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CRITERIA FOR SOLAR DRYING PROJECTS IN MALAYSIA

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RINGKASAN : *Satu analisis sinaran suria di beberapa buah bandar utama di Malaysia menunjukkan bahawa sinaran suria boleh digunakan sebagai tenaga alternatif untuk pengeringan bahan pertanian. Sehubungan dengan itu, beberapa kajian telah dijalankan di Malaysia yang menggunakan tenaga suria yang memberi tumpuan kepada kesan persekitaran dan penggunaan tenaga yang sedikit. Malangnya tidak terdapat kaedah yang sistematik dan kaedah sistem pakar boleh digunakan untuk mereka bentuk sistem tenaga suria bagi membantu penggubal keputusan. Dalam rencana ini satu temuduga dengan beberapa penyelidik dalam bidang tenaga suria telah dijalankan. Temuduga ke atas kumpulan penyelidikan tenaga suria di Universiti Kebangsaan Malaysia (UKM) telah dijalankan bagi mendapatkan parameter dan kriteria bagi kegunaan tenaga suria di Malaysia. Daripada parameter yang telah dipilih, dapat dibuat kesimpulan bahawa sistem pakar boleh digunakan bagi mereka bentuk berbagai jenis sistem tenaga suria di Malaysia oleh kerana pelbagai kajian yang telah dijalankan menunjukkan julat keserupaan dalam kebanyakan parameter tersebut. Perubahan dalam parameter boleh diperhatikan kerana terdapatnya arah aliran. Contoh sistem pakar prototaip akhirnya dipersembahkan.*

ABSTRACT : An analysis of solar radiation at several main towns in Malaysia shows that solar radiation is possible to be used for agricultural drying. Thus several studies have been done to use the abundant solar energy in Malaysia with concern of environmental impact and less energy consumption. Unfortunately there is no expert system catering for solar designs to assist decision makers. In this paper an interview with some researchers in the field of solar energy group at Universiti Kebangsaan Malaysia (UKM) was conducted, in order to get the parameters and criteria of solar energy use in Malaysia. From the selected parameters it is concluded that it is possible to use expert system for solar energy in Malaysia, and that is due to many studies, which showed a range of similarity in most of those parameters. The fluctuated parameters can be observed since the trend was there. Example of the prototype expert system is finally presented.

KEYWORDS : Solar drying, collector performance, solar energy, expert system.

INTRODUCTION

For thousands of years human civilisation has used non-concentrated solar energy to produce light and heat and to grow food. Subsequently the technologies are being developed to concentrate sunlight and utilise its energy for producing electricity, steam and hot water for industrial processes (Thomas *et. al.,* 1993). Analytical studies of solar radiation at several main towns in Malaysia show that solar radiation is possible to be used for different purposes (Mohd. *et. al.,* 1996a). Since Malaysia is located at latitude 1° 20′ N-6° 40′ N and longitude 99° 35′ E-103° 20′ E with an equatorial climate, it received an amount of 400-800 W/m^2 solar radiation intensity daily.

The use of solar energy in Malaysia is limited to dry agricultural products, water heating and photovoltaic system for remote area electrification but its contribution is still small (Mohd. *et. al.,* 1996a; Supranto *et. al.,* 1999b; Jubran *et. al.,* 2000). This small percentage of solar energy use in Malaysia is attributed to the intermittent behaviour of solar radiation due to heavy cloud and high water evaporative demand (Sopian *et. al.,* 1999). But in spite of that Malaysia has great interest in new and renewable energy sources particularly in the use of agricultural solar drying, losses of fruits and vegetables are estimated to be 30- 40% of production. The post harvest losses of agricultural products in the rural areas can be reduced drastically by using well-designed solar drying system (Karim and Hawlader, 2003).

A prototype of V-groove back pass solar collector was designed and tested in order to utilise the abundance of solar energy in Malaysia (Mohd. *et. al.,* 1996b). Mufadal (2003) conducted the performance evaluation of the photovoltaic assisted V-groove with single pass solar collector for drying under humid conditions. Sopian *et. al.* (1999) and Supranto *et. al.* (1999a) designed and constructed double pass solar collector with porous media in the second channel to assist drying system. The thermal efficiency obtained exceeded 75% and outlet temperature of 80-90°C was achieved. An experimental solar assisted dryer for palm oil fronds was designed. Malaysia is one of the largest producers of palm oil and the supply of fronds is plentiful. The collector is of the double pass type and the dryer is of the batch type. The simulation studies show that a temperature rise of 25°C to 30°C can be obtained and a collector thermal efficiency of 50 to 60% can be obtained (Supranto *et. al.,* 1999b). Researchers are currently working on the possibility of utilising the solar energy in various applications in Malaysia.

The present study aims to determine the criteria of solar drying based on the results of different approaches conducted by various researchers and to use these criteria as the data to be used in the development of expert system for solar drying study in Malaysia.

SOLAR SYSTEM

Solar system can be classified into two categories namely active solar system and passive solar system and it is illustrated in Figure 1. Each type of collector has an appropriate set of applications and choosing the correct collector for a given application is an important task of the solar engineer.

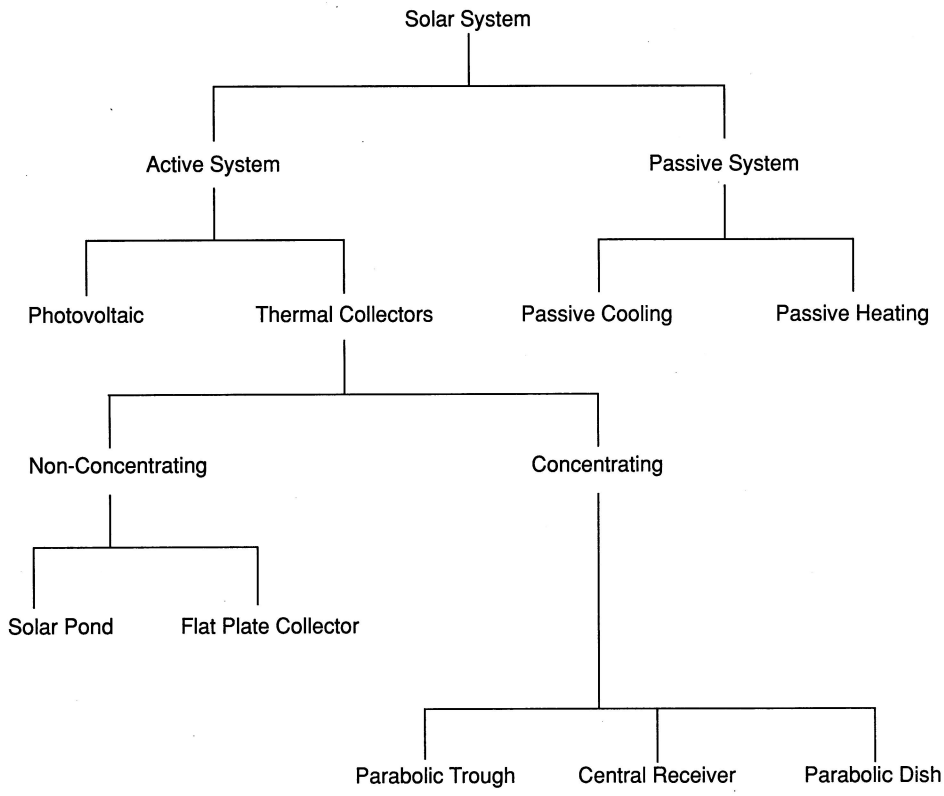


***Figure 1**. Solar system classification (Garg and Kandpal, 1999)*

In Malaysia, a flat plate collector has been largely used in drying agricultural products and water heating. Its design simplicity and ease of construction from cheap and locally available materials result in economical operation and maintenance of this collector (Mohamed, 1997). The working fluid normally used is liquid or air. One important advantage of using air as a transport energy medium in flat plate collector in Europe and USA is that it will not freeze, but this advantage is also valid for water as a transport energy medium in the tropical weather of Malaysia.

The essential part of a flat-plate collector is the "black" absorber plate, which transfers the absorbed energy to a fluid. The transparent cover limits heat losses through the so-called "green house effect", and the thermal insulation limits back losses (Garg and Kandpal, 1999). The surface of the absorber plate determines how much of the incident solar radiation is absorbed and how much it is emitted at a given temperature. Thus the cover plate should have a high transmittance for solar radiation and should not deteriorate with time. Insulation is used in the enclosure to prevent heat losses from the absorber back and the sides. It should be protected from water and should be non-flammable.

The useful extracted energy of a collector is the difference between the absorbed energy and the energy losses. The minimisation of the heat losses of the designed collector shows an acceptable efficiency for practical application, where a good collector performance always showed high efficiency and little losses in energy. The equations used to obtain useful energy and thermal efficiencies can be found in Garg and Kandpal (1999), Kreider *et. al.* (1989) and Duffie and Beckman (1991).

SOLAR DRYING IN MALAYSIA

An analysis of solar radiation at several main towns in Malaysia shows that solar radiation is possible to be used for different purposes, as Malaysia received an amount of 400-800 W/m^2 solar radiation intensity daily, and characterised with an equatorial climate. Winds are generally of low variable speed, and they come in two dominant directions, from the northeast and southwest, and rainfall is high throughout the year averaging from 2500 to 3000 mm (Yuan, 1987).

The specific parameters which affect solar drying projects in Malaysia were selected from the results of research carried out by the solar energy group at Universiti Kebangsaan Malaysia (Mufadal, 2003; El-radi, 2001; Salah, 2004 and Nazri *et. al.,* 2003). These parameters are presented in Table 1 and the specifications of solar system are shown in Table 2. The results of all projects showed that the global solar radiation incident on solar collector during the day had large fluctuations in solar irradiance, but it increased in the morning from 9:00 am. to 11:00 am with peak point at 1:00 pm and started to decrease after that time. The intensity of solar radiation is measured by means of a pyranometer. The ambient temperature was fairly uniform with an average of about 33°C. Figures 2a - 2c illustrate the researchers' investigation in the solar radiation, such as mass flow rate, solar radiation and output temperature.

Table 1. Parameters affecting solar drying projects in Malaysia

Researcher	Objectives	Parameters
Mufadal (2003)	Evaluation of the performance of the photovoltaic assisted V-groove with single pass solar collector for drying of sliced papaya under humid condition.	• Air flow • Temperature • Global solar radiation • Relative humidity • Moisture content
El-radi (2001)	Determine the performance of double-pass solar air collector with porous media in lower channel	• Solar radiation • Porosity • Mass flow rate • Temperature rise
Salah (2004)	Determine drying bin performance of V- groove forced convective solar dryer	• Solar radiation • Output temperature of the collector • Air flow • Energy input to the collector • Heat loss from the chamber
Nazri *et. al.* (2003)	Design of double pass photovoltaic thermal solar collector to be used in drying system	• Mass flow rate • Solar radiation • Distance between absorber and cover • Output temperature

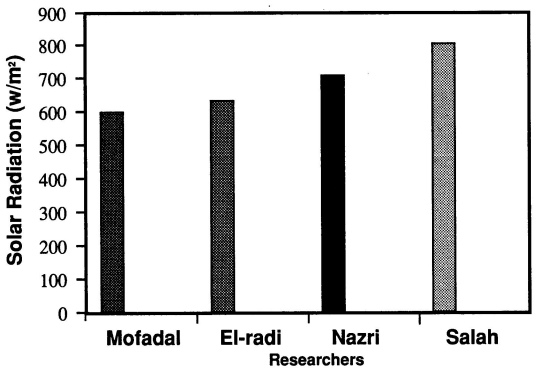
EXPERT SYSTEM APPROACH

From the above parameters, a prototype internet based computer programme was developed in the current study to support the design of flat plate collector used for drying agricultural products in Malaysia. Dream weaver combined with the Active Server Pages (ASP) as an extension environment was chosen as the development software tool. The programmatic code was written by VBScript as scripting language to execute commands on a computer. In order to represent the knowledge for design, rules have been used where rule-based programming is one of the most commonly used techniques for developing expert systems. It is composed of "IF hypothesis THEN conclusion" (Omar and Azlan, 1996). The knowledge base contains two different databases, static and dynamic one. The static database contains the knowledge about the domain, represented in certain formalism. It is created once, when the system is being developed. The dynamic database is enriched during each execution of the programme but the information is lost when the execution is terminated. The required data are classified into three groups.

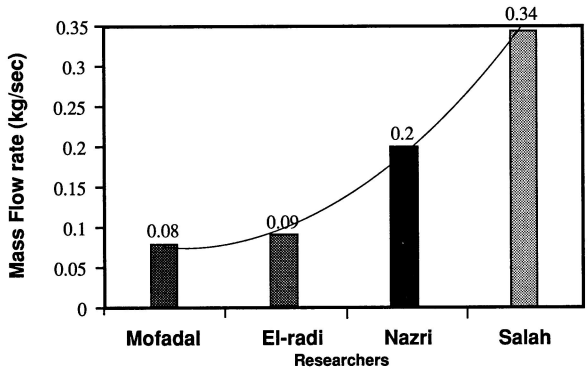
Table 2. Specifications of solar system

System Components	**Specifications**			
Researcher	**Mufadal (2003)**	**El-radi (2001)**	**Salah (2004)**	**Nazri *et. al.* (2003)**
Collector				
Tilt angle	10° facing sun	Local latitude + 10°	10°	10° facing sun (south)
Type of absorber	V-groove single pass	Double pass	V-groove back pass	Double pass PV/T collector
Absorber plate	Folded aluminum sheet SWG22	Black painted mild steel of 0.8 mm thickness ($\alpha = 0.9$)	Folded aluminum sheet SWG22: 244 cm x 112 cm	Aluminum of 0.2 mm thickness paint flat black
Angle of groove	29° and height 7.8 cm	----------	49° and height 7.8 cm	----------
Collector area	234 x 198 cm^2	120 x 240cm^2	100 x 460 cm^2	122 x 85.5 cm^2
Cover				
Material	Glass (one side tempered)	Ordinary glass ($\tau = 0.85$)	Glass (one side tempered)	Glass
Thickness	2.5 mm	3 mm	2.5 mm	5 mm
Insulation				
Material	Fibre glass wool	Fibre glass	Fibre glass wool	Glass wall
Thickness	2.5 cm and density 46 kg/m^3	5 cm	2.5 cm	5 cm

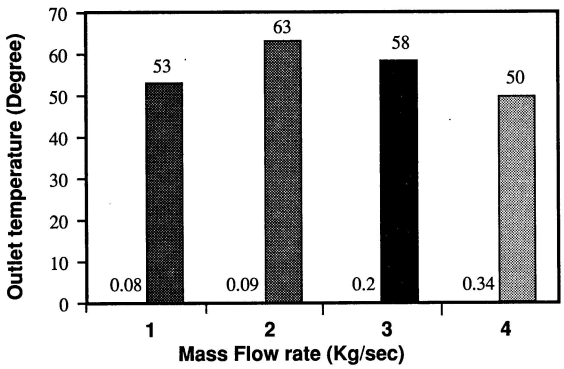
The first group is called general input data concerning the metrological condition (ambient temperature, global solar radiation and wind velocity), and the second group is called collector characteristics, which contains all specific manufacturing attributes related to the collector (collector dimensions tilt angle, absorber, cover and insulation characteristics). The third group is called energy characteristics, which contain measured data about inlet temperature and mass flow rate related to the transfer media inside the collector. All the data are related to the parameters, which are needed for the calculation of final useful energy and system thermal efficiency. Figure 3 shows the flow chart process for the developed prototype.



(2a)



(2b)



(2c)

Figure 2. *Experimental reports for*
(2a) researcher versus solar radiation;
(2b) researcher versus mass flow rate;
(2c) comparison between mass flow rate and outlet temperature.

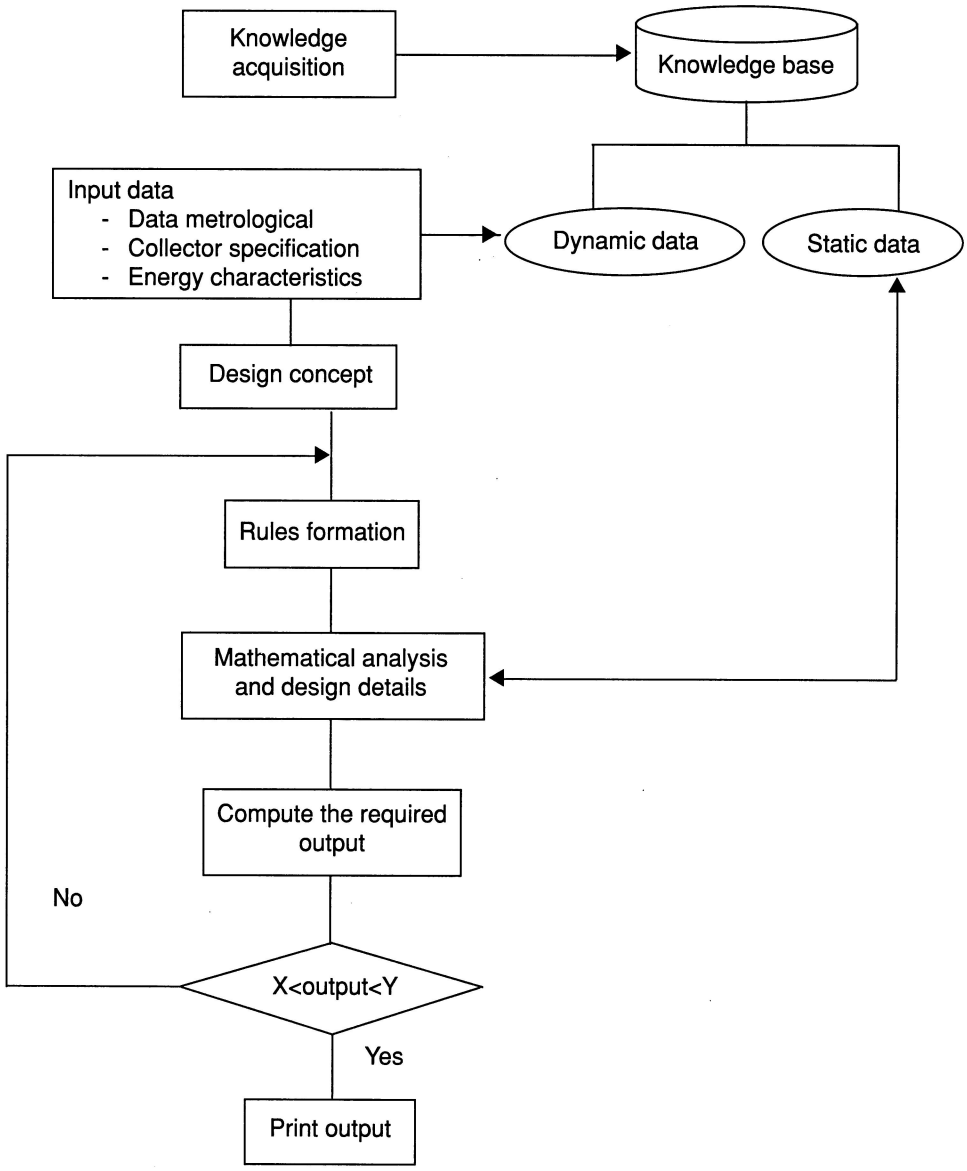


Figure 3. *Flow chart of the developed prototype*

CONCLUSION

The study conducted is a criterion of solar drying processes in Malaysia. All studies were concerned with utilisation of the abundant solar system which can dry several commodities in Malaysia. Some of these studies are the double pass solar air collector with porous media in lower channel and the solar drying system with double pass photovoltaic thermal solar collector which have achieved the maximum output temperature to be stabilised for purposes of drying. Studies also include V-groove single pass collector that could maintain the fluctuating temperature stability with controlled airflow. Since the attempt to develop simple solar drying systems for drying agricultural and forest products is an important issue, development of an expert system technique to help determine the thermal performance for a flat plat collector is presented. This system should be able to save time of design and give a detailed specification about the drying system according to chosen parameters with design rules that incorporate the human expertise in the field. The use of an internet based system makes the sharing of knowledge easier.

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