**. … … : MODEL DEVELOPMENT AND OPTIMIZATION … … PROCESS ……………..**

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# SOLAR ASSISTED … … : MODEL DEVELOPMENT AND OPTIMIZATION … … PROCESS HEAT APPLICATIONS

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# LIST OF SYMBOLS AND ABBREVIATIONS

|  |  |  |
| --- | --- | --- |
| **Symbols:** | | |
|  | | |
| *Aa* | : | Absorber area (m2) |
| *Ap* | : | Aperature area (m2) |
| *cp* | : | Specific heat at constant pressure (J/kg K) |
| *……………* |  |  |
|  |  |  |
|  |  |  |
| **Abbreviations:** | | |
|  |  |  |
| CPC | : | Compound parabolic collector |
| ETC | : | Eevacuated tube collectors |
| FPC | : | Flat plate collectors |
| GHG | : | Greenhouse Gases |
| HFC | : | Heliostat field collector |

# INTRODUCTION

The worldwide energy demand is growing day by day due to economic evolution and modernization …. …. projected to be large. Therefore, …. …. future large energy demands (Hosenuzzaman et al., 2015; R. Kumar & Rosen, 2011). Also, … …. and transformation in the industrial sector (Hasanuzzaman et al., 2012). The …… …. achieve a secure and sustainable energy future (Hosenuzzaman et al., 2015). It is also …. ….. … 2010 to 2030 and the consumption of fossil fuels … …. be increased in the future (Abdelaziz, Saidur, & Mekhilef, 2011). The energy utilized … …. energy in the industrial sector in around the globe is about 35% (L. Kumar, Hasanuzzaman, & Rahim, 2019).

Furthermore, most common process … …. consumes a major portion of energy. All …. …. processing food, dyeing, drying, pulp and paper processing, petroleum refining, etc. (Einstein, Worrell, & Khrushch, 2001; S. Kalogirou, 2003). Therefore, … …. major cause of climate change. The most important …. …. warming as stated by the Intergovernmental Panel on Climate Change (IPCC). Among all kinds of … … global warming is 76% (IPCC, 2014). In 2015, world energy-related CO2 emissions were 32.294 Gton with a percentage change of 57.5% from 1990 to 2015. The industrial sector … …. the total emissions (Agency, 2017).

…. …. ….

Solar PV systems are most popular technology … …. efficiency due to increase in cell temperature of module. On the other hand, Solar thermal (ST) systems are special kinds of energy converters …. ….. industries and various applications. But the main drawback of solar thermal technology is it cannot generate electricity. Consequently, the combination of solar PV and solar thermal (ST) …. drawback of PVT technology is it cannot give thermal … …. (Li, Zhong, Ma, Kazemian, & Gu, 2020; Nahar et al., 2019). Therefore, the novel concept of …. …. drawbacks of isolated STC and PVT.

## 1.1 Importance of the Proposed Research

…. ….. …..

## 1.2 Research Gaps

Industrial process heating is one of biggest energy intensive sector, …. .

Careful and subtle scrutiny of the information gatherd from literatute reveals the following research gaps in the pertinent field:

1. Although there are different types … … but efficient thermal energy … … is still a quandary.
2. No customized configuration … …
3. Optimized and well-engineered integration … … is a still a challenge.

## 1.3 Problem Statement

A range of studies regarding the potential of using … …. ire industry or individual processes. Also, feasibility analysis of the integration …. heating (IPH) is still a challenge. The following problems have been identified in the present research work:

## 1.4 Research Questions

In order to address the problem statement as mentioned it is split into the following specific research questions:

1. What are the major …. ….. requirement?
2. How to stanchly portray the … … IPH applications?
3. What would be optimized configuration, …. … thermal energy?
4. …. ?
5. ….. ?

Table 1: Link between the research problem, research questions, and research objectives

|  |  |  |
| --- | --- | --- |
| **Research Problem** | **Research Questions (RQ)** | **Research Objectives (RO)** |
| What interventions …. heat supply for low to meduim … …. applications? | RQ 1 | RO 1 |
| RQ 2 | RO 2 |
| RQ 3 | RO 3 |
| RQ 4 | RO 4 |
| RQ 5 | RO 5 |

## 1.5 Research Objectives

Based on the research questions as mention above, the following objectives have been set for the present research:

1. To assess thermal … … technology that best meet the requirement.
2. To develop a dynamic simulation model ….
3. To validate the model … ….
4. To evaluate the performance … ….
5. To optimize …. ….

## 1.6 Scope of the Research

The aim of the present research proposal is to develop a …. …. enhanced thermal and electrical efficiency. In order to accomplish this aim, the following scopes of work have been set:

1. Different industrial processes … …. processes will be produced.
2. Solar thermal … …. apt solar themal technology.
3. Dynamic simulation models ….
4. Experimental investigation with the fabricated … ...
5. Thermodynamic performance … …. energy and exergy analysis.
6. Economic merit and environmental ….
7. A practicable integration scheme … ….

# 2. METHODOLOGY

The research methodology adopted in the present research is a combination of simulation and experimental investigation. The major research activities have been discussed in subsequent sections.

## 2.1 Modeling Development and Simulation

The concept of integrated solar assisted heating system …. ….. Figures 2 illustrates the block diagram of the TRNSYS model.

**Figure 2:** TRNSYS model flow diagram

## 2.2 Experimental Investigation and Validation

The integrated solar assisted heating system comprises …. . In this section, description of the experimental setup is discussed in detail. The experimental setup (Figure 4) has an …. …. . As indicated in the figure, the intended experimental setup consisted of six main components: (1) …. (2) …. (3) …. (4) …. (5) …. (6) …. The physical characteristics of collectors are given in Table 4.

The experimental setup consisted of six main components for instrumentation and data logging: (1) Auxiliary energy logger (Model No. EL 4000) that records the energy consumption of the connected equipment (Logger, 2019). (2) Data Taker (Model No. DT80) is universal input data logger that connects the range of sensors through the multiple channels (Tracker, 2019). (3) Pyranometer (4) Flow meter (Model No. GARDENA 8188-20)(Gardena, 2019). (5) Temperature sensors (6) Micro Weather Station (Brand: HOBO) for measuring and recording data at a definite time interval. The ranges and accuracy of the instruments are given in Table 5.

**Table 4:** Physical characteristics of the FPC, HPETC and PVT

|  |  |  |
| --- | --- | --- |
| **Collector** | **Characteristics** | |
| Flat-plate collector (FPC) | Number of copper riser tubes  Tube outer diameter  Absorber Area  Intercept efficiency (*a0*)  Efficiency slope (*a1*)  Efficiency curvature (*a2*)  Glass transmittance  Absorber plate absorptance  Absorber plate emittance  Maximum operating temperature  Maximum operating pressure | 10  ... m  ...  m2  ~76%  3.70  0.015 W/m2. K  ~90%  ~94-95%  ~5-6%  130°C  1000 kPa |
| Evacuated tube collector with heat pipes (HPETC) | Number of glass tubes with heat pipe | 10 |
| Glass Material  Outer tube diameter  Inner tube diameter  Heat pipe inner diameter  Heat pipe inner diameter | Borosilicate  .... m  .... m  .... m  .... m |
| Aperture area  Gross area | ....  m2  ....  m2 |
| Intercept efficiency (*a0*) | ~ 82% |
| Negative of the first-order efficiency coefficient (*a1*) | 2.19 |
| Negative of the second-order efficiency coefficient (*a2*) | 0.01 W/m2. K |
| Glass transmittance | ~ 95% |
| Absorber plate absorptance | ~ 95% |
| Absorber plate emittance | ~ 5.0% |
| Maximum operating pressure | .... kPa |
| Photovoltaic thermal collector (PVT) | Collection Area | .... m2 |
| Rated power output | 100 W |
| Module efficiency | 14.9% |
| Maximum voltage (*Vmax*)and current (*Imax*) | 18 V and 5.56 A |
| Open-circuit voltage (*Voc*) and Short-circuit current (*Isc*) | 22 V and 6.06 A |

**Table 5:** Ranges and accuracy of the Instruments and Sensors

|  |  |  |
| --- | --- | --- |
| **Instrument** | **Measuring Range** | **Accuracy** |
| Data Logger (Model: DataTaker DT80) | - 270 to 1372°C | ±2% |
| Pyranometer | 0 to 2000 W/m2 | ±5% |
| Digital Flow meter | 0.5 to 30 LPM | ±0.5 |
| Thermocouple (K-Type) | -200 to 1000°C | ±5% |

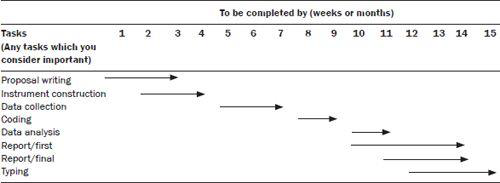
The experimental system was installed on the Solar Garden, UM Power Energy Dedicated Advances Center (UMPEDAC), University of Malaya, Kuala Lumpur, Malaysia. Experiments were performed from 8.30 am to 4.30 pm during days of almost similar ambient conditions for a period of 05 months logging data in 15 seconds intervals. The auxiliary water heater could vary the water temperature as per the requirement. Solar thermal collector and PVT panels were mounted on metallic structure held at an optimum angle for maximum radiations through the day.

# 3. Cost Estimate

(Give a cost estimate of the project in a table with detail break down and justification of the expense)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Name and specification** | **Quantity** | **Unit price**  **(BDT)** | **Total price**  **(BDT)** | **Remarks** |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

# 4. Work Schedule



# References

Emission reduction

Payback period

Bill Saving

Energy Saving