Transportation of Objects by Spherical Bodies through a Water Pipeline That Depends on Difference in Elevation in Iraq

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Abstract

In this research we study the water elevation in some dams in Iraq (Hadeetha, Diala and Abasia) and the distance among them with respect to Basra city as example by using Google earth program, and we certain the difference in elevation with respect to the city that wanted to transport object (we take sulfur as example of density= 2000kg/m^3) to it. Also we calculate the capsule velocity and pressure drop caused by passing the capsules through the pipeline, and calculate the head loss due to friction. The increase in pipe diameter will increase capsule velocity. The increase in capsule/pipe diameter ratio (k) will increase capsule pressure drop and head loss due to friction. The increase in transportation distance will increase the head loss due to friction.

Key word: capsule flow, capsule pipeline, hydro transport, hydraulic transport pipeline, freight pipeline.

Introduction

Capsule pipelines are underground pipes designed to transport hollow cylindrical containers (capsules) as shown in **fig. (a)**. The function of the capsules is to transport things from A to B. Potential applications include carrying items such as mail (letters and parcels), minerals, for example coal, agricultural products, for example wheat, packaged products (in boxes or bags), and waste (household garbage or industrial waste). There are two main types of system:

Pneumatic capsule pipelines (PCPs) and hydraulic capsule pipelines (HCPs). In PCPs,

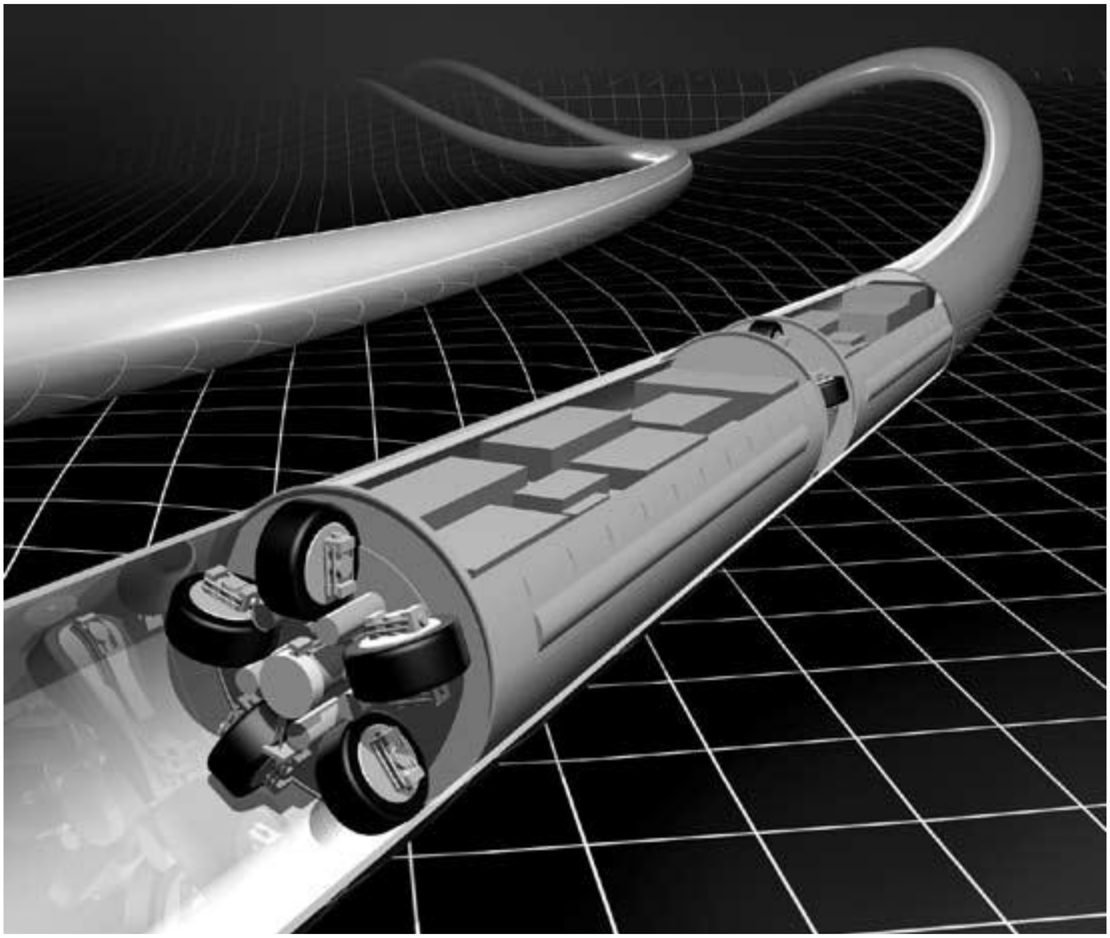

Figure (a) capsule flow pipeline

The capsules are propelled by air, which is blown into the pipeline at one end and flows along it, driving the capsule forward. In order to limit friction between the outside of the capsule and the inside of the pipeline, capsules can be fitted with wheels (see the picture). In HCPs the pipeline is filled with water which is pumped along the pipeline. The capsules are watertight and are immersed in the water. They are driven along the pipeline by the flow of water. Small-diameter PCPs were popular in the second half of the 19th century and in the first half of the 20th century, for carrying documents – used mainly by government departments and postal authorities in large cities. Such systems were used in Berlin, Hamburg, London and Paris. A network in Prague is still in use today. A large diameter PCP was built in Russia, for carrying minerals. More recently, PCPs have been used on a smaller scale to carry cash inside banks and large stores. Recent feasibility studies have been carried out into the possibility of using capsule pipelines for transporting waste out of New York City, and also for carrying mail between New York and Washington DC. According to Freight Pipeline Company, an American R&D organization, a 900 mm diameter PCP can carry approximately 25 tones of cargo at a speed of about 40 km/h. HCPs are much slower, able to travel at just 7 to 11 km/h, but have a greater volume and weight capacity and are more energy-efficient. By taking freight traffic off road-going trucks and running it underground, the potential advantages of capsule pipelines are reduced traffic congestion, fewer road accidents and less pollution. The main disadvantage is the high cost of laying underground pipe networks, either by cut-and-cover for pipes relatively close to the surface, or by tunneling, where pipes are deeper underground [Cambridge,2008].

Figure (b) the map of the region of study

Pipelining science and technology may be regarded as developing through several generations, the first two being fluid and slurry pipelining, respectively, third generation pipelining in which it may be possible to extend the practice and economics of such transportation methods to an even wider spectrum of commodities may be defined as the flow of materials in capsule forms, as massive rigid or semi rigid segments of the supporting fluid. The flow of such capsule forms is recognized as a flow configuration which is stable, being normally encountered in the flow of equal-density immiscible fluids over a wide range of conditions, because the capsule forms occupy appreciably less than the total cross-sectional area of the pipe, they move at a velocity greater than the average over-all velocity. In addition, the pressure gradient of a stream in turbulent flow tends to be reduced, rather than increased, by the presence of capsule forms [Hodgson, 1963].

Capsule transport is a technique proposed for conveying bulk solids in pipes. The originates with Canadian investigators who studied the pipe flow of oil water mixtures. They were interested in the reduction of the pressure gradient over pipeline carrying highly viscous oil by mixing the oil with water [Polderman, 1982].

Capsule pipeline is the transport of freight (solids) in capsules (containers or vehicles) moving through pipelines. when the fluid used for propelling the capsules in the pipe is air or another gas, it is called pneumatic capsule pipeline(PCP);when the fluid for propelling the capsules is water or another liquid, it is called hydraulic capsule pipeline(HCP).both PCP and HCP have distinct characteristics and have nichesor"windows of opportunity"[Henry,2002].

The feasibility of using hydraulic capsule pipeline to transport coal is examined with respect to technical economical and environmental (social) feasibilities. It is concluded that HCP is technically feasible although more extensive research and development are needed to perfect the technology before it can be used reliably [Henry, 1981].

Advantages claimed for capsule pipelining as distinct from slurry pipeline flow rate [Govier, 1972]:
a. freedom from contamination and ease of separation of the solid.
b. lower power requirements per unit of solid transported.

Disadvantages include:
a. cost of encapsulating or forming into capsule shape.
b. mechanical complications associated with the introduction and removal of the capsules to and from the pipe and at pumping stations.

No analysis of the pressure gradient for the flow of either concentric or eccentric spherical capsules is known. in the former case, however, where, there is no energy loss due to solid friction, it is reasonable to assume that the pressure gradient in the presence of a capsule train would be close to that which would occur with the flow of a single-phase liquid of mixture density and at the mixture velocity, specifically we might expect a pressure gradient in a horizontal line:

$$(\Delta p/L)_c=2f\rho_{Mc}V^2_M/g_cD \qquad (1)$$

Where f is the single-phase friction factor, ρ_{Mc} is the density of the capsule –liquid mixture. it may readily be shown that capsule-liquid mixture densities are given by:

$$\rho_{Mc}=\rho[2/3k^2(s-1)+1] \qquad (2)$$

It is found that the head loss due to friction can be calculated from the following equation:

$$h_f = f\,(L/D)(V^2/2g) \qquad (3)$$

h_f = frictional head loss, ft-lb/lb
L = pipe length, ft
D = pipe diameter, ft
V = average flow velocity of fluid (= Q/A), ft/sec
g = acceleration due to gravity = 32.2 ft/sec^2
f=friction factor

Results and Discussion

Results were obtained for the flow of spherical bodies(capsules) containing sulfur through a water pipeline of pvc material depending on the difference in elevation for three dams (Hadeetha,Diala and Abasia) with respect to Basra city as case of study [**Fig.(b)**].

Fig.(1) represents the relationship between pipe diameter and capsule velocity, from which we found that capsule velocity will increasing with increase the pipe diameter. **Figs.(2,3 and 4)** represent the relationship between pipe diameter and capsule pressure gradient for Hadeetha,Diala and Abasia dams respectively, from which we saw that the increasing in pipe diameter will increase the capsule pressure gradient for diameters between 30 to 50 inch then it will be reduced between 50 to 55 inch then increased between 60 to 65 inch and then decreased above 65 inch, and we can deduce from these figures that the increase in diameter ratio(k) will increasing the capsule pressure gradient. **Fig.(5)** represent the relationship between pipe diameter and head due to friction for Hadeetha,Diala and Abasia dams with respect to Basra city, we saw that the head due to friction will be larger in Hadeetha than Diala and Abasia dams which due to the linear**ly** proportional between the head and the distance**. Figs. (6, 7 and 8)** represents the relationship between capsule velocity and capsule pressure gradient for Hadeetha, Diala and Abasia dams respectively. from which we can deduce that the capsule pressure gradient will increasing with increasing capsule velocity up to velocity of0.26m/s then fluctuating from velocities 0.26 to o.315 m/s then decreasing after velocity 0.315m/s, and we saw that the increasing in diameter ratio will increase the pressure gradient.

Tables Hadeetha dam with respect to Basra city, Head = 120 m, Distance =751 km

k=0.39

$Q(m^3/s)$	D(inch)	$u_m(m/s)$	$u_c(m/s)$	$\Delta p/L)_c(N/m^3)$	$h_f\,(m^2/s^2)$)
0.0758	30	0.166	0.184	1.214	207
0.151	39	0.196	0.217	1.29	219
0.227	45	0.221	0.245	1.411	240
0.303	50	0.239	0.265	1.446	247
0.379	55	0.247	0.274	1.39	293
0.455	59	0.258	0.286	1.408	267
0.531	62	0.272	0.302	1.48	252
0.606	65	0.283	0.314	1.517	259
0.682	68	0.291	0.323	1.522	260
0.758	71	0.297	0.33	1.4	238

K=0.60

$Q(m^3/s)$	D(inch)	$u_m(m/s)$	$u_c(ft/s)$	$\Delta p/L)_c(N/m^3)$	$h_f(m^2/s^2)$
0.0758	30	0.166	0.184	1.367	207
0.151	39	0.196	0.217	1.452	219
0.227	45	0.221	0.245	1.59	240
0.303	50	0.239	0.265	1.63	247
0.379	55	0.247	0.274	1.57	293
0.455	59	0.258	0.286	1.58	267
0.531	62	0.272	0.302	1.66	252
0.606	65	0.283	0.314	1.71	259
0.682	68	0.291	0.323	1.714	260
0.758	71	0.297	0.33	1.57	238

K=0.69

$Q(m^3/s)$	D(inch)	$u_m(m/s)$	$u_c(ft/s)$	$\Delta p/L)_c(N/m^3)$	$h_f(m^2/s^2)$
0.0758	30	0.166	0.184	1.452	207
0.151	39	0.196	0.217	1.542	219
0.227	45	0.221	0.245	1.688	240
0.303	50	0.239	0.265	1.73	247
0.379	55	0.247	0.274	1.66	293
0.455	59	0.258	0.286	1.684	267
0.531	62	0.272	0.302	1.77	252
0.606	65	0.283	0.314	1.814	259
0.682	68	0.291	0.323	1.82	260
0.758	71	0.297	0.33	1.67	238

K=0.79

$Q(m^3/s)$	D(inch)	$u_m(m/s)$	$u_c(ft/s)$	$\Delta p/L)_c(N/m^3)$	$h_f(m^2/s^2)$
0.0758	30	0.166	0.184	1.561	207
0.151	39	0.196	0.217	1.658	219
0.227	45	0.221	0.245	1.815	240
0.303	50	0.239	0.265	1.859	247
0.379	55	0.247	0.274	1.793	293
0.455	59	0.258	0.286	1.811	267
0.531	62	0.272	0.302	1.902	252
0.606	65	0.283	0.314	1.95	259
0.682	68	0.291	0.323	1.957	260

0.758	71	0.297	0.33	1.80	238

K=0.89

$Q(m^3/s)$	D(inch)	$u_m(m/s)$	$u_c(ft/s)$	$\Delta p/L)_c(N/m^3)$	$h_f(m^2/s^2)$
0.0758	30	0.166	0.184	1.685	207
0.151	39	0.196	0.217	1.789	219
0.227	45	0.221	0.245	1.958	240
0.303	50	0.239	0.265	2.006	247
0.379	55	0.247	0.274	1.935	293
0.455	59	0.258	0.286	1.954	267
0.531	62	0.272	0.302	2.053	252
0.606	65	0.283	0.314	2.105	259
0.682	68	0.291	0.323	2.119	260
0.758	71	0.297	0.33	1.943	238

Conclusions

From the present work we can deduce the following conclusions:
1. The increase in pipe diameter led to increase the capsule velocity.
2. Increasing the diameter ratio will increase the pressure gradient.
3. Increasing the pipe diameter will increase the head due to friction. The head in the line of hadeetha-Basra city is larger than Diala-Basra city which larger than Abasia-Basra city.

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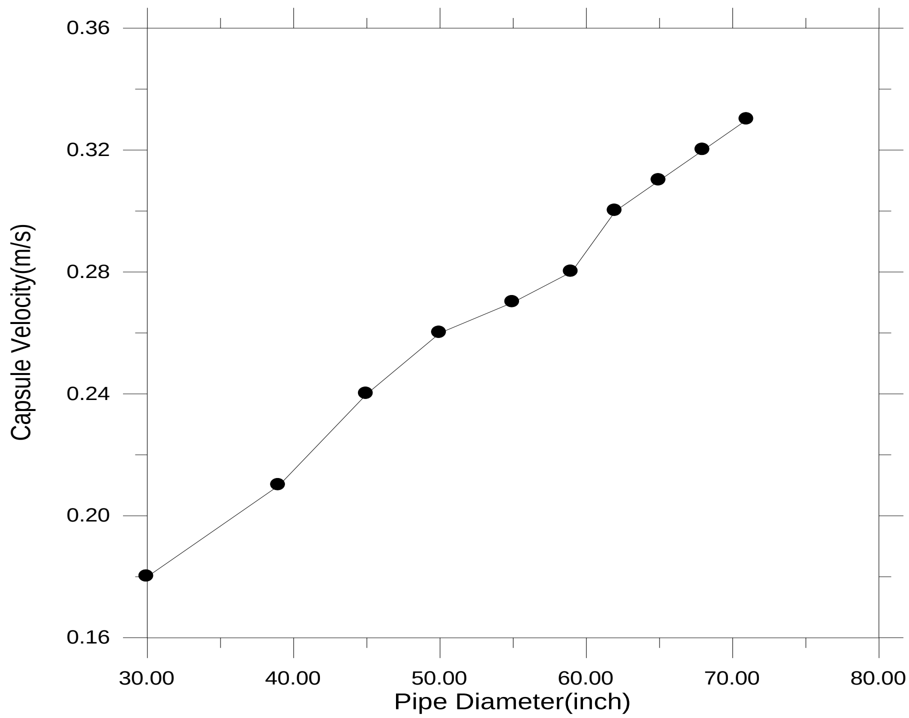
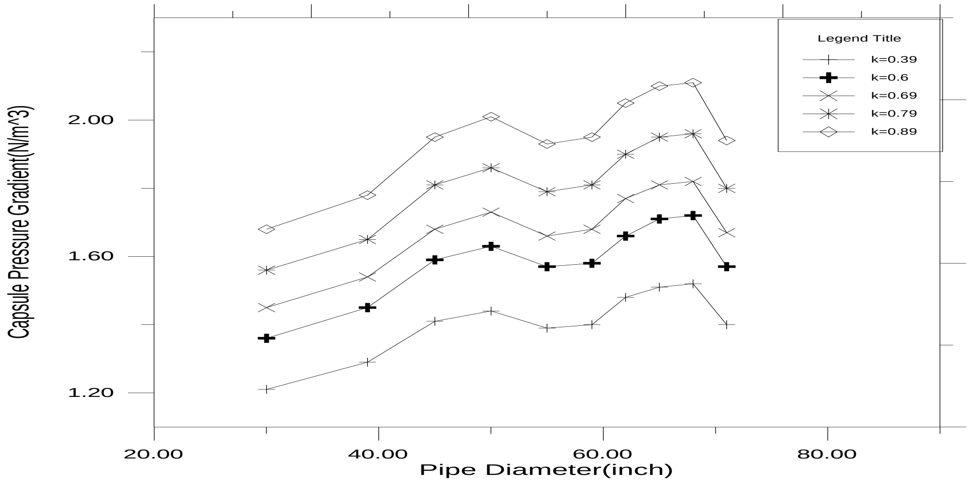
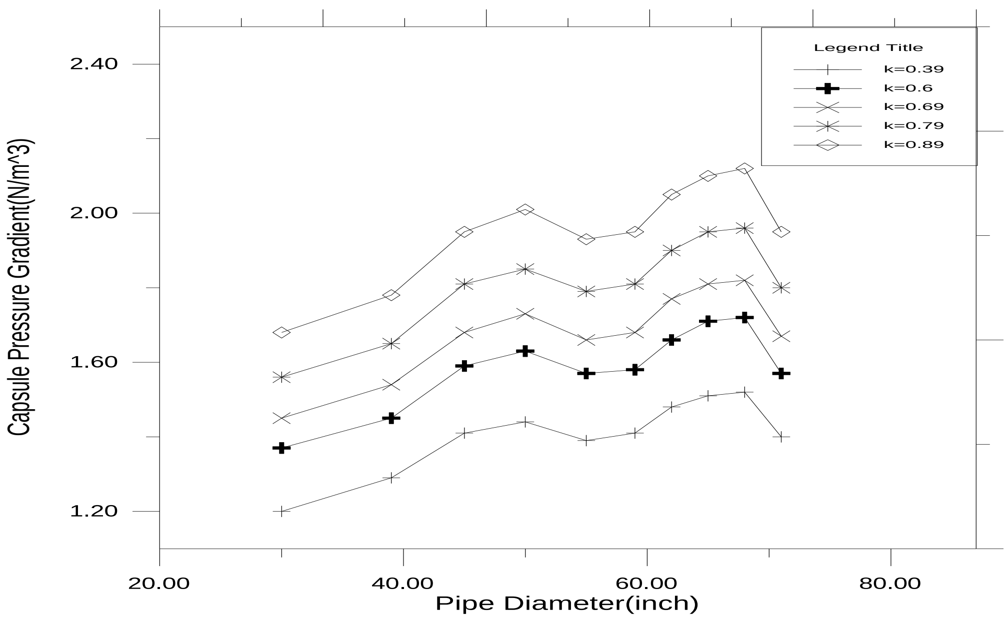


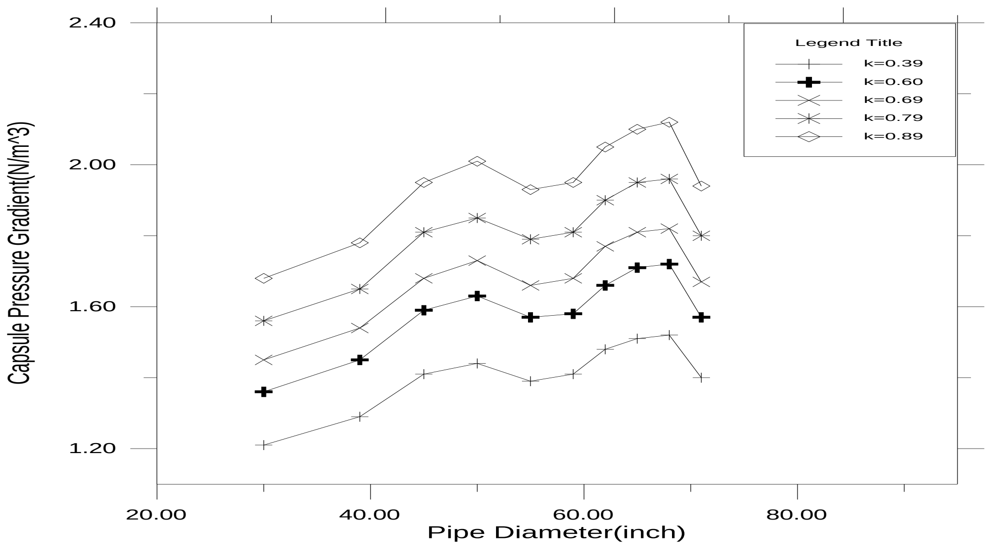
Fig(1)Variation of Pipe Diameter with Capsule Velocity for Hadeethe,Diala and Abasia Dams with respect to Basra City



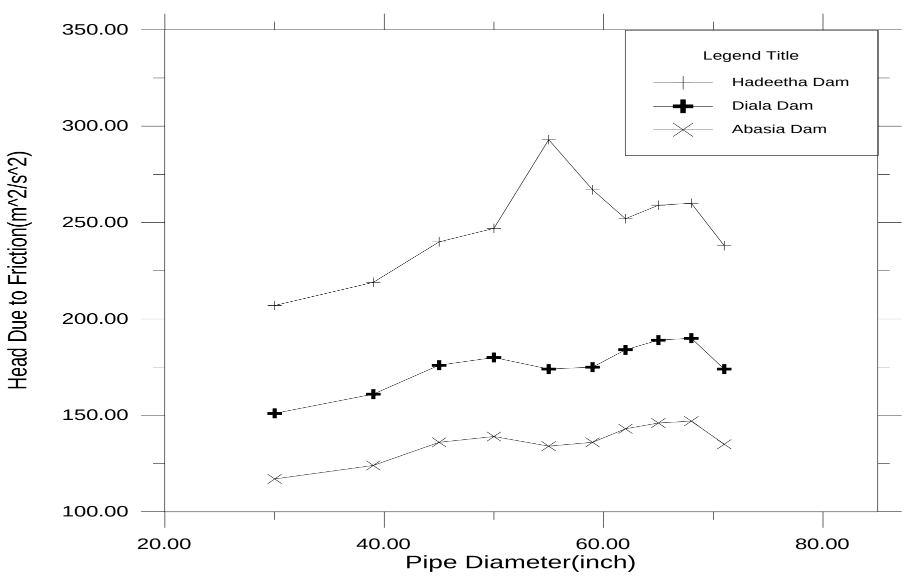
Fig(2)Variation of Pipe Diameter with Capsule Pressure Gradient for Hadeetha Dam with respect to Basra City



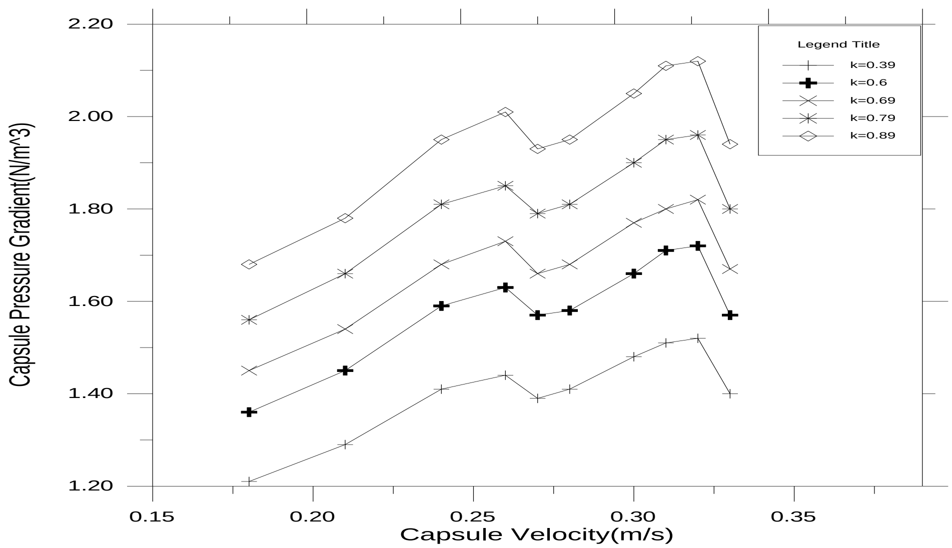
Fig(3) Variation of Pipe Diameter with Capsule Pressure Gradient for Diala Dam with respect to Basra City



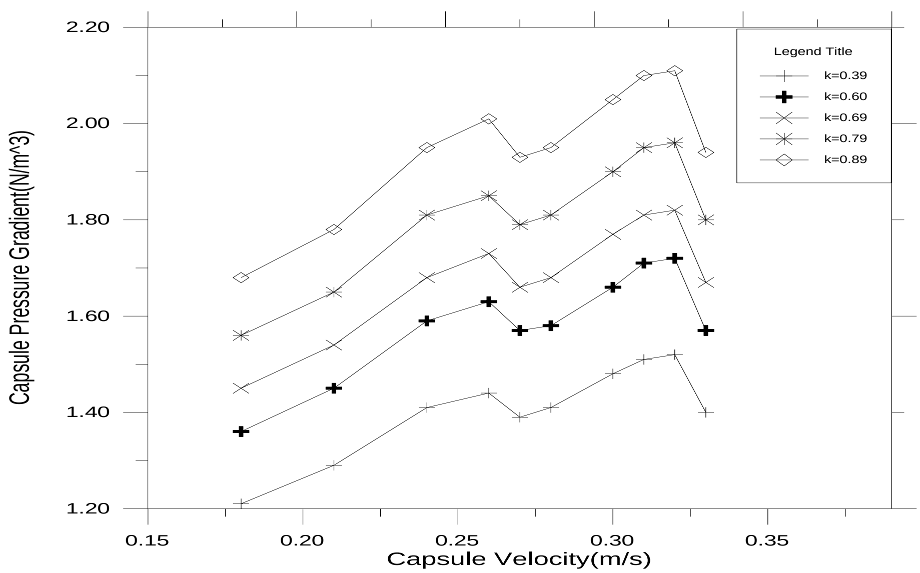
Fig(4) Variation of Pipe Diameter with Capsule Pressure Gradient for Abasia Dam with respect to Basra City



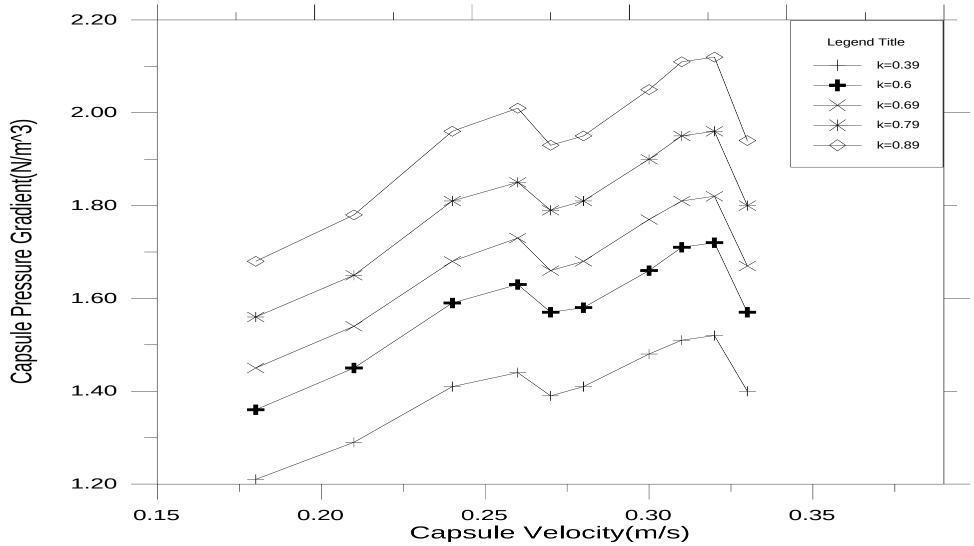
Fig(5) Variation of Pipe Diameter with Head due to Friction for Hadeetha,Dial and Abasia Dams with respect to Basra City



Fig(6)Variation of Capsule Velocity with Capsule Pressure Gradient for Hadeetha Dam with respect to Basra City



Fig(7)Variation of Capsule Velocity with Capsule Pressure Gradient for Diala Dam with respect to Basra City



Fig(8)Variation of Capsule Velocity with Capsule Pressure Gradient for Abasia Dam with respect to Basra City