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The Effect of MWCNTs particles on the Heat Capacity of Distilled Water

Kheria M. Essa[1], Ahmad Khalile Ismail[1], Jamal M.Ali*[2]

[1]Ministry of Science and Technology, Baghdad, Iraq
[2]Technology University, Baghdad, Iraq

Abstract

The technique of adding Carbon Nano-Tubes to What liquids is a new important method used to enhance the thermal properties of liquids such as specific heat and heat capacity.
The experimental part was carried out using water-based nanoparticles such as Carbon Nano Tubes, with different concentrations at (0.1, 0.3, o.5and 0.7wt %) of MWCNT (Multi Wall Carbon Nanotubes) and distilled water as a base, in different temperatures. The change in the value of heat capacity of a liquid was investigated. The value of heat capacity for Nano fluids increased with increasing the Carbon NanoTubes particles,when as compared with the value of heat capacity for distilled water . The best concentration of MWCNTs was improved with heat capacity about 60 at 0.5 % wt% at temp. 50 c.

Keywords: Heat transfer _ MWCNTs_ Nanofluid_ Specific Heat

تاثير انابيب الكاربون المتعددة الجدران النانوية على السعه الحرارية للماء المقطر

خيرية مطر عيسى[1]، أحمد خليل اسماعيل[1]، جمال مانع الربيعي*[2]

[1]وزارة العلوم والتكنولوجيا، بغداد، العراق
[2]الجامعه التكنولوجية، بغداد، العراق

الخلاصة

تعتبر تقنية اضافة المواد النانوية الى هذه السوائل من اهم الطرق التي تستخدم في تحسين الخواص الحرارية للسوائل مثل السعه الحرارية والحرارة النوعية.نفذت التجارب باستخدام الموائع النانوية ذو الاساس المائي باستخدام الانابيب النانويه الكاربونية (Carbon Nano tubes) بتراكيز مختلفة (0.1,0.3,0.5,0.7%) وبنسب وزنية من الانابيب الكاربونية متعددة الجدران (MWCNTs) والمطعمة ب 0,1 من اوكسيد الحديد، والماء المقطر كقاعدة. وبدرجات حرارية مختلفة.لمعرفة التغيير الحاصل في قيمة الحرارة النوعية للسائل.

تمت مقارنة القيم الناتجه للحرارة النوعيه للسائل النانوي مع قيم الحرارة النوعية للماء النقي حيث اظهرت النتائج زيادة بتلك القيم وان هذه الزيادة تزداد مع زيادة تركيز الانابيب النانوية.
وقد لوحظ ان افضل تركيزتتحسن عنده السعة الحرارية للسائل النانوي كان عند(0.5 %)نسبة وزنيه من انابيب الكاربون المتعدد الجدران ،اذ وصلت نسبة التحسن الى60% مقارنة مع السعة الحرارية للموائع النانوية الاخرى عند تراكيز مختلفة وعند 50م^0 .

Introduction

More efficient heat transfer systems are increasingly preferred because of the accelerating, on the one hand, and increasing heat flux, on the other. In many industrial processes, including power generation,

*Email: jmal _ Ali2003@yahoo.com

chemical processes and heating or cooling processes, heat transfer fluids such as water, mineral oil, and ethylene glycol always play vital roles in these systems. [1]

The performance of any cooling or heating systems depends on some factors one of these is the heat transfer fluid which its heat transfer efficiency that depends on its thermal properties (thermal conductivity (K), heat capacity (c_p), viscosity (μ) and the thermal expansion coefficient.

The heat capacity of the heat transfer fluid is one of the most important characteristics of liquid for calculating the coefficient of heat transfer of these fluids in the air conditioning systems and power plants.

Heat capacity is defined as the ability of a liquid to store a quantity of heat and transfer it from one place to another and its unit of measurement is J\K.kg. An important way to improve the thermal properties of fluids, is using nanoparticles solid powders that is suspended in traditional fluids, to get new nanofluids that have higher thermal conductivities than those of the basefluid. A novel kind [2].

Nanofluids are fluids (such as water,oil,or any other liquid) that contains nanoparticles with dimensions in the nanometer scale between (1-100 nm). These nanofluids have higher thermal properties than the base fluids.

Nanofluids have some characteristics such as:-

1. Higher heat transfer rate between the particles and fluids due to the high surface area of the particles
2. Better dispersion stability with predominant Brownian motion which reduces particle clogging
3. Reduced pumping power as compared to the base fluid to obtain equivalent heat transfer, [3]

In 1995, nanofluids (liquids) were first used in Argonne National Laboratory USA (Choi) [4] to describe liquid suspensions containing nanoparticles with thermal conductivities, of orders of magnitudes higher than the base liquids, and with sizes significantly smaller than 100 nm.

J. A. Eastman, [5] showed that a Nano fluid consisting of Nano copper dispersed in ethylene glycol has a much higher effective thermal conductivity than either pure ethylene glycol or ethylene glycol containing the same volume fraction of dispersed oxide nanoparticles. The effective thermal conductivity of ethylene glycol is shown to have increased by up to 40% for a nanofluid consisting of ethylene glycol containing approximately 0.3% by volume of Cu nanoparticles of mean diameter <10 nm.

Li et al. [6] studied heat transfer of water-CuO nanofluids of different concentrations at (0.05% and 0.2% by weight) on copper plate. They observed a deterioration of heat transfer as compared to the base fluid of about 15%.

Wen and Ding [7] carried out an experimental investigation concerning the heat transfer of aqueous based alumina nanofluids. Systematic experiments were carried out to formulate stable aqueous based nanofluids containing γ-alumina nanoparticles (primary particle size 10–50 nm), and to investigate their heat transfer behavior under nucleate pool boiling conditions. The results showed that alumina nanofluids can significantly enhance boiling point.The heat transfer increase with increasing the nano particle weight concentration reaching 0% at weight ratio 1.25%.

Shin and Banerjee [8] obtained Nanomaterials by dispersing silica nanoparticles in eutectic salt mixtures. The synthesis protocol was varied to obtain different nanomaterial samples of the same composition. The synthesis protocols that led to agglomerated nanoparticles resulted in coarse powders (Type-A samples) and the protocols that led to (un-agglomerated) well dispersed nanoparticles resulted in fine grained powders (Type-B samples). Measurements using differential scanning calorimeters showed that the average heat capacity of the Type-A samples was enhanced by ~20 % (solid phase) and ~75 % (liquid phase); while that of Type-B samples was enhanced by ~34 % (solid phase) and ~100 % (liquid phase).

Ho and Pan. [9] looked for the optimal concentration of alumina nanoparticles in a molten ternary salt mixture. They obtain a specific heat capacity increase of about 20 % at a very small nanoparticle concentration.

Jo and Banerjee, [10], MWCNTs with different concentrations (0. 1, 0.5,1, and 5 wt%)were prepared. It was observed that the heat capacity was enhanced by doping with the nanotubes in both solid and liquid phase. It increased with increasing the MWCNTs concentration.

Experimental part

A schematic diagram of the experimental apparatus is shown in Figure-1. The experiments were carried out under atmospheric pressure using distilled water. The heating surface which was made of stainless steel grade 316 was submerged in fluid A glass window was designed on one side of the vessel for visual observations.

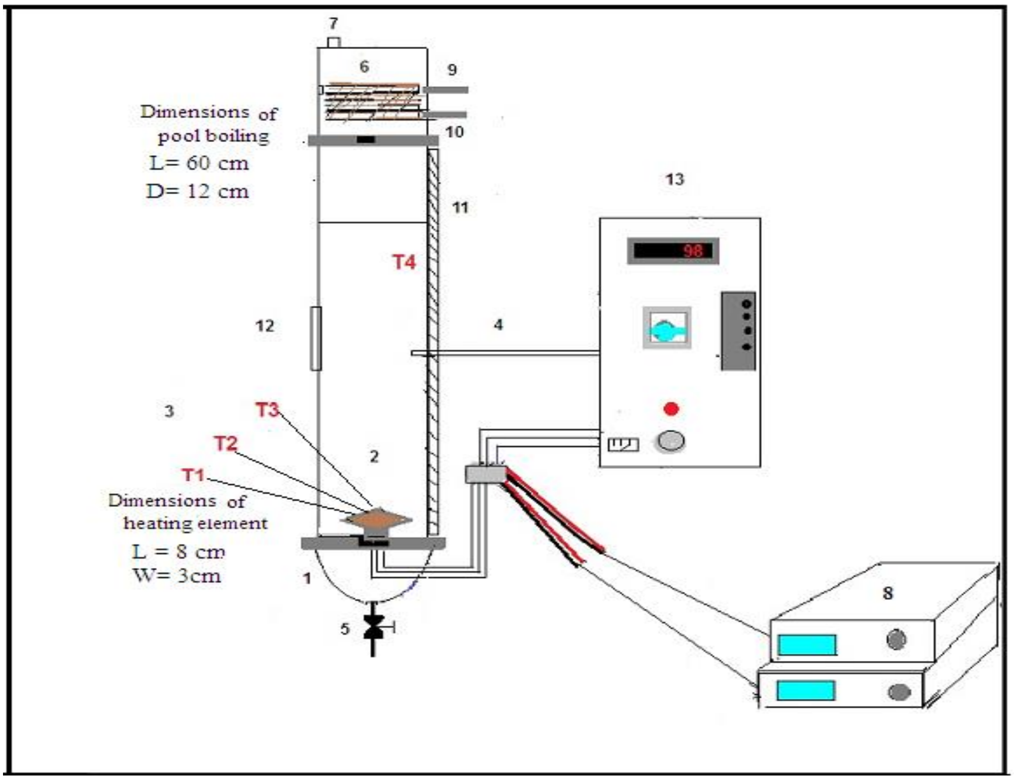

Figure 1-Schematic diagram of the experimental apparatus.

1	Transfer heat vessel	9	Condenser water input
2	Heating element	10	Condenser cooling water out put
3	Thermocouples of heating element surface	11	Thermal Insulation
4	Thermocouples in the Bulk	12	Observation Window
5	Discharge valve	13	Control board with digital temperature reader
6	Condenser		
7	Vent		
8	Varic Power supply		

To prepare the nanofluid, it is necessary to disperse the dry nanoparticles uniformly into the whole base fluid. MWCNTs are used as nanoparticles, in a cylindrical tube form, with inside diameter (5) nm and outside diameter (10)nm and tube length of (10) µm. Table-1 contains details of MWCNTs Properties and Figure-2 shows SEM image of MWCNTS in a powder state .
The base fluid used was distilled water. MWCNTs were dispersed in pure water. Different concentrations were used at (0.1, 0.3, 0.4, 0.5 and 0.7wt %).The amounts of nanoparticles required was mixed with the base fluid by magnetic stirrer for 2 hours and in an ultrasonic path for 0.5 hour, to ensure that there are not significant agglomerated particles inside the vessel.

Table 1-MWCNTs Properties

Structure	MWCNTs Nanopowder
Purity	90wt%
Particle size	50 nm
Inside diameter	5 nm
outside diameter	10nm

length of tube is	10µm
Surface area SSA	200m2/g
Color	Black
Morphology	cylindrical tubes

SEM (Scanning Electron Microscope (SEM0) was used, after nanoparticles were dispersed in distilled water, to be sure it is well dispersed in a base fluid, and then the nanofluid will be was ready for to be used in the experiment. And look clearly the suspended small particles in distilled water after mixed together in Figure-3.

Heat capacity was calculated for

1. Distilled water
2. Nanofluids Calculating The amount of heat was calculated through tree for three different values of voltages and current,
3. q =I *V=W -----q*t =J power formala formula (1.1) [11]
4. The heating element surface temperatures were recored recorded and the (ΔT) was calculated the (ΔT) which is the difference different of temperatures between the heating element surface and the bulk fluid (Tsur. - Tb).The result data is are shown in Tables- (1,2 and3) .

Calculate the heat capacity was calculated by equation below:-

$$Cp=q/(kg(Tsur.-Tb)) \quad (1.2)$$

Where, Tsur. Is the A average surface temperature (i.e. the average of three readings); (Tb.) the bulk fluid temperature.

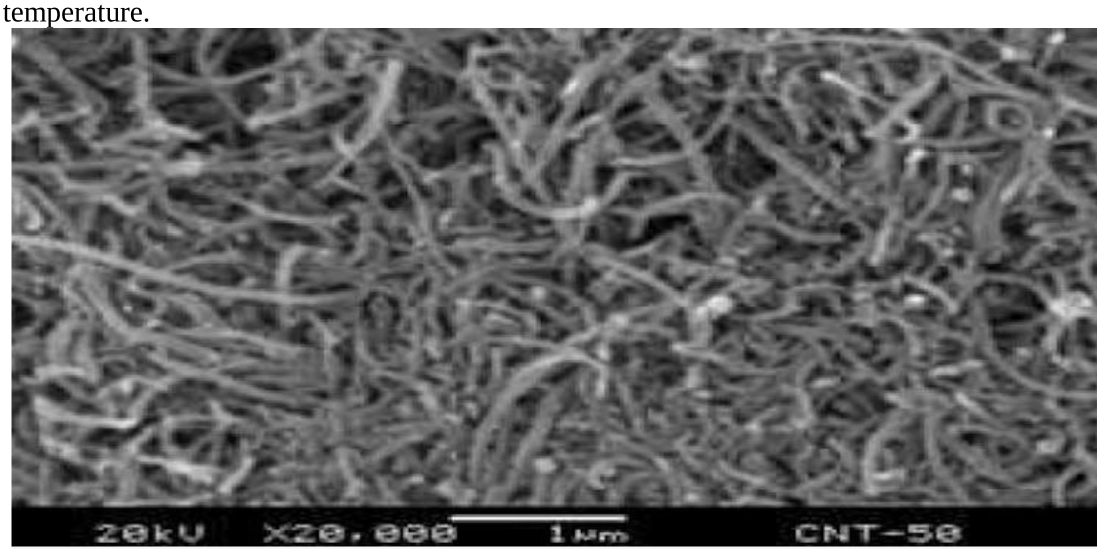

Figure 2-SEM image of of MWCNTS nanoparticle in powder state

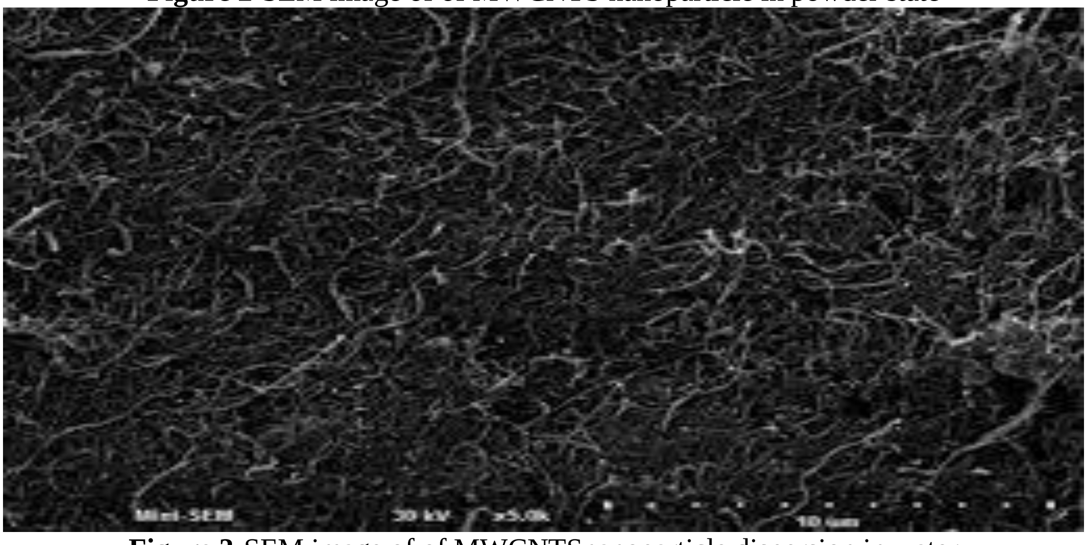

Figure 3-SEM image of of MWCNTSnanoparticle dispersion in water

Results and Discussion

Experimental data from calculated heat capacity of pure water and of nanofluids of water-MWCNTs are described in this part. The results of different weight ratio of MWCNTs (0.1, 0.3, 0.5 and 0.7wt %) are presented, and the optimum enhancement value in of heat capacity is identified. In addition, statement on the characteristics of nanomaterial is given in this part.

The Effect of MWCNTs particles Concentrations Distilled water has various values of heat capacity (Cp) in different temperatures, such as: the heat capacity of water at 20 0c, equal 4.80 J\kg.k and at 30 0c,it is equal about 4.183 J\kg.k and at 400c , it is equal about 4.182 J\kg.K, and at 500c , it is equal about 4.188 J\kg.k. It is obvious that the CP Thesevalues have increased with the increased temperatures .Figures- (1and 2) show the values relationship of heat amount and heat capacity of distilled water values with temperatures of distilled water. These values of Cp will be changed after adding ed MWCNTs particles,. Figures- (3,4and 5) show clearly that the value of Cp is increases ing with the increase of the concentration of MWCNTs particles, and t This enhancement in the values shows as a linearl y proportionality to the increase of the volume fraction .This behavioris behavior is shown clearly in Figure-6 and (the data clearly are presented in Tables-(2,3 and4) .The reason for this e increase is due to the large surface area of those particles, becausesince the large surface area of their nanofluids gives large area of for heat transport and the large surface area of nanoparticles per unit volume allows for more heat transfer between solid particles and base fluids(distilled water). This result is in agreement with result that of Wei, Y., and Huaqing, X.[12],And will be show clearly enhancement in this value with increase volume fraction, this value was compared with approximately data at the same temperature for example, at (20 0c), Cp values of MWCNTs nanofluids are the following : (5.1,5.45, and 5.83) J\ kg.k of volume fraction at (0.067,0.23 and 0.34) respectively, t These results data have been noted,are shown in Table-6 shows where an increase in Cp values with increased volume fraction is noticed ,. This is due to because the MWCNTsparticles were suspended in the base fluid is very well, t This was evident in the images of special Scanning Electron Microscope y of samples.

Additionally, the Brownian motion of nanoparticles is the main reasons responsible for increasing the thermal conductivity and the heat capacity of nanofluid. Brownian motion is the random motion of particles suspended in a base fluid , resulting from their collision with the quick atoms or molecules in the liquid. [13]. This transport is discrepant phenomenon ,the particle moves randomly when it immersed in a fluid, the interaction between the particles and its surrounding fluid molecules is due to an increase in thermal properties.

The better a good value of heat capacity was calculated in a concentrationsat of (0.5 wt %) of MWCNTs, (This value shows clearly in Tables-(4 and 5) and in. Figures-(6 and 7) which gives show a typical enhancement plots quantifying the extent of heat capacity of MWCNTs Nano fluids.

These figures show a maximum enhancement in the value of heat capacity of about (60%), higher than other that of the other concentrations.

In general, the reason for this enhancement is due to the large surface area, the better particle activity and phase stability of MWCNTs,in addition to the many other and having many characteristics, such as high value of hardness, easy dispersion and strong permeability in distilled water in a stable form. And t The cylindrical tubes shape of MWCNTs particle, which is facilitateing and accelerates ing their movement between the molecules of distilled water, as well as to gate the better dispersion of MWCNTs particle in the base fluid.

Table 2- Experimental data of Voltage (v), Current (I), different temperature ΔT (^{0}C) and Heat amount (q) J for various temperatures at 0.1wt% of MWCNTs

T(^{0}C)	**T(k)**	**Voltage (v)**	**Current I (Ampere)**	**Heat amount q J**	**Area of heating surface (m^2)**	**ΔT (k)**
20	293	5	3.06	15.3	0.0024	3
30	303	6	3.75	27.25	=	4
40	313	7	5.41	29.15	=	6
50	323	8	4.07	32.56	=	5

Table 3-Experimental data of Voltage (v), Current (I), different temperature ΔT (^{0}C) and Heat amount (q) J for various temperatures at 0.5wt% of MWCNTs

(^{0}C)	T(k)	Voltage (v)	Current I (Ampere)	Heat amount q J	Area of heating surface (m^2)	ΔT (k)
20	293	9	3.24	37.92	0.0024	5
30	303	10	3.8	41.61	=	6
40	313	11	4.97	54.72	=	8
50	323	12	5.23	62.76	=	9

Table 4- the values of Heat amount for distilled water and value of CP J\ k before and after addition ed of MWCNTs particles.

Temp. ^{0} C	D.W	pafter adding MWCNTs at 0.1	C_P after adding MWCNTs at 0.3	C_P after adding MWCNTs at 0.5	C_P after adding MWCNTs at 0.7
20	4.180	5.1	5.45	5.83	5.32
30	4.183	5.63	5.92	6.32	5.52
40	4.182	6.32	6.51	6.84	5.75
50	4.188	6.512	6.74	6.92	5.93

Table 5-values of C_p-for MWCNTs-nanofluids with various volume fraction MWCNTs at 50 $^{\circ}$C, 223 k

Particle volume fraction	CP of Nanofluid J\kg.K
0.067	6.512
0.23	6.74
0.34	6.92
0.44	5.93

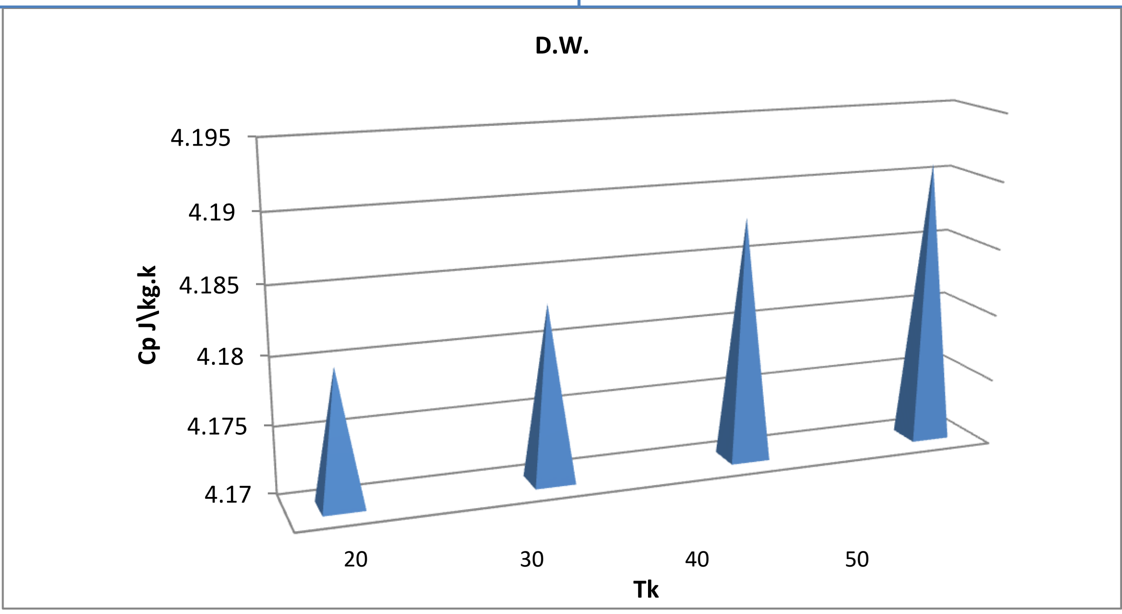

Figure 4-Relationship between the heat capacity and temperaturesof distilled water.

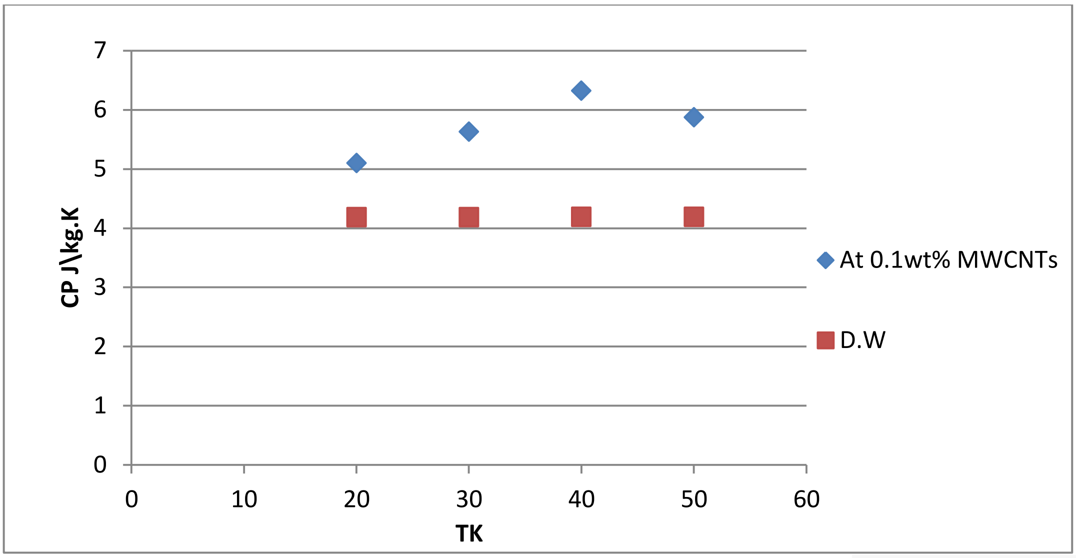

Figure 5-Heat capacity at 0.1wt% concentrationof MWCNTs- Nano fluid in various temperatures compared with heat capacity of distilled water

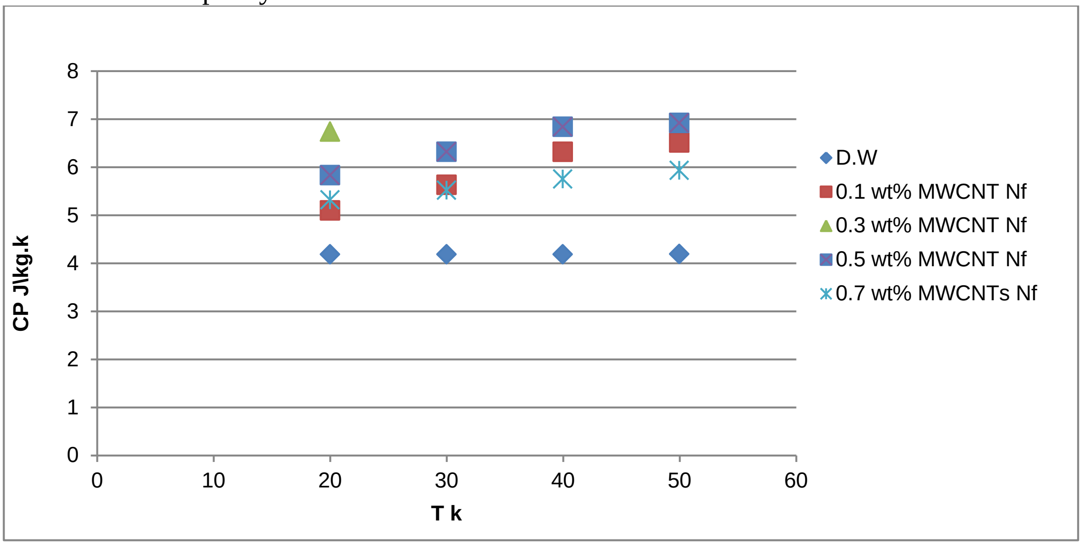

Figure 6-Heat capacity at different concentrations of MWCNTs-nanofluid different temperatures compared with heat capacity of distilled water

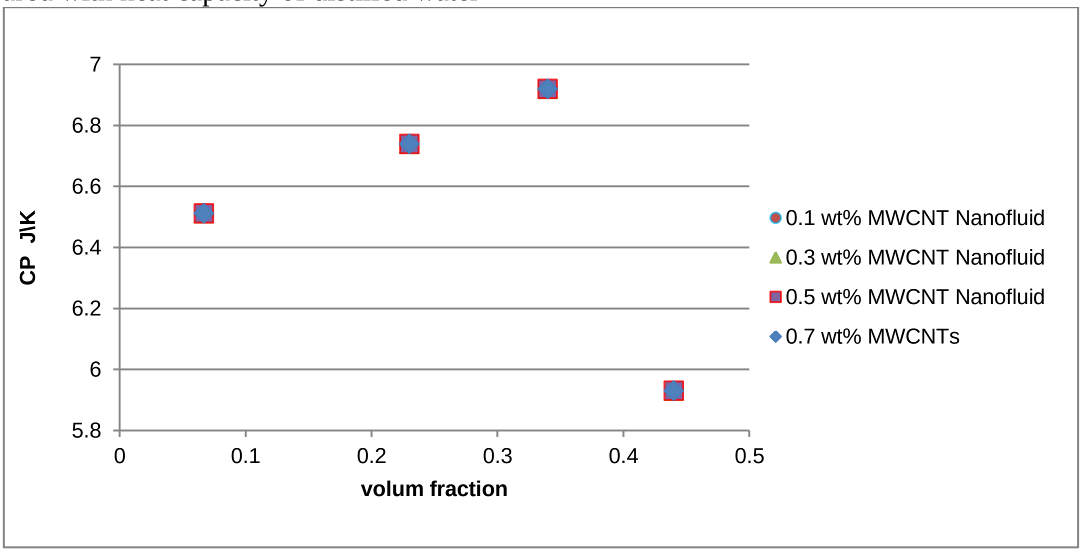

Figure 7-Heat Capacity enhancement of MWCNTs nanofluid with the variation of volume fraction at different concentrations.

Conclusions

Some important conclusions of this research are

1. The values of heat capacity dramatically increased, with the presence of MWCNs High values of heat capacity was reported compared to pure water.
2. Heat capacity increased with increasing Carbon Nano Tube.
3. MWCNTs must be dispersed very well in a base fluid to get better value of heat capacity.
4. The best value of the heat capacity of MWCNTs-Nano fluid at (0.5wt %).

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