di mana semakin besar

kecekapan penumpu parabola suria, semakin besar peranan tenaga boleh diperbaharui

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Yaaseen Rafeeu

I certify that an Examination Committee has met on 31st January 2011 to conduct the final examination of Yaaseen Rafeeu on his Degree of Master of Science thesis entitled "Thermal Performance of Parabolic Concentrators under Malaysian Conditions" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommended that the student be awarded the Degree of Master of Science.

The members of the Extermination Committee were as follows:

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

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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 institution.

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YAASEEN RAFEEU

Date: 31st January 2011

TABLE OF CONTENTS