Report Title: **TENTH TECHNICAL PROGRESS REPORT ON HYDRODYNAMIC MODELS FOR SLURRY BUBBLE COLUMN REACTOR**

Report Type: QUARTERLY	Reporting Period Start Date: 10/01/1996 End Date: 01/31/1997

Principal Author(s): Dimitri Gidaspow

Report Issue Date: 01/31/1997	DOE Award No.: DE- FG22 -94PC94028

Submitting Organization(s) Name & Address

Department of Chemcial and Environmental Enginnering
ILLINOIS INSTITUTE OF TECHNOLOGY (1)
10 W. 33 rd St. Chicago , IL. 60616

(2)

(3)

(4)

(5)

DISCLAIMER

Abstract

The objective of this investigation is to convert our "learning gas - solid - liquid " fluidization model into a predictive design model . The IIT hydrodynamic model computes the phase velocities and the volume fractions of gas , liquid and particulate phases . Model verification involves a comparison of these computed velocities and volume fractions to experimental values .

A paper "Liquid-Solid Fluidization Using Kinetic Theory " by D.Gidaspow and L.Huilin was presented at the Chicago ANNUAL AIChE meeting in November 1996 . It will be published in the Symposium Series on Fluidization and Fluid Particle Systems . We have also computed the particle Reynolds stress for three-phase fluidization .

Using an IIT Reflected Light Microscope we have determined the particle size distribution of the Air Products catalyst . The catalyst disintegrated during fluidization . We believe it is necessary to design a better catalyst . This can be done by finding an optimum particle size by considering diffusion and reaction in the catalyst and mixing resistance to mass transfer in the fluids . Our theory permits us to determine such an optimum particle size and best operating particle concentration .

Particle Attrition

Air Products methanol catalyst particles that have been used as the solid phase in our three phase fluidization have been examined to find the breakage .

The fresh catalyst was analyzed by a sieve method .The distribution of particle size is given in figure 1 .

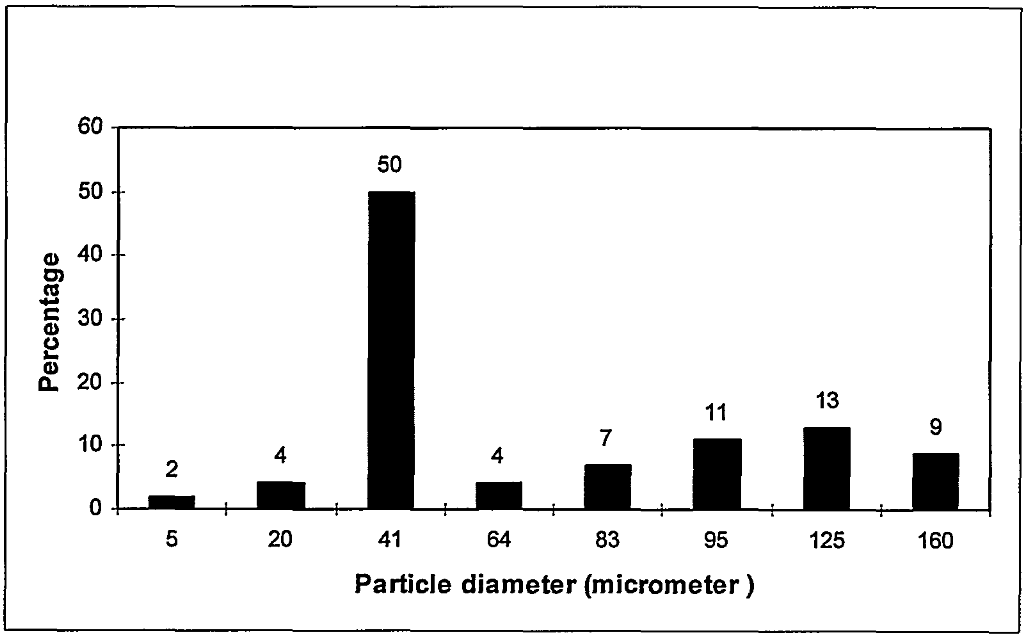

Figure 1 - Fresh catalyst size distribution

After one year usage of the catalyst in the bed in which the air was always flowing at a velocity of at least 0.2 cm/sec through seven jets , the particles have been analyzed by a Reflected Light Microscope . The pictures from microscope were transferred to our image processing software (IPPLUS) where the particles size were measured . Two pictures that have been captured are shown in figure 2 .

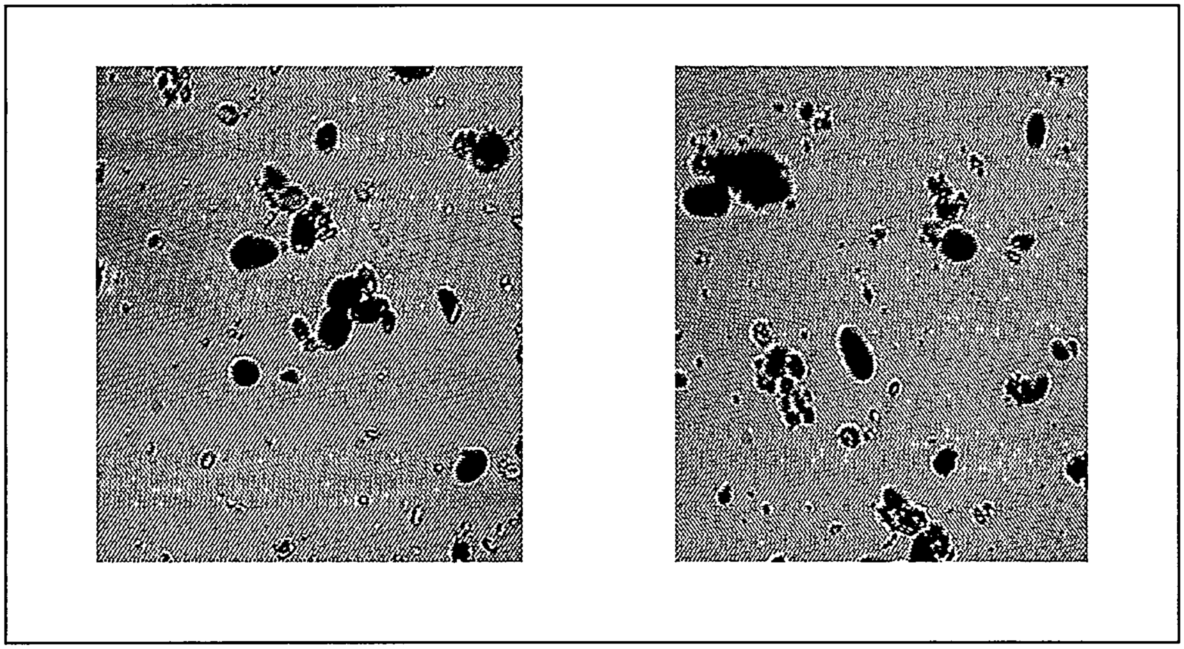

Figure 2- Used catalyst particles pictures captured by microscope

The distribution of particle size is given in figure 3.

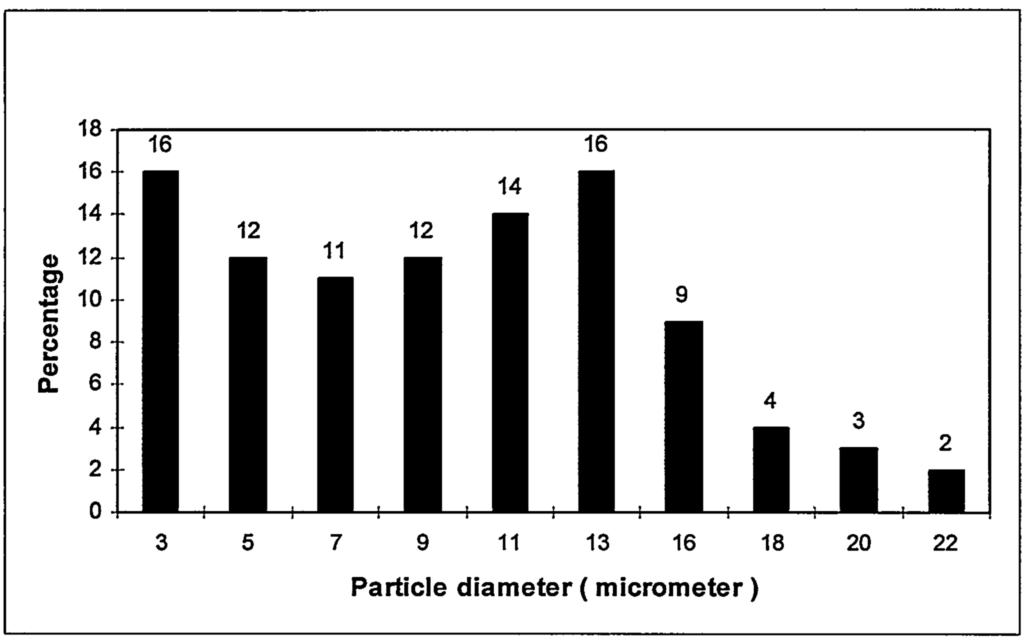

Figure 3 - Size distribution of used catalyst

As can be seen the used catalyst is mostly fines and much smaller than the original fresh catalyst . The distribution has double peak . It shows that there was a lot of fine production due to jets and particle-particle and particle-wall collisions .

Cluster Formation

As shown in figure 4 , some clusters are formed . These clusters are a group of four and more particles and may be considered as one moving object . Indeed the viscosity of the Air Products catalyst measured with a Brookfield viscometer was ten times that estimated using kinetic theory based on 45 μm size.

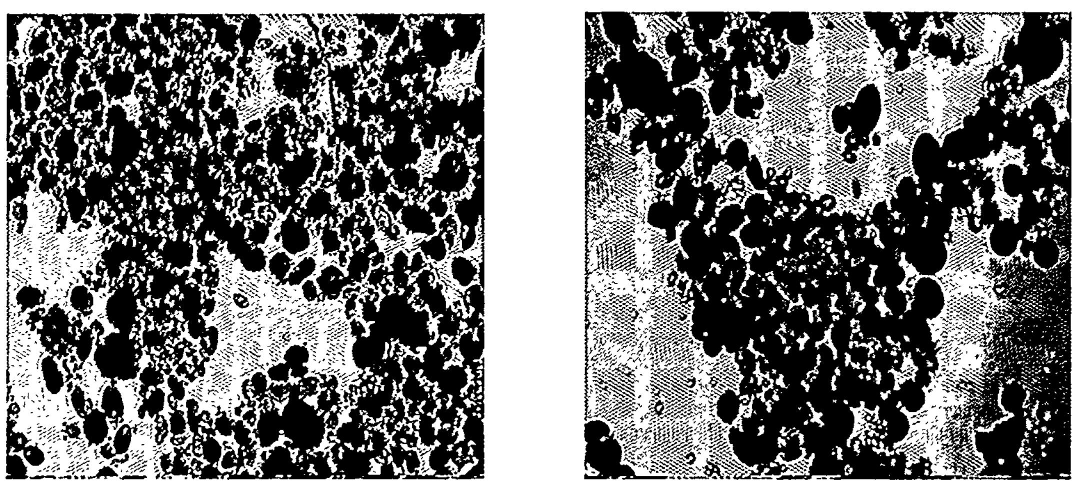

Figure 4 - Cluster formation from small particles

Reynolds Stress

A series of measurements have been carried out on our three phase fluidization bed in order to calculate the particle Reynolds stress and shear rate . All the measurements were made by our CCD camera and the IPPLUS image processing software . The bed consists of seven identical air jets and the liquid and solid phases are the stationary phases in the system. The bed dimensions are 40×19×1 inches (H×W×D) and the jets are 3×7/8×7/8 inches (H×W×D).

In the first set of experiments the solid volume fraction has been varied and the Reynolds stress has been calculated using the following formula :

$$\overline{u'v'} = \frac{1}{N}\sqrt{\sum\left(uv - \overline{uv}\right)^2}$$

The result is shown in figure 5. It can be seen that the trend is the same as granular temperature behavior in DOE progress report No. 8. The gas superficial velocity is 2.8 cm/s and all the data are taken at the height of 28 inches, ten inches away from the side wall.

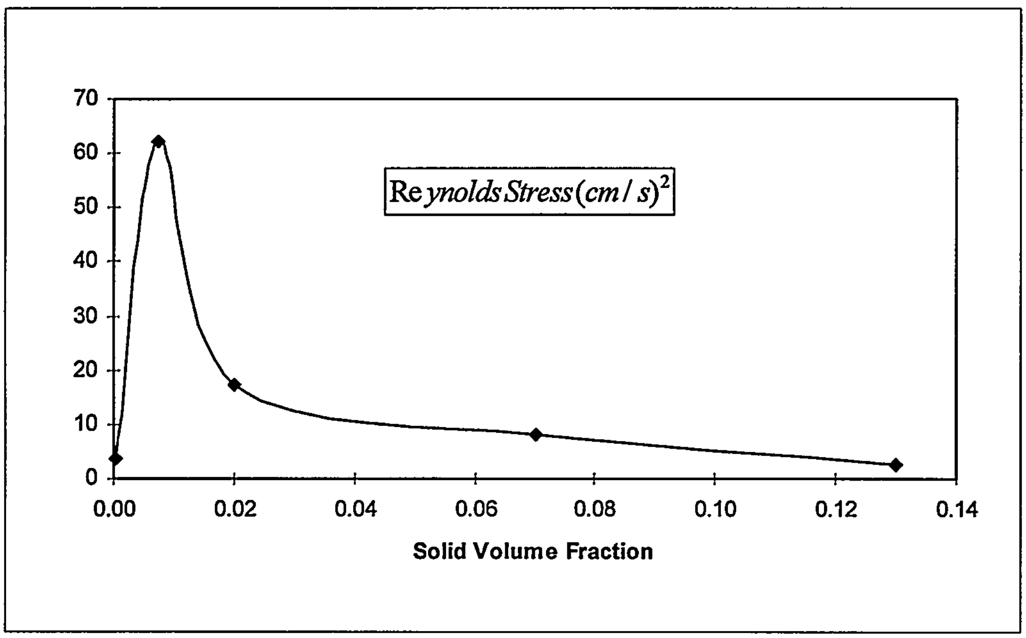

Figure 5 - Particle Reynolds Stress for a three phase bed with $U_g = 2.8$ cm/s

The next set of data are the velocity profiles at different locations obtained to calculate the shear rate. Figures 6 and 7 show particle horizontal and vertical velocity profile variations with the radial distance. These experiments have been done at a height of 29 inches and at a solid volume fraction of 0.13. The shear rate calculated from figure 7 is about 1 sec $^{-1}$. This is very small compared to the value for gas-solid system. The calculated granular temperature of this system is presented in figure 8 . As can be seen there is a great difference in the granular temperature at different locations .

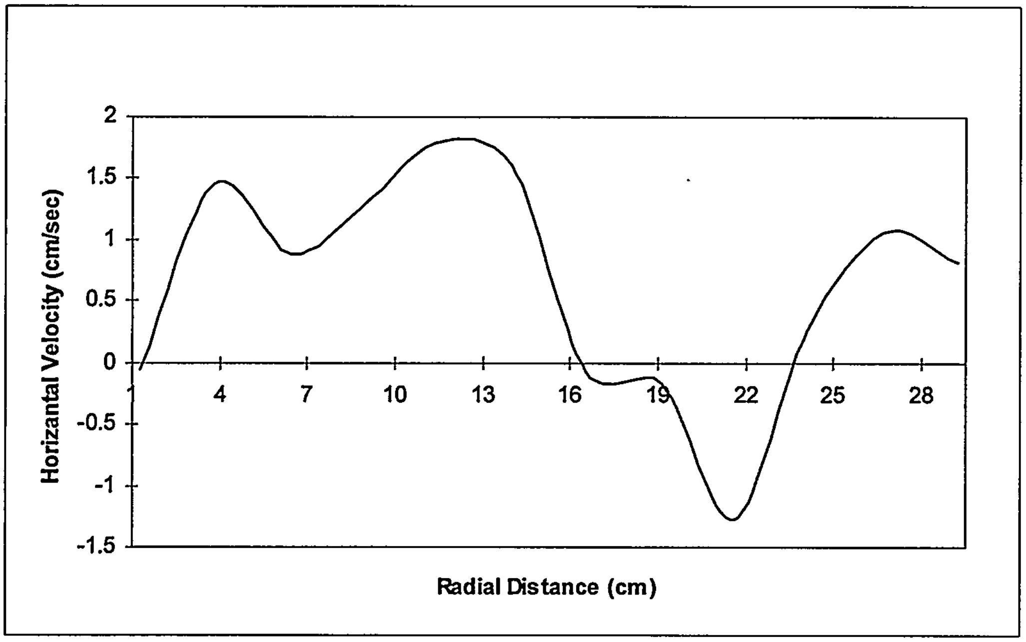

Figure 6 - Solid Horizontal Velocity in a three phase bed

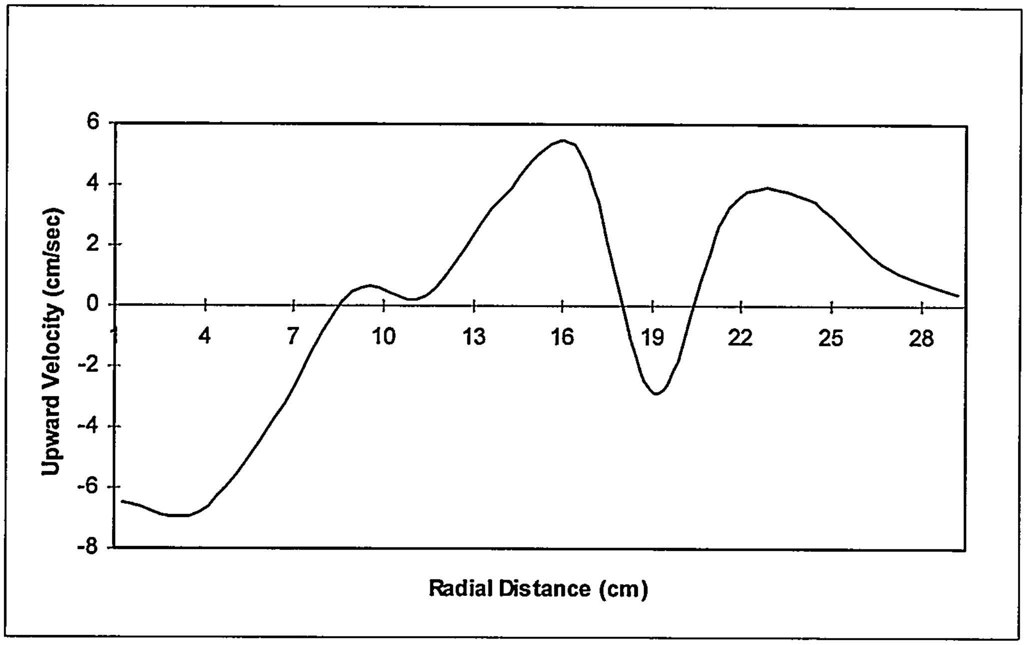

Figure 7 - Solid Vertical Velocity in a three phase bed

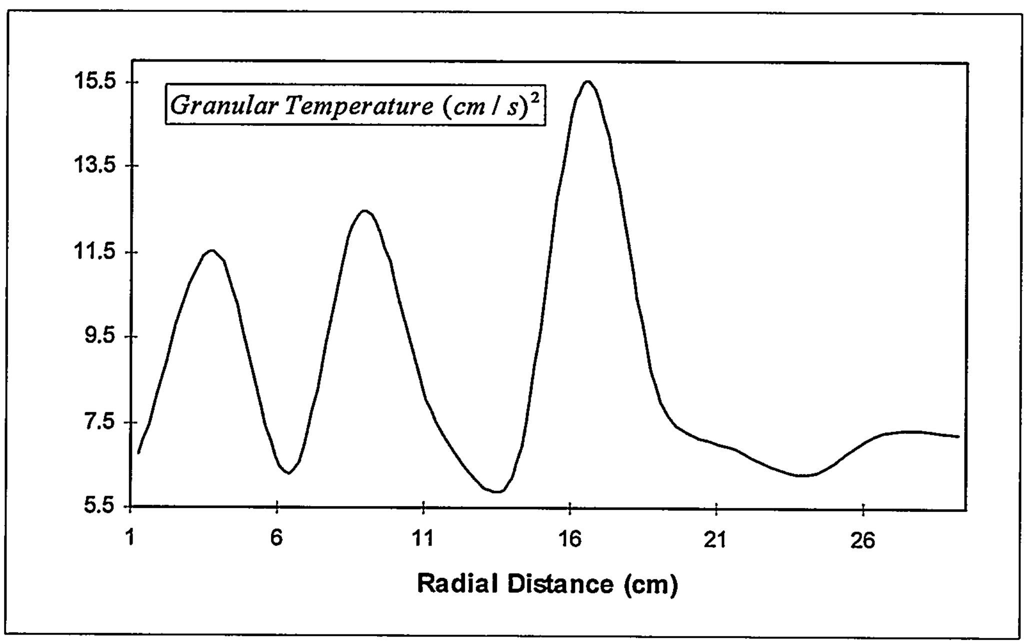

Figure 8 - Solid Granular Temperature in a three phase bed