IJRAME
ISSN (ONLINE): 2321-3051

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

Experimental Analysis of Heat Transfer Enhancement through Porous Medium

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Abstract

Heat transfer is the basic phenomenon in thermal application. It plays a vital role in heating and cooling of the material and system as well as it is very important phenomenon in many of the thermal applications like internal combustion engine for its cooling and lubrication, Heat Exchanger to transmit the heat energy from one system to another in refrigeration, air conditioning etc., Heat transfer enhancement motivate to identify new technique and the material through which it can be improved.
Enhancement in heat transfer depends upon the various dimensionless parameters along with porosity of the porous material and its aspect ratio. It has been proven that the porous material can enhance the heat transfer rate. During the experimentation by the researchers it is observed that the to evaluate the heat transfer rate from the system and the result were quiet impressive to extend the study for further research.

Keywords: heat, porous material, dimensionless number, porosity.

1. Introduction

Comparative analysis of heat transfer on the basis of temperature variation. Evaluated the performance testing of heat transfer rate without using porous material and with using porous material i.e., aluminum chips.

1.1 Heat Transfer

Heat transfer is defined as transfer of heat from one body to another due to temperature gradient. The convective heat transfer is one mode of heat transfer from hot surface to surrounding between two fluids. It can be increase by increasing the surface area, heat transfer coefficient or temperature gradient. Enhancement occurs due to passage of fluid through the open, interconnected void structure; exposing the fluid to large internal surface area.

Vol.2 Issue.3,
March 2014.
Pgs: 135-145

Modes of Heat Transfer

Heat transfer is defined as transmission of energy from one region to another as a result of temperature gradient takes place by the following modes:

(i) Conduction *(ii)* Convection *(iii)* Radiation

1.2 POROSITY

A **porous medium** (or a **porous material**) is a material containing pores (voids). The skeletal portion of the material is often called the "matrix" or "frame". The pores are typically filled with a fluid (liquid or gas). Thus, it causes increase in heat transfer in the flow field. The skeletal material is usually a solid, but structures like foams are often also usefully analyzed using concept of porous media. Porous mediums have been identified as a means to reduce the thermal resistance at the gas/solid interface and enhance heat transfer rates. By using the porous medium as transport medium, fluid mixing and the heat exchange area between the solid matrix and fluid phase, flowing through the porous medium, increase and this leads to significant enhancement in heat transfer.

Porosity (ϕ) is defined as a ratio of pore volume (V_P) to bulk volume (V_B) of a reservoir rock.

$$\phi = \frac{V_P}{V_B}$$

$V_P = V_B - V_S$

Where is volume occupied by the solid grains of the rock. The pore spaces in reservoir rocks are most frequently the intergranular spaces between the sedimentary particles. The void space is microscopic in scale, rarely exceeding a few, or very few, tens of microns. The higher porosity, larger pore diameter foam layers produce the greatest enhancements in heat transfer. The porous medium with random porosities is used to enhance heat transfer and the random porosities Therefore, a porous medium with larger porosity and the proper bead diameter could provide more heat dissipation.

The porosity is one of the main parameters for studying porous media. Two major models are used to define the distribution of porosity in porous media for conveniently investigating the phenomena of thermal and flow fields. The one in which the porosity distributed in the porous medium is uniform is called the constant porosity model.

Variable porosity model : The one in which there is a variation in porosity and is assumed to be an exponential function of the distance from solid wall. Analysis shows that the porous material enhanced the heat transfer rate and also increases the efficiency over heat exchanger.

Examples of porous materials include: dry wall, wood, concrete, gunite, rubber, some plastic.

Porous media has a wide range of applications such as catalytic and inert packed bed reactors, enhancing drying efficiency such as food drying, filtering, geothermal energy management and harvesting, insulation, lubrication.

2. Specification Of Experimental Set Up

S.N.	Elements	Description
1	Aluminum block	Dimension= 120 *50*150 mm Thickness of Aluminum Sheet = 3 mm
2	Bakelite	Thickness of Bakelite Sheet = 4mm
3	Heater	Capacity of Heater =1000 W
4	Digital Thermometer	Temp. Range = - 50 ˚C to 70 ˚C.
5	Water pump	Capacity of water pump = 0.2 hp
6	Digital temp. indicator	Temp. Range = -200 ˚ C to 800 ˚C
7	Down Flow Radiator	No. tubes=10, length=30 cm, OD = 3mm, ID= 2mm, pitch =1.5 cm

The setup consists of basic elements as-

a) Aluminum rectangular model
b) Heater
c) Bakelite material (Insulator)
d) Water pump
e) Down Flow Radiator
f) Temperature indicator and Digital thermometer

2.1 Experimental Set Up

Figure 1: Experimental Setup

2.2 Experimental Procedure

The steps carried out for experimentation are as follows :

a) Fill up the tank with fresh water.
b) Make the proper connection and put the main Switch on.
c) Put knob 1 on which makes temperature indicator shows some reading
d) Put on switch 2 which makes the water circulating through the system right from tank to via. Aluminum block and radiator and return back to the tank again and also start the radiator fan.
e) Now adjust the heater by regulator 2 at some specific watt.
f) Now the water from the tank goes the heat making water warm and then circulate towards radiator here we note the temperature T_1, T_2, resp. T_1 is temperature at inlet and T_2 outlet of the aluminum block with the help of thermocouple at regular interval of time for 200 watt.
g) Here note surface temperature of aluminum block i.e., $T_{s.}$
h) Now warm water flow through radiator to dissipate the heat.
i) By flowing through no. of coils and radiator fan fitted back and the coil blows the air on tubes which makes dissipate the heat from water to temperature i.e, Ta and T_b resp.
   Ta is the temperature at the back of radiator fan.
   T_b is the temperature at the front of radiator.

j) Now the cold water recirculate to back to the tank.
k) Now same above procedure is repeat again by inserting porous material i.e., Aluminum chips is in specific proportion i.e., 50 gm. For the same coil watt.

3. Testing and Experimentation

3.3.1 Testing of experimental set up without porous material with input 200 W

In this table after every five minute of time interval the temperature like T_1, T_2, T_s, T_a T_b, T_{ro}, is note down. On the basis of that the heat gain by water **(**Q = $mC_p\Delta T$) heat transfer coefficient and Nusselt number is calculated.

Table 1: Testing of experimental set up without porous material input at 200 W

Time interval (min.)	**Inlet temp (T_1) ℃**	**Outlet temp. (T_2) ℃**	**Surface temp. (T_s) ℃**	**Radiator temp. air in (T_a) ℃**	**Radiator temp. air out (T_b) ℃**	**Radiator water outlet temp. (T_{ro}) ℃**	**Heat gain by water Q = $mC_p\Delta T$ Watt**	**Heat transfer coefficient h (w/m^{2}k)**	**Nusselt no. N_u**	**Q' = hAsΔT Watt**
5	26.8	27.2	43	27	27.8	25.4	29.74	46.61592	3.694451	53.00197
10	27	27.5	49	27	27.8	25.4	37.18	48.00307	3.780064	66.161
15	27.1	27.9	56	27	27.9	25.5	59.49	50.20056	3.899598	86.9714
20	27.3	28.3	63	27	27.9	25.6	79.57	50.95605	3.924479	108.3764
25	27.5	28.7	70	27	27.9	25.7	91.47	52.94101	4.046497	129.941
30	27.7	28.9	75	27	27.9	25.8	93.70	52.16201	3.958199	145.6216
35	27.8	29.2	81	27.1	27.9	25.9	107.09	49.93177	3.762391	164.4119
40	28	29.8	86	27.1	28	26	139. 06	54.33709	4.082153	179.174
45	28.4	30.4	90	27.2	28	26.1	150.22	54.69079	4.088047	191.4802
50	28.7	30.9	94	27.2	28	26.2	169.55	59.14945	4.405024	203.478
55	29.1	31.5	99	27.2	28	26.3	181.45	65.66323	4.872162	218.2281
60	29.4	32	105	27.2	28	26.5	198.56	67.72895	5.017327	236.707
65	29.6	32.8	110	27.2	28	26.7	244.67	69.85127	5.166211	251.9114
70	29.9	33.6	114	27.2	28	26.9	257.31	75.51279	5.576770	263.9613
75	30	34.1	119	27.2	28	27	309.37	78.65759	5.798844	287.9571

3.3.2 Testing of experimental set up without porous material with input 200 W

On the basis of temperature like T_1,T_2,T_s and area, perimeter of Aluminum block we calculated Re, P_r, Nusselt no. N_u.

Table 2: Testing of experimental set up without porous material input at 200 W

T_f	**D_h**	**k**	**u**	**ν**	**T_b**	**Re = (u D_h)/ν**	**P_r**	**h_t**	**Nusselt no. N_u**
47.825	0.0505	0.6372	0.00268	0.000000582	27.65	232.5429553	3.85	71.59645	5.853961073
53.2	0.0505	0.6413	0.00268	0.000000538	28.4	251.5613383	3.49	71.93642	5.851071128
59.025	0.0505	0.6501	0.00268	0.000000485	29.05	279.0515464	3.09	72.81103	5.824157757
65.325	0.0505	0.6557	0.00268	0.000000449	29.65	301.4253898	2.82	73.34829	5.840928328
71.55	0.0505	0.6607	0.00268	0.000000415	30.1	326.1204819	2.56	73.79389	5.837265529
76.325	0.0505	0.6655	0.00268	0.000000387	30.65	349.7157623	2.39	74.33725	5.838223434

82.525	0.0505	0.6702	0.00268	0.000000355	31.05	381.2394366	2.15	74.7373	5.834276275
85.775	0.0505	0.6722	0.00268	0.000000344	31.55	393.4302326	2.08	74.94992	5.823351096
91.575	0.0505	0.6756	0.00268	0.000000327	32.15	413.883792	1.94	75.20669	5.833273649
96.4	0.0505	0.6781	0.00268	0.00000031	32.8	436.5806452	1.84	75.488	5.837735755
101.375	0.0505	0.6806	0.00268	0.000000291	33.75	465.0859107	1.73	75.7767	5.825821239
105.725	0.0505	0.6817	0.00268	0.000000281	34.45	481.6370107	1.65	75.81888	5.820662211
110.6	0.0505	0.6828	0.00268	0.00000027	35.2	501.2592593	1.58	75.91903	5.821333211
115.125	0.0505	0.6838	0.00268	0.000000258	36.25	524.5736434	1.52	760741	5.821011821
120.1	0.0505	0.685	0.00268	0.000000247	37.2	547.9352227	1.44	76.16631	5.816523024

3.3.3 Testing of experimental set up with porous material with input 200 W at 50 gm chips

In this table after every five minute of time interval the temperature like T_1, T_2, T_s, T_a T_b, T_{ro}, is note down. On the basis of that the heat gain by water **(**$Q = mC_p\Delta T$) heat transfer coefficient and Nusselt number is calculated.

Table 3: Testing of experimental set up with porous at 50 gm chips with material input at 200W

Time interval (min.)	**Inlet temp. (T_1) ℃**	**Outlet temp. (T_2) ℃**	**Surface temp. (T_s) ℃**	**Radiator temp. air in (T_a) ℃**	**Radiator temp. air out (T_b) ℃**	**Radiator Water outlet temp. (T_{ro}) ℃**	**Heat gain by water $Q = mC_p\Delta T$ Watt**	**Heat transfer coefficient h (w/m^{2}k)**	**Nusselt no. N_u**	**Q'= hAs (ts-tb)**
5	27.2	28.2	44	27	28	26	60.17	87.89074	7.14041558	48.502
10	27.4	28.5	51	27	28	26.1	66.19	68.37104	5.50939416	69.028
15	27.9	29.6	57	27	28	26.1	102.3	86.21997	6.89814436	85.044
20	28.1	29.9	65	27	28	26.2	108.31	71.6336	5.68967708	109.11
25	28.5	30.4	72	27	28	26.3	114.33	63.97516	5.03780655	130.29
30	28.9	31.2	77	27	28	26.4	138.40	70.18611	5.50885732	143.94
35	29.3	32.1	81	27	28	26.6	168.47	79.74534	6.22817745	155.07
40	29.7	32.9	87	27	28	26.7	192.51	82.29033	6.39234226	172.28
45	30	33.7	93	27.1	28	26.9	222	86.4385	6.68680186	190.19
50	30.4	34.4	97	27.1	28	27	240.7	88.71443	6.83981507	201.46
55	30.9	35.2	103	27.1	28	27.2	258.7	88.05609	6.75707760	218.54
60	31.2	35.9	108	27.1	28	27.4	282.8	90.44101	6.91801135	233.57
65	31.6	36.7	113	27.1	28	27.5	306.9	92.67144	7.05655548	248.41
70	31.9	37.2	118	27.1	28	27.7	318.4	90.84425	6.89351533	263.52
75	32.3	38	122	27.1	28	28	343	94.03186	7.11508647	275.04

3.3.4 Testing of experimental set up with porous material with input 200 W at 50 gm chips

On the basis of temperature like T_1,T_2,T_s and area, perimeter of Aluminum block we calculated Re, P_r, Nusselt no. N_u.

Table 4: Testing of experimental set up with porous material at 50 gm chips with input at 200 Watt

T_f	**D_h**	**k**	**u**	**ν**	**T_b**	**P_r**	**Re = (uD_h)/ν**	**h_t**	**N_u**
34.35	0.0505	0.6216	0.00306	0.000000728	27.7	4.98	212.2664835	70.84788	5.75582005
39.475	0.0505	0.6267	0.00306	0.00000067	27.95	4.49	230.641791	71.30283	5.745640252

42.875	0.0505	0.6312	0.00306	0.000000647	28.75	4.24	238.8408037	71.67676	5.734594797
47	0.0505	0.6358	0.00306	0.000000592	29	3.86	261.0304054	72.16772	5.732100787
50.725	0.0505	0.6413	0.00306	0.000000554	29.45	3.68	278.9350181	72.90852	5.74127606
53.525	0.0505	0.6434	0.00306	0.000000538	30.05	3.49	287.2304833	72.99823	5.72957821
55.85	0.0505	0.6466	0.00306	0.000000513	30.7	3.35	301.2280702	73.40321	5.7328523
59.15	0.0505	0.6501	0.00306	0.000000485	31.3	3.09	318.6185567	73.64419	5.72070679
62.425	0.0505	0.6528	0.00306	0.00000046	31.85	2.98	335.9347826	74.05615	5.728914777
64.7	0.0505	0.655	0.00306	0.000000445	32.4	2.86	347.258427	74.25495	5.724999719
68.025	0.0505	0.6581	0.00306	0.000000433	33.05	2.69	356.8822171	74.38906	5.708322931
70.775	0.0505	0.6602	0.00306	0.000000417	33.55	2.62	370.5755396	74.69882	5.713859907
73.575	0.0505	0.6632	0.00306	0.000000398	34.15	2.49	388.2663317	75.01081	5.711770113
76.275	0.0505	0.6655	0.00306	0.000000387	34.55	2.39	399.3023256	75.18719	5.705413799
78.575	0.0505	0.6674	0.00306	0.000000374	35.15	2.31	413.1818182	75.40264	5.705474098

3.3.5 Testing of experimental set up without porous material with input at 400 Watt.

In this table after every five minute of time interval the temperature like T_1, T_2, T_s, T_a T_b, T_{ro}, is note down. On the basis of that the heat gain by water **(**Q = $mC_p\Delta T$) heat transfer coefficient and Nusselt number is calculated.

Table 5 : Testing of experimental set up without porous material with input at 400 Watt

Time interval (min.)	**Inlet temp. (T_1) ℃**	**Outlet temp. (T_2) ℃**	**Surface temp. (T_s) ℃**	**Radiator temp. air in (T_a) ℃**	**Radiator temp. air out (T_b) ℃**	**Radiator outlet temp. (T_{ro}) ℃**	**Heat gain by water Q = $mC_p\Delta T$ Watt**	**Heat transfer coefficient h (w/m²k)**	**Nusselt no. N_u**	**Q'=hA_s (T_s-T_b)**
5	27	27.5	54	26.8	27.6	25.3	37.18	33.09301	2.657756	81.7562
10	27.3	27.9	65	26.8	27.6	25.4	44.62	28.40591	2.261189	115.239
15	27.6	28.6	76	26.8	27.7	25.5	74.36	36.96192	2.906536	149.443
20	28	29.1	88	26.8	27.7	25.7	89.29	35.76034	2.782584	186.811
25	28.4	29.7	101	26.8	27.7	25.9	96.67	31.98981	2.464133	228.273
30	28.7	30.2	114	26.8	27.8	26	111.55	31.4128	2.401009	270.097
35	29	30.8	127	26.8	27.8	26	133.86	32.8233	2.485123	312.753
40	29.3	31.4	136	26.8	27.8	26.2	156.17	35.19483	2.651557	341.523
45	29.6	31.8	145	26.8	27.8	26.3	163.61	34.08116	2.557353	371.301
50	30	32.4	153	26.8	27.8	26.5	178.04	34.80335	2.600724	396.944
55	30.4	33	161	26.8	27.8	26.7	193.35	35.6038	2.651906	422.174
60	30.7	33.6	169	26.9	27.8	26.9	223.1	38.81553	2.880929	448.427
65	30.9	34.3	176	26.9	27.8	27.1	252.85	41.98213	3.111842	470.738
70	31.2	34.9	184	26.9	27.8	27.3	275.16	43.40132	3.212321	495.401
75	31.6	36	193	26.9	27.8	27.5	327.22	48.93814	3.617354	523.466

3.3.6 Testing of experimental set up with porous material with input at 400 Watt

On the basis of temperature like T_1,T_2,T_s and area, perimeter of Aluminum block we calculated Re, P_r, Nusselt no. N_u.

Table 6: Testing of experimental set up with porous material with input at 400 Watt

T_f	**D_h**	**K**	**u**	**T_b**	**v**	**Re = (uD_h)/v**	**P_r**	**h_t**	**N_u**
40.625	0.0505	0.6288	0.00378	27.25	0.000000657	290.5479	4.34	72.7692	5.844218473
46.3	0.0505	0.6344	0.00378	27.6	0.0000006	318.15	3.93	73.36332	5.839923741
52.05	0.0505	0.6422	0.00378	28.1	0.000000542	352.1956	3.56	74.28325	5.841333503

58.275	0.0505	0.649	0.00378	28.55	0.000000497	384.0845	3.14	74.81755	5.821704537
65.025	0.0505	0.6556	0.00378	29.05	0.000000449	425.1448	2.82	75.5397	5.818723317
71.725	0.0505	0.6607	0.00378	29.45	0.000000415	459.9759	2.58	76.06017	5.813589254
78.45	0.0505	0.667	0.00378	29.9	0.000000377	506.3395	2.31	76.68915	5.806299892
83.175	0.0505	0.6703	0.00378	30.35	0.000000353	540.7649	2.13	76.9664	5.798602696
87.85	0.0505	0.673	0.00378	30.7	0.000000333	573.2432	2.03	77.34484	5.803736114
92.1	0.0505	0.6758	0.00378	31.2	0.00000032	596.5313	1.93	77.59488	5.798374778
96.35	0.0505	0.678	0.00378	31.7	0.00000031	615.7742	1.84	77.73993	5.790363749
100.575	0.0505	0.6804	0.00378	32.15	0.000000293	651.5017	1.74	78.01862	5.790623384
104.3	0.0505	0.6813	0.00378	32.6	0.000000283	674.523	1.69	78.1594	5.793409191
108.525	0.0505	0.6823	0.00378	33.05	0.000000275	694.1455	1.61	78.14029	5.78350406
113.4	0.0505	0.6832	0.00378	33.8	0.000000263	725.8175	1.55	78.28821	5.786818929

3.3.7 Testing of experimental set up with porous material at 50 gm chips with input at 400 Watt

In this table after every five minute of time interval the temperature like T_1, T_2, T_s, T_a T_b, T_{ro}, is note down. On the basis of that the heat gain by water **(**$Q = mC_p\Delta T$) heat transfer coefficient and Nusselt number is calculated.

Table 7: Testing of experimental set up with porous material at 50 gm chips with input at 400 Watt

Time interval (min.)	**Inlet temp (T_1) ℃**	**Outlet temp. (T_2) ℃**	**Surface temp. (T_s) ℃**	**Radiator temp. air in (T_a) ℃**	**Radiator temp. air out (T_b) ℃**	**Radiator water outlet temp. (T_{ro}) ℃**	**Heat gain by water $Q = mC_p\Delta T$ Watt**	**Heat transfer coefficient h (w/m²k)**	**Nusselt no. N_u**	**Q'=hAs(t_s- t_b)**
5	26.8	27.8	55	27.1	27.9	25.1	66.19	56.89359	4.563415	83.0008
10	27	28.4	67	27.1	27.9	25.2	84.24	51.03599	4.05366	119.137
15	27.3	29.3	78	27.1	28	25.3	120.3	57.6315	4.525565	152.305
20	27.5	29.9	89	27.1	28	25.5	144.4	57.0165	4.429744	186.348
25	27.8	30.5	103	27.1	28	25.7	162.47	52.38095	4.029918	230.246
30	28	31.1	116	27.1	28	25.8	186.55	51.37845	3.914032	272.489
35	28.4	31.7	128	27.1	28	26	198	48.12951	3.639078	310.252
40	28.7	32.5	138	27.1	28	26.2	228	50.54536	3.803517	341.384
45	29	33.1	146	27.1	28	26.4	246	50.95383	3.855512	361.953
50	29.3	33.7	155	27.1	28	26.5	264	50.89647	3.800491	395.450
55	29.6	34.5	162	27.1	28	26.7	294	53.86687	4.00807	416.805
60	29.9	35.3	171	27.1	28	27	318	54.70685	4.059207	445.506
65	30.2	35.9	177	27.1	28	27.2	343	56.73266	4.203961	463.971
70	30.6	36.5	186	27.2	28	27.4	355	55.44363	4.10122	491.799
75	31.2	37.9	194	27.2	28	27.6	385	57.48929	4.247562	514.831

3.3.8 Testing of experimental set up with porous material at 50 gm chips with input at 400 Watt

On the basis of temperature like T_1,T_2,T_s and area, perimeter of Aluminum block we calculated Re, P_r, Nusselt no. N_u.

Table 7: Testing of experimental set up with porous material at 50 gm chips with input at 400 Watt

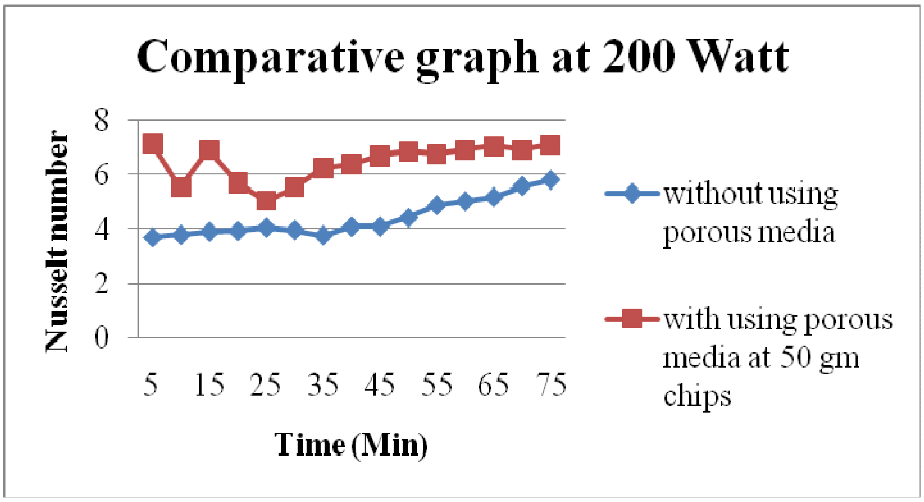
T_f	**D_h**	**K**	**u**	**ν**	**T_b**	**Re = (uD_h)/ν**	**P_r**	**h_t**	**N_u**
41.15	0.0505	0.6296	0.00306	0.000000671	27.3	230.2980626	4.29	71.34336	5.722426069

47.35	0.0505	0.6358	0.00306	0.000000591	27.7	261.4720812	3.86	72.17821	5.732934497
53.15	0.0505	0.6431	0.00306	0.000000538	28.3	287.2304833	3.49	72.96419	5.72957821
58.85	0.0505	0.65	0.00306	0.000000497	28.7	310.9255533	3.14	73.57978	5.716583114
66.075	0.0505	0.6564	0.00306	0.000000445	29.15	347.258427	2.78	74.23243	5.711056603
72.775	0.0505	0.6629	0.00306	0.0000004	29.55	386.325	2.53	75.04729	5.717134374
79.025	0.0505	0.6679	0.00306	0.00000037	30.05	417.6486486	2.27	75.41563	5.702184896
84.3	0.0505	0.6711	0.00306	0.000000349	30.6	442.7793696	2.11	75.68164	5.695012215
88.525	0.0505	0.6674	0.00306	3.462E-07	31.05	446.3604853	2	74.97128	5.672833978
93.25	0.0505	0.6763	0.00306	0.000000319	31.5	484.4200627	1.92	76.23872	5.692821834
97.025	0.0505	0.6787	0.00306	0.000000309	32.05	500.0970874	1.82	76.36735	5.682262188
101.8	0.0505	0.6806	0.00306	0.000000291	32.6	531.0309278	1.73	76.64228	5.686798816
105.025	0.0505	0.6815	0.00306	0.000000281	33.05	549.9288256	1.67	76.74146	5.686638207
109.775	0.0505	0.6827	0.00306	0.000000272	33.55	568.125	1.6	76.80891	5.6816317
114.275	0.0505	0.6835	0.00306	0.000000261	34.55	592.0689655	1.53	76.87614	5.679948665

4. Result And Discussion

4.4.1 The Graph on the variation in Nusselt number with time input at 200 W

The following graph is plotted between Nusselt number verses time at 200 Watt. The graph shows the comparison of Nusselt number between with and without porous material. On the basis of graph at 60 gm chips Nusselt number increases as compared to the without porous media and also at 50 gm chips.
It also concluded that for constant heat supply Nusselt number is increased for 60 gm chips



Graph 1: The variation in Nusselt number with time input at 200 W

4.4.2 The graph on the variation in Heat transfer with time input at 200 W

The following graph is plotted between heat transfer rate verses time at 200 Watt. The graph shows the comparison of heat transfer rate between with and without porous material. From the graph it has been concluded that the heat transfer rate is increased for 60 gm chips of porous media it increased by 68 % .It is also observed that as the porosity decreases the heat transfer rate is increases.

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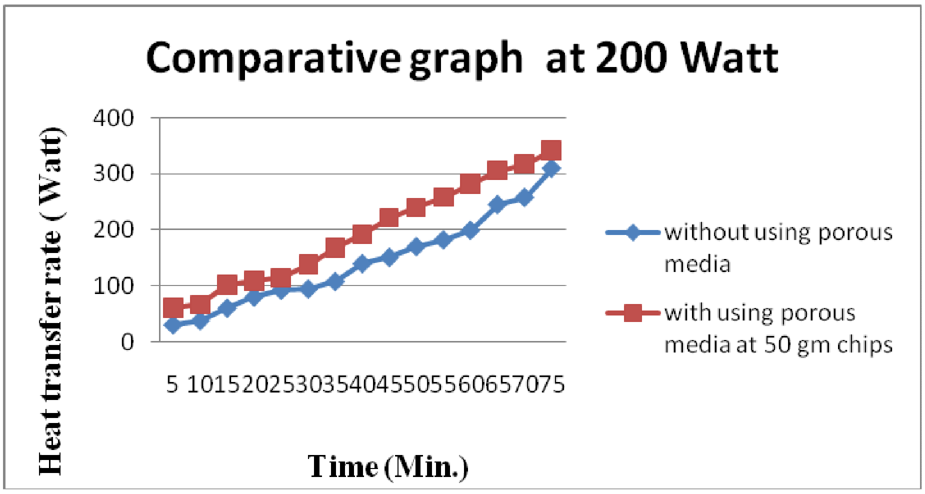
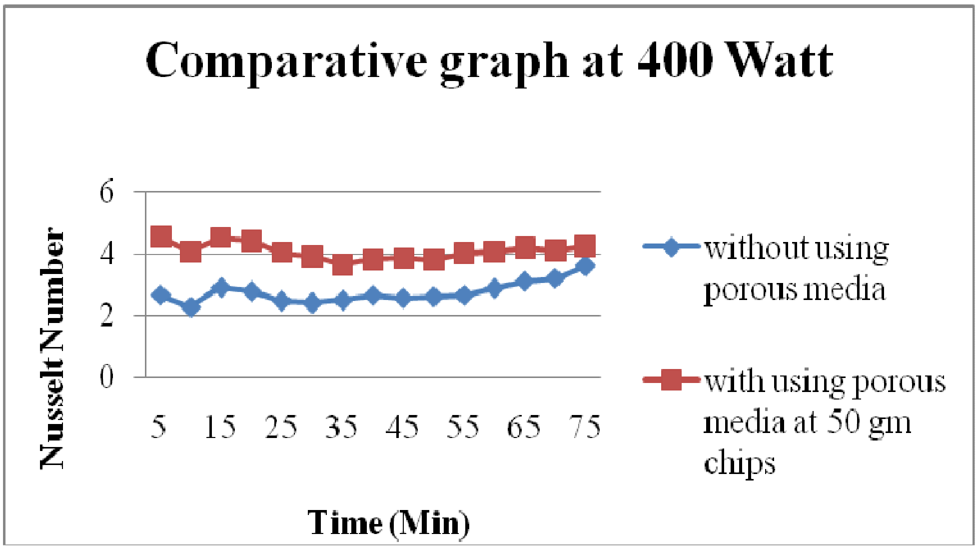


Graph 2: The variation in Heat transfer with time input at 200 W

4.4.3 Graph on the variation in Nusselt number with Time input at 400 W

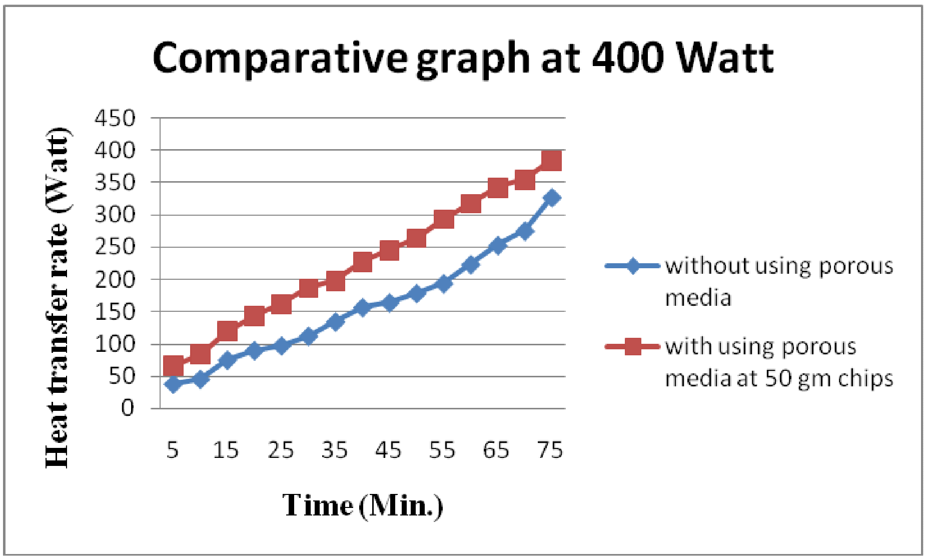
The following graph is plotted between Nusselt number verses time at 400 Watt. The graph shows the comparison of Nusselt number between with and without porous material. On the basis of graph at 60 gm chips Nusselt number increases as compared to the without porous media and also at 50 gm chips.It also concluded that for constant heat supply Nusselt number is increased for 60 gm chips.



Graph 3: The variation in Nusselt number with Time input at 400 W

4.4.4 Graph on the variation in Heat Transfer rate with Time input at 400 W

The following graph is plotted between heat transfer rate verses time at 400 Watt. The graph shows the comparison of heat transfer rate between with and without porous material. From the graph it has been concluded that the heat transfer rate is increased for 60 gm chips of porous media it increased by 71% .
It is also observed that as the porosity decreases the heat transfer rate is increases.



Graph 4: The variation in Heat Transfer rate with Time input at 400 W

5. CONCLUSIONS

On the basis of experimentation carried out on different temperature and different condition. It has been concluded that as the quantity of porous media increases the heat transfer rate will get increased. Overall conclusion is as follows.

i. Heat transfer rate at 200 W without using porous media is 309 Watt.
ii. Heat transfer rate at 400 W without using porous media is 327.22 Watt.
iii. Heat transfer rate at 200 W for 50 gm chips is 343 Watt.
iv. Heat transfer rate at 400 W for 50 gm chips is 385 Watt.

From the experimentation the heat transfer rate is more by using porous material as compare to the 50 gm chips of porous material and without porous material.

Heat transfer rate also govern by the maximum quantity of chips.

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