EXPERIMENTAL VERIFICATION OF CHARGING AND DISCHARGING PROPERTIES OF A PACKED BED HEAT RESERVOIR FOR SPACE HEATING

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AIM OF THE PROJECT

To better utilize solar energy and design an efficient system which can use it for space heating and eventually reduce the energy imprint of fossil fuels and their adverse effect on environment

OBJECTIVES

To determine a suitable material to act as thermal reservoir

To determine the optimum mass flow rate for the system.

Calculate optimum timing for working condition.

Variation of charging and discharging characteristics with bed parameters.

INTRODUCTION

ENERGY STORAGE METHODS:

- Mechanical Energy Storage
- Electrical Energy Storage
- Chemical Energy Storage
- Biological Energy Storage
- Thermal Energy Storage

THERMAL ENERGY STORAGE

- Sensible Heat Energy Storage
- Latent Heat Energy Storage
- Thermochemical Energy Storage

WHY PACKED BED HEAT RESERVOIR ?

- Freedom in choice of storing material
- Applicability in a wide temperature range, with limiting temperatures given by the material's melting point
- Direct heat transfer between working fluid and storage material
- No degradation or chemical instability
- No safety concerns
- Elimination of chemicals and corrosive materials

LITERATURE SURVEY

Author	Analysis	Investigation	Material Used	Results
Furnas, (1930)	Experimental Analysis of heat transfer in bed.	Heat transfer Coefficient, relation with different velocity	Broken solid bed-Fluid	Varies along velocity.
Lof and Hawley, (1948)	Determined the heat transfer coefficient in packed bed.	Heat transfer Coefficient, Mass flow rate	Granite gravels-Fluid	Heat transfer coefficient increases.
Littman et al., (1968)	Heat transfer study for low range of Reynolds number in packed bed.	Heat transfer Coefficient and Nusselt number Ranges	Rocks-Fluid	H = 6 - 99.2 and Nu = 2 – 6
Farber, (1982)	Numerical approach of Heat transfer process in packed bed.	Heat transfer process hv = 700. (G/dp)0.75	Rocks-Fluid	Heat transfer coefficient increases
Ismail and Stuginsky, (1999)	Parametric study on fixed packed bed model.	Parameters, Pressure drop and Heat transfer	PCM and heat storage material	Heat transfer coefficient increases

LITERATURE SURVEY

Lof et al., (1963)	**Designed an air heating system.**	**Reliability**	**Rocks-Fluid**	**Operate reliably over many years with little maintenance.**
Garg et al., (1990)	**Investigation of rock bed solar collector.**	**Constructing collector consists of rocks.**	**Rocks-Fluid**	**Satisfactory overall efficiency.**
Audi, (1991)	**Experimental study of a solar space heating model.**	**Fulfill energy demand for 220 m2 floor area**	**Jordanian rocks,tar sand Zeolite**	**An alternative to traditional packed bed system.**
Hughes et al., (1976)	**Storage models for solar air heating and cooling systems.**	**Storage size, Mass flow rate**	**Gravels-fluid**	**Values of NTU greater than ten, Insensitive the mass flow rate.**
Chandra and Willits, (1981)	Pressure drop and heat transfer characteristics of air.	Pressure drop and heat transfer inside the bed.	Rocks-Fluid	Depend upon the rock size , air flow rate and bed porosity.
Sanderson, (1995)	Construct a Vertical packed bed system. .	Thermal Behavior, Packing	Polyethylene spheres	Thermally Short packing were provided more energy storage capacity.

LITERATURE SURVEY

Mocker et al., (2012)	**Design a Pebble bed Regenerator.**	**Energy Balance for CHP**	**Rocks-Fluid**	**Waste fuel Recovery, Reliability**
Steinhagen et al., (2013)	Create a model for packed bed for high applications.	Thermo Mechanical Behavior	Rocks-Fluid	Thermally stable, feasible
Saxena et al., (2013)	Design a solar air heater for low and moderate temperature.	Thermal Performance	Rocks-Fluid	Thermally stable, feasible
Steinfeld et al., (2011)	Create a Heat Transfer model.	Charging and Discharging Characteristic	Rocks-Fluid	Charging efficiency decreases with increase in mass flow rate

LITERATURE SURVEY

Steinfeld et al.,(2012)	Packed-bed thermal storage for concentrated solar power	Formation of a dynamic numerical storage system with separate fluid and solid phases	unit yields 95% overall thermalefficiency
Aydin et al., (2014)	Recent advancements in Heat storage Systems	Comparison on thermodynamic properties of various materials	Concrete and Calcium Chlorideidentified as promising materials
Kaushik and Gupta et al., (2016)	Packed-Bed with Clay and waste Rubber	Experimentation with different mass flow rates and temperatures	Ideal Mass flow rates and Temperature for Packed bed identified

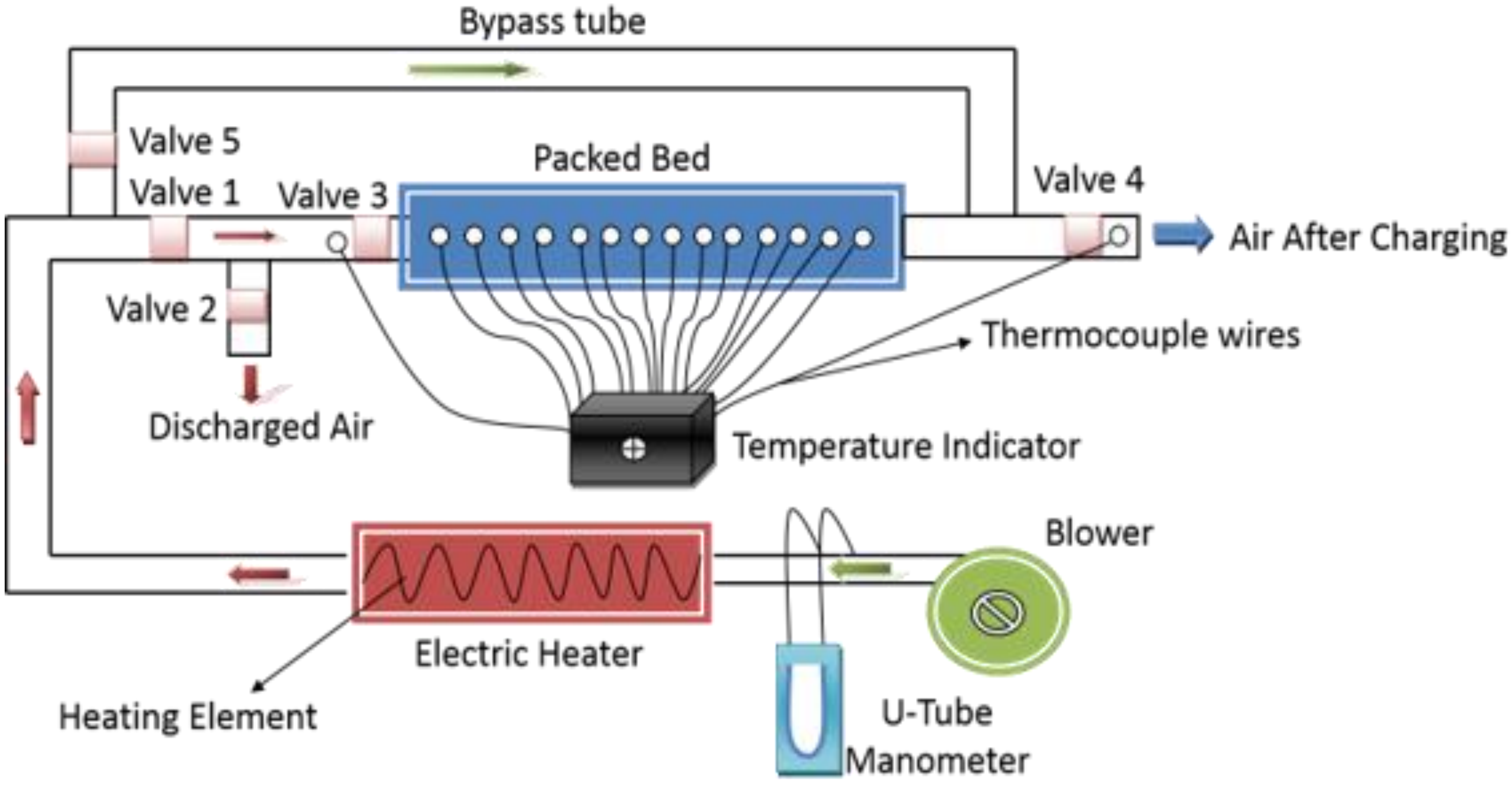
SUMMARY OF LITERATURE SURVEY

- Previous studies identify Packed Bed as the most suitable and economical heat storage solution for commercial purpose
- Various Materials have been tested with Packed Bed heat storage systems including but not limited to clay, rocks, rubber, plastic, marble etc.
- A material suitable for commercialization of this system is still far from reach and there is a large room for improvement and a huge potential for growth

SUMMARY OF LITERATURE SURVEY

- Following Materials have been identified through the survey

Energy Storage Type	Material	Density (Kg/m3)	Specific Heat Capacity (KJ/kg)	Latent Heat of Fusion (KJ/Kg)	Reaction Enthalpy (KJ/Kg)
	Rock	2240	0.9	-	-
	Sandstone	2200	0.71	-	-
Sensible	Brick	1600	0.84	-	-
	Soil	1300	0.46	-	-
	Concrete	2240	1.13	-	-
	Teflon	**2200**	**1.4**	**-**	**-**
Latent	Paraffin Wax	1802	-	174.4	-
Thermochemical	CaCl2.H2O	2100	3.06	-	433.6
	Zeolite	650	1.07	-	1107
	Silica Gel	600	1.13	-	1380



EXPERIMENTAL SETUP

METHODOLOGY

- Building the piping framework which houses the Packed Bed Chamber
- Sealing of all potential leakage points
- Fabrication and Insulation of Heater
- Installation of thermocouples, flow meters, various measuring unit and heater on appratus
- Insulation of appratus