# Effect of sand impact on the erosion behaviour of HDPE 100 and PVC pipes

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## ABSTRACT

Experimental were carried out to study the effect of sand impact on the erosion behaviour of HDPE 100 and PVC pipes. The erosion wear is evaluated at different impingement angles (30, 45, 60, 90) degree at two different velocity (34m/sec and 109 m/sec). The erodent used is silica sand with the size rang 200-600 μm of irregular shape. The result shows the same brittle behavior with maximum erosion rate at 90 degree impingement angle for both pipes and the erosion rate increased with increasing the size of the sand particles and reduced with increasing distance traveled by the jet or particles.

**KEYWORDS:** Erosion, impact sand –plastic pipes.

## INTRODUCTION

Plastic pipe lines are exposed to many hazardous influences during their life time. To main deteriorating factors belong chemical and thermal degradation, stress corrosion, external loads and pressure. One of the important deteriorating processes is wear as a result of solid abrasive particles influence [1].

Erosive wear of materials occurs by the removal of target material from the impact zone due to repeated impact of the erodent by a micromechanical deformation / fracture process.

Erosion is a complex process that is affected by numerous factors and small or subtle changes in operational conditions can significantly affect damage it causes. This can lead to the scenario in which high erosion rates occur in one production systems, but very little erosion occurs in other seemingly very similar system. Detection of erosion as it progresses is also difficult and plant operations rarely have a good measure of the internal condition of the pipe work in their systems. This makes erosion management difficult, especially for those unfamiliar with the manner in which erosion occurs [2].

Damage caused by erosion has been reported in several industries for aide range situation. Examples can be sited for transportation of airborne solids through pipes, boiler tubes exposed to flash and gas turbine blades [2-3].

It is widely recognized that polymers and their composites have poor resistance. Their erosion rates are considerably higher than metal. So much work has been reported on the erosive wear behaviour of metals and comparatively less has been reported on the erosive wear performance of polymers this is because operating companies are reluctant to publicize their problems and that erosive maybe more common than published data implied. Another reason for this maybe that the sporadic nature and complexity of erosion problems make it difficult to draw conclusions from statistically based field studies [2, 4, 5].

In general the erosive wear behavior of material depends on various operating parameters suck as velocity , partial size , shape and hardness , target material , time , angle of impact , distance between target and erodent particles [4,5,6,7].

The aim of the present study is therefore to investigate the erosion behavior of the two most common pipes of plastics used in the word under different conditions.

## EXPERIMENTAL PROCEDURE

the material, the HDPE 100 granular it is source from SABIC (KSA) and carbon granular in which it is mater batch about 50-60 % then both granular are mixed and the mixing it

produced according to ASTM 1603 to obtain HDPE 100 pipes with 2%C [9]. Then the mixed granular is plotted in extruded cylinder hoppers to produced pipes with 3 mm thicknesses by extrusion process.

PVC pipes (polyvinyl chloride) made up of about 43 % polyvinyl and 57% chlorine from rock salt. And produced pipes like HDPE with 3 mm wall thicknesses also.

The quadrate samples (20 X 20 X 3) mm in size, were prepared from the pipes and held at selected angles (30, 45, 60, 90) degree to work at 34 m/sec and 109 m/sec [6-10].

Sand of high silica percentage (four different grades 200, 250, 355, 600) was used in all tests at 20w% concentration. It was angular in shape with sharp edges as show in fig.1.

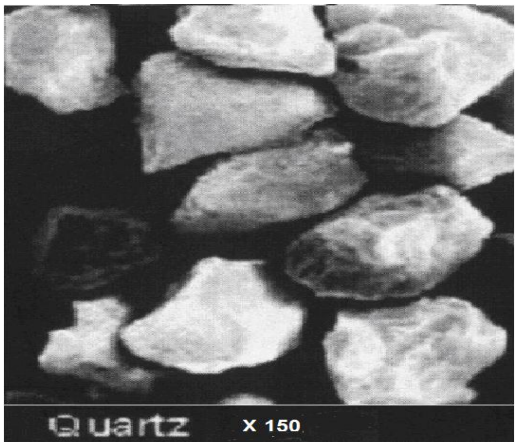



Fig. 1 micrograph of silica sand

The erosion device shown in fig.2 consist of an acceleration pipe with an injection carbide nozzle of 4 mm diameter ,this pipe was connected to the compressor to accelerate the mixture of sand and water ,the compressor has affixed out put and 1.4 N/m 2 pressure, driven by 3 h.p motor

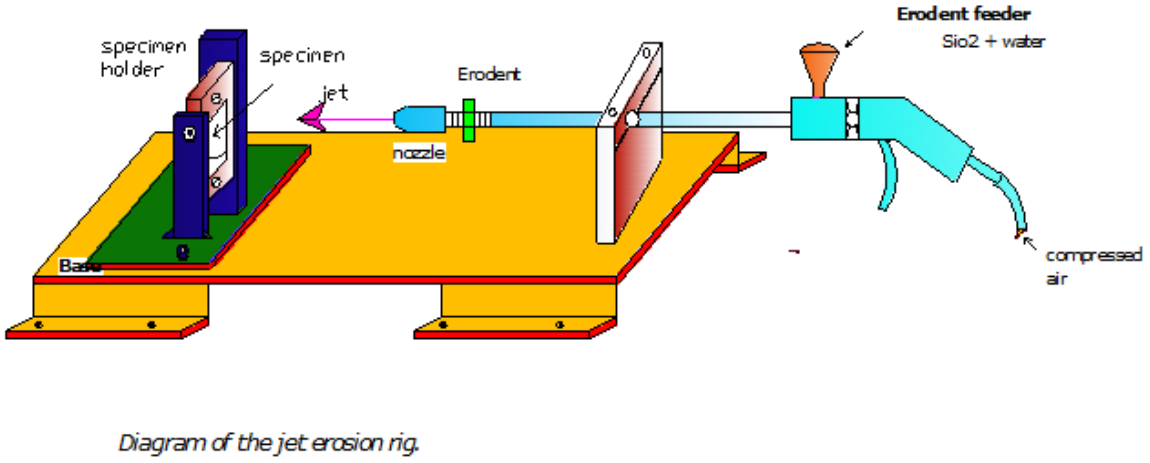



*Diagram of the jet erosion rig.*

Fig.2 Erosion device

The specimen was mounted in specialized device that has the capability of changing the impact angle. The experimental rig incorporated continuous circulation of the mixture and provided for the nozzle to be on the same centre line of the specimen (nozzle and specimen can be regarded as having a centric geometry).

The distance between the target material and the nozzle was approximately (20) mm for the tests and (40 -60 -80 -100) mm distance was tried also.

Erosion rate measured by the weight loss method. Samples were cleaned with acetone

before and after each test. Eroded samples were cleaned with a brush to remove fine sand particles attached to the surface and then wiped with a cotton plug dipped in acetone to avoid any entrapment of wear debris in the samples.

## RESULT AND DISCUSSION

The result which is obtained in this investigation can be classified into several categories according to the variables used.

Solid particle erosion is a wear process in which the material is removed from the surface by the action of a high velocity stream of erodent particles entrained in a high velocity fluid stream .The particles strike against the surface with known impact angle and promote material loss.

The fig.3 [ reference 10] show the impact velocity or force which have two components , one normal to the specimen surface and one parallel to1t .

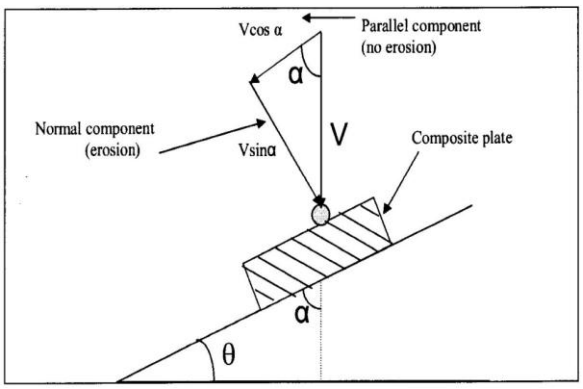
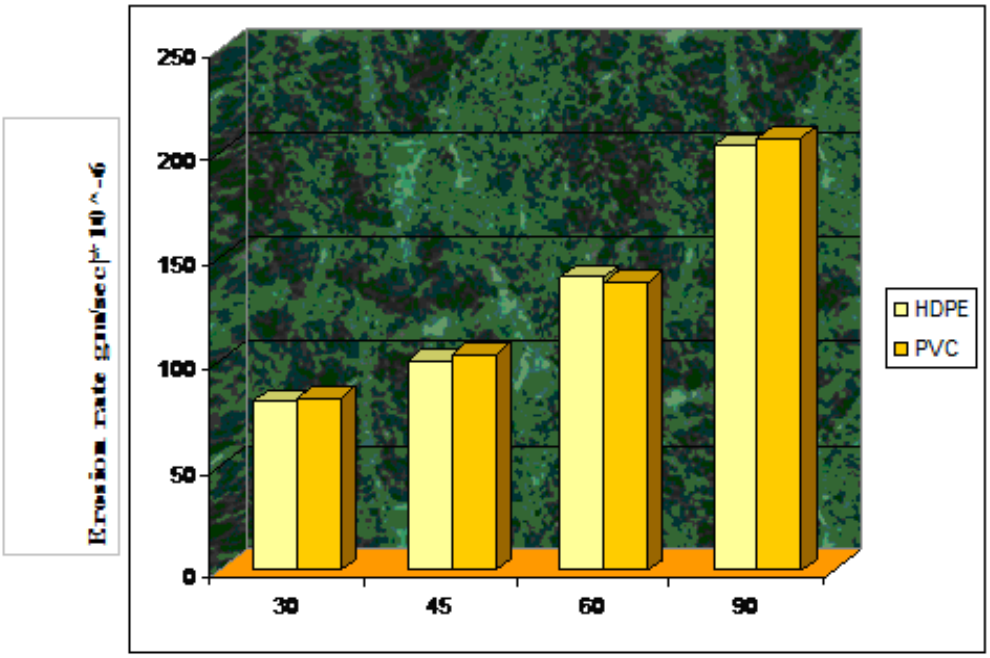


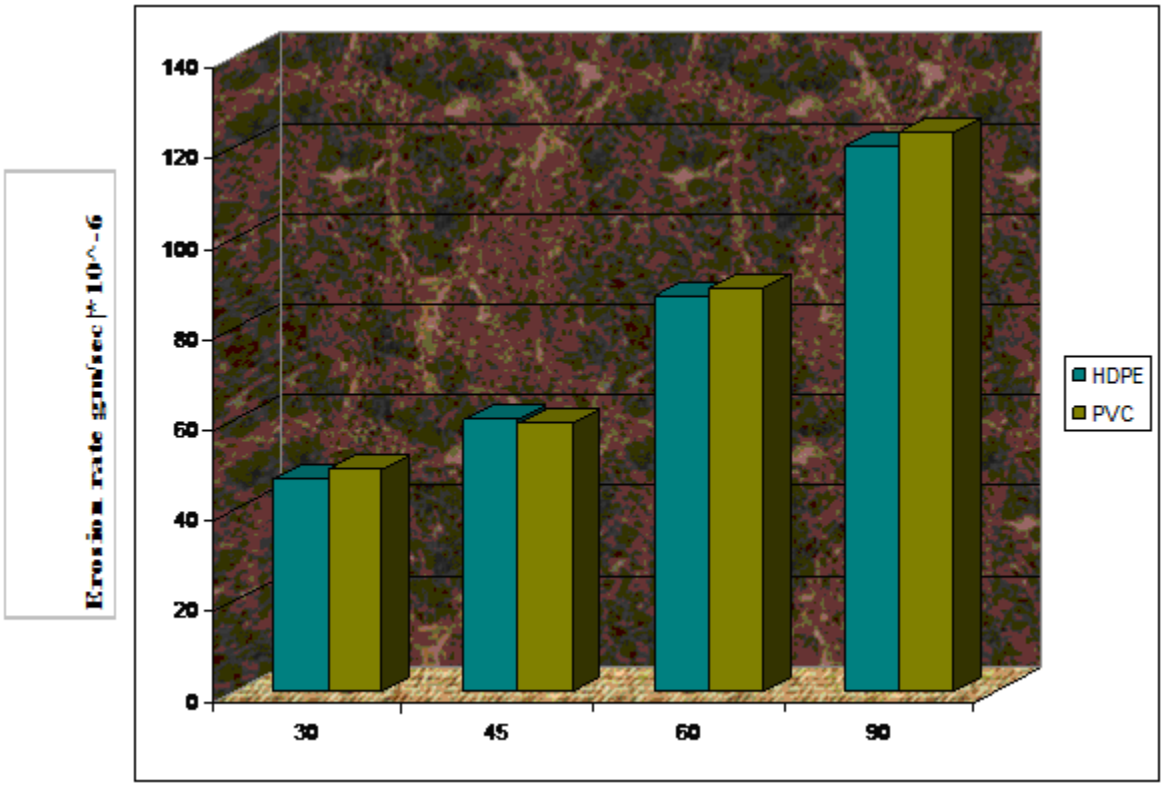

Fig 3. Resolution of impact velocity in normal and parallel direction

When the impact angle is equal to 30 degree, there will be no erosion due to the parallel component and the indentation or erosion is assumed to be caused entirely by the component normal force only to the specimen surface, but in impact angle equal to 90 degree the force can not be resolved and it become normal component only with high kinetic energy, so the erosion rate increased as shown in figs (4 -5).




Angle of impact (degree)

Fig.4 Relation between erosion rate and angle of impact, 12 hrs test duration, 2cm distance ,20w%s and concentration, 200µm particle size, 34 m/sec velocity.




Angle of impact (degree)

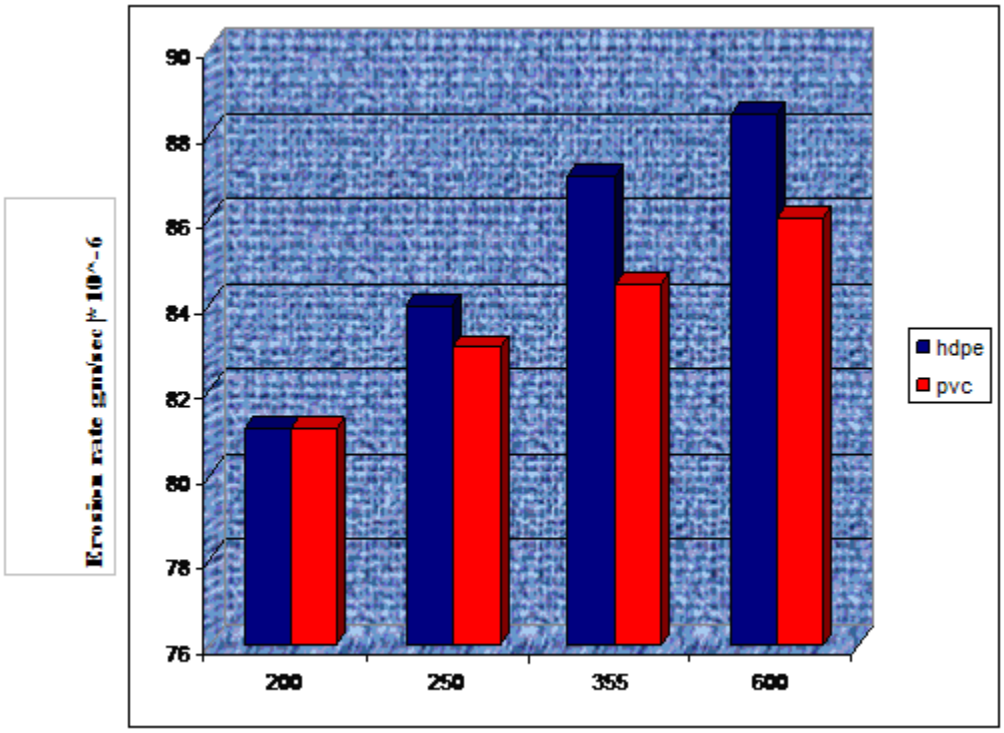
Fig.5 Relation between erosion rate and angle of impact, 12 hrs test duration, 2cm distance ,20w%s and concentration, 200µm particle size, 109 m/sec velocity.

At high velocity (109 m/sec) the erosion rate reduced due to little loss in the quantity of sand (flying out of the container), hence at higher velocity no correlation emerged between erosive wear rate and the mechanical properties [5].

In this context different result were obtained individually, Harinath [6] show that polymer composite show brittle type failure and maximum erosion rate is observed at 90 degree, but Arjala [8] show that high –performance thermoplastic polymer have exhibited maximum erosion rate at 30 degree impact angle .

It is available in the literature that there are no fixed trends available which correlates ductility or brittleness of materials with maximum impact angle or minimum .It is found that some polymers erode in a ductile manner, some show evidence of both ductile and brittle characteristics [11 ,12].

Fig. 6 shows the relation between erosion rate and the size of sand particles, when the size increased it means increasing in kinetic energy so the impact forces and erosion rate increased. The smaller range of particle size gives a smaller erosion rate since not all the (light –weight) particles will reach the target material.




Particle size µm

Fig.6 Relation between erosion rate and particle size µm, 12 hrs test duration, 2cm distance, 20w%s and concentration, 34 m/sec velocity.

The erosion rate decreased with increasing distance traveled by the jet or particles as shown in fig .7, when the distance was small (2 cm ) a high stresses concentration will occur within a short period of time because of the high impact force and the sand particles traveling short distance will not lose a lot of their kinetic energy.

When the distance increased (10 cm) the particle reaches the material at ales impact force, also there is an orientation of the particles in other directions, hence the erosion rate decreases.

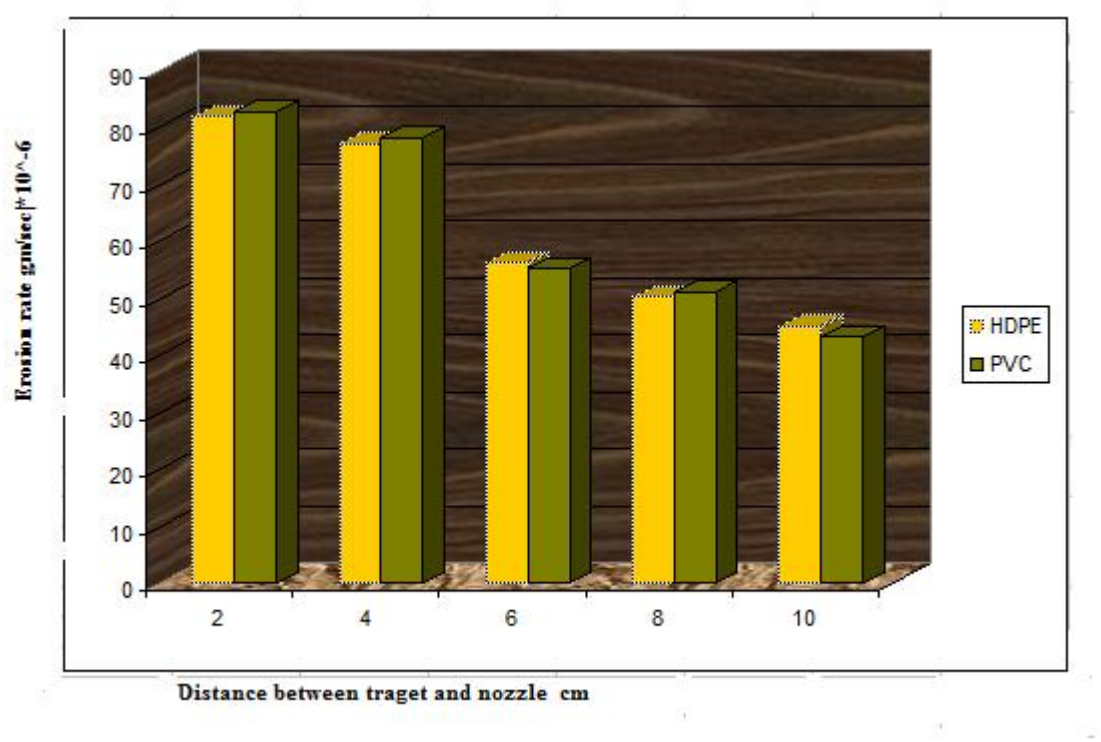



Fig.7 Relation between erosion rate and Distance between target and nozzle cm, 12 hrs test duration, 200 µm particle size ,20w%s and concentration, 34 m/sec velocity.

Erosion is a complex subject and there is still much uncertainty in erosion such as erosion mechanism, way in which sand is transported through the pipes …etc.

## CONCLUSIONS

Based on the study of the erosive wear behavior of HDPE 100 and PVC pipes at various impingement angles at low and high velocity, sand particle size, distance between the target and nozzle, following conclusions are drawn :-

1-The important and new conclusion was that PVC and HDPE 100 are approximately equal in erosion (abrasion) rate although there are some different in mechanical and physical properties.

2-The HDPE 100 and PVC exhibited a maximum erosion rate at an impingement angle of 90 degree under present experimental condition indicating brittle behavior.

3- At high velocity erosion rate were decreased for both pipes HDPE 100 and PVC.

4-The erosion rate increased with increasing the size of the sand particles and reduced with increasing distance traveled by the jet or particles.

5-In the future the study can be extended to other polymer pipes which are most popular in the market today.

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