

Performance Investigation of an Experimental Shale Shaker in Filtration of Water-Sand Slurry

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Outline

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- Shale Shaker
- Particle Dynamics Modeling
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Goal

- ***Experimental***

➢ A bench scale shaker made by M-I SWACO is going to be tested for finding an operating envelop of the shaker in filtration of mud.

- ***Theoretical***

➢ A particle dynamics model This model is going to predict particle motion and position of particles.

Introduction

- Mud is injected into the borehole to lubricate and cool the drill bit as well as convey the drilled cuttings away from the bore hole.
- The drilling mud is one the costly part of the drilling operations.
- Separation of particles from mud is the first process in drilling industry.
- A shale shaker is the first equipment used in drilling operations for separating particles from drilling fluids.

Shale Shaker

- After mud returns to the surface of the well, the used drilling fluid flows directly to the shale shakers where it begins to be processed.

- Mechanism of filtration is controlled by the filter caked formed on the screen.

- Parameters affecting performance of a shaker

  - Acceleration
  - Frequency
  - Deck Angle
  - Fluid Rheology
  - Type of Screen

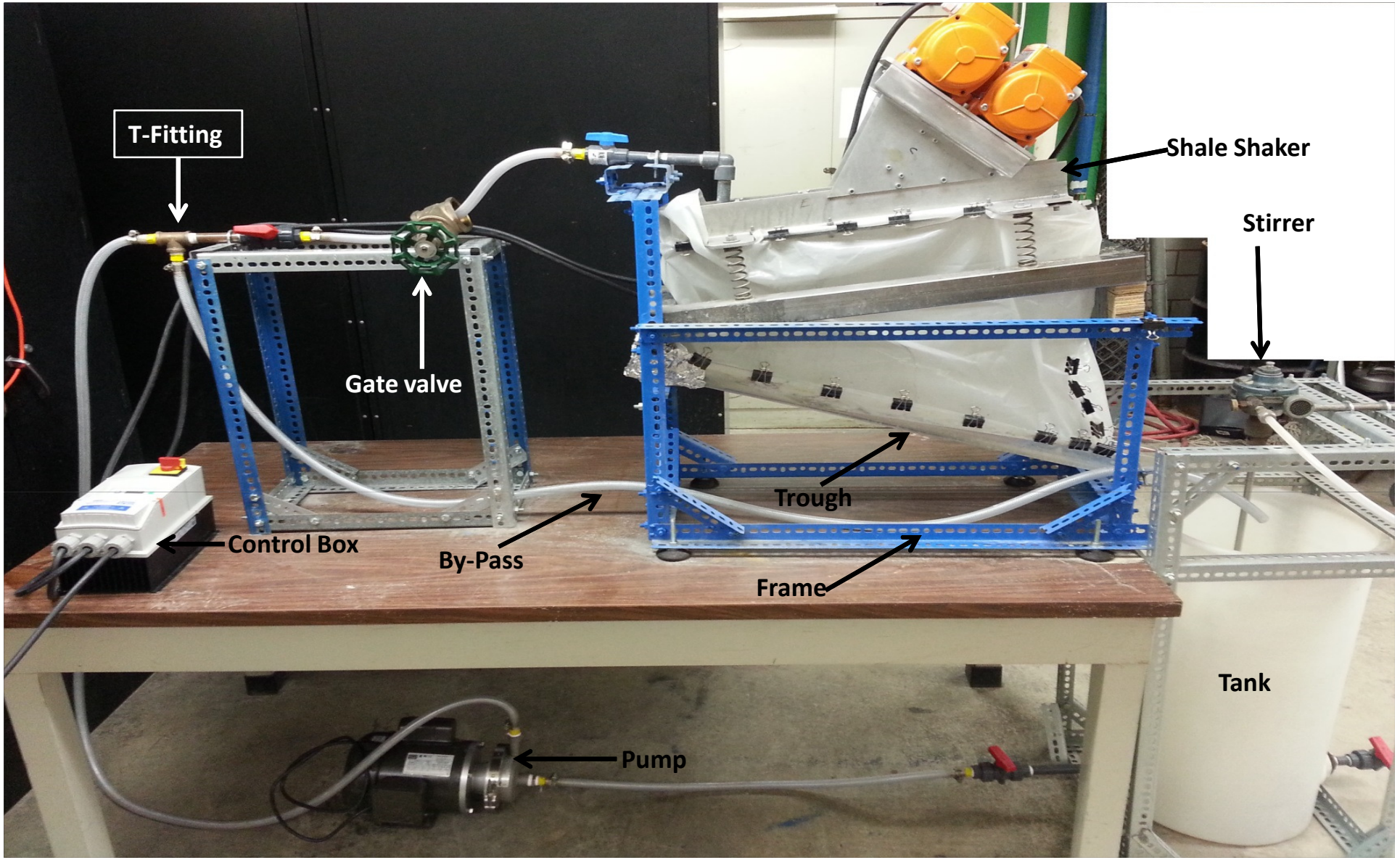


Fig.1) Photo of experimental set up

Particle Dynamics Modeling

- During screening process, the particles move in different directions
- Gravity, buoyancy, and drag force are involved in the modeling.
- When particles pass wall sides, they reenter at opposite wall (Periodic Boundary Conditions).
- Screen surface is treated as an array of spherical surfaces.
- When a particle bounces the screen surface, the location and velocity of particles are unknown so random number generator is used to determine the location of particles.
- Lagrangian approach is used for particle motion.

- Governing equations used in modeling:

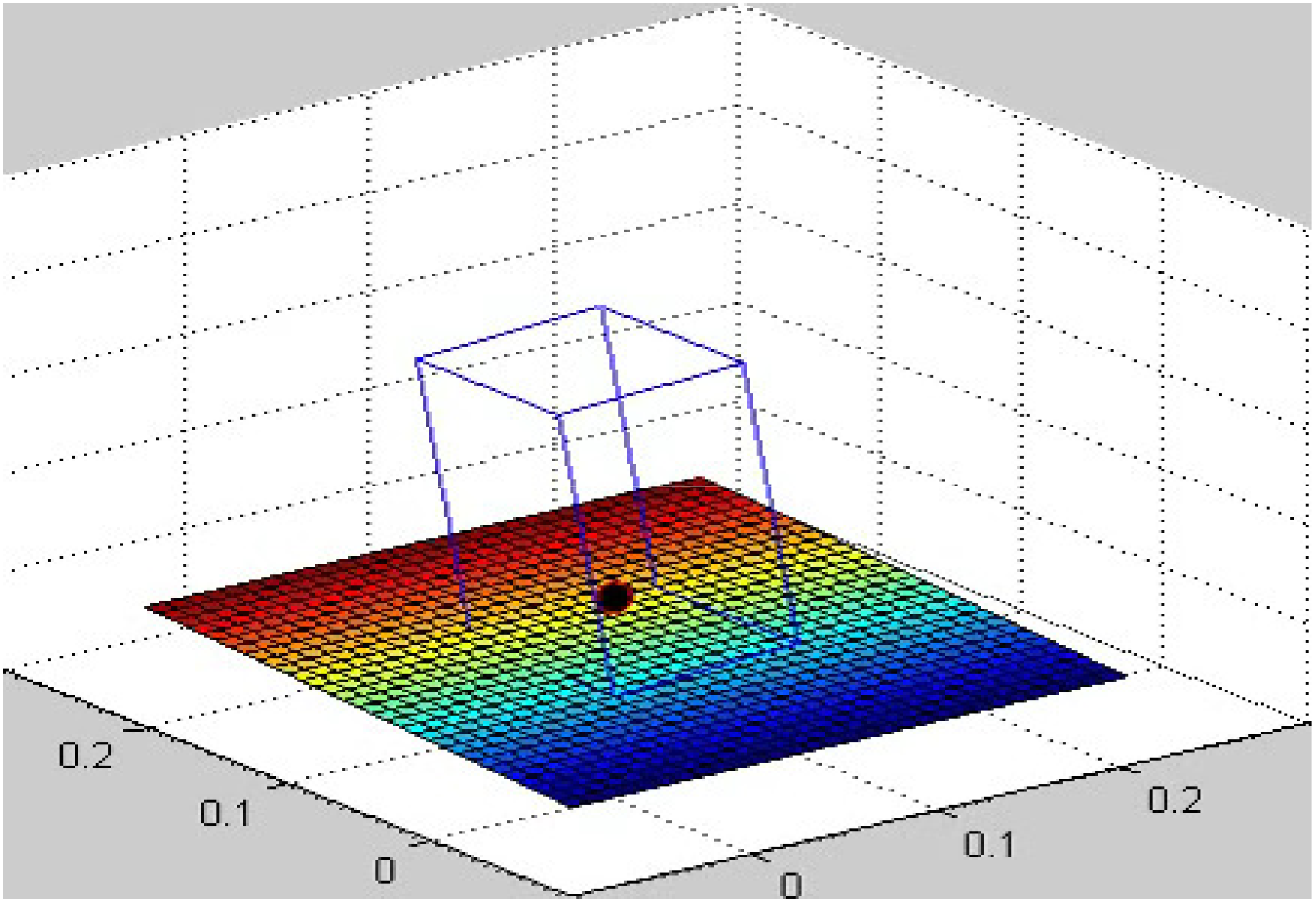
  Force balance:

- $\frac{du}{dt} = g\left[\frac{\rho_p - \rho}{\rho_p}\right] - C_D \frac{A_p}{2v_p}\frac{\rho}{\rho_p}|u|u \;\; ;$ **(1)**
- Screen surface is determined by (r,θ,φ) coordinates. This coordinates shows the direction.

- By analyzing velocities components on the screen, the resultant velocity after collision is calculated by
- $\vec{R} = \vec{u} - (2(\vec{u} - \vec{w}).\overline{n})\overline{n}$ **(2)**

- $\vec{u}$: $particle\ velocity\ \ before\ collision$; $\vec{w}$: $Screen\ velocity$; $\overline{n}$: $unit\ vector\ of\ screen\ at\ the\ point\ of\ collision$

- $$\begin{cases} w_x = \frac{A_x}{2\pi f}\sin(2\pi f t) \\ w_y = 0 \\ w_z = \frac{A_z}{2\pi f}\sin(2\pi f t) \end{cases} \quad (3) \qquad \begin{cases} \theta = \frac{\pi}{2}r_1 - \frac{\pi}{4} \\ \varphi = \frac{\pi}{2}r_2 - \frac{\pi}{4} \\ -\frac{\pi}{4} \le \theta \le \frac{\pi}{4} \\ 0 \le \varphi \le 2\pi \\ 0 \le r_1, r_2 \le 1 \end{cases} \quad (4)$$



Video.1. Tracking of tow particles coded in MATLAB

Motor Weight (Acceleration)

- The shaker's vibrators usually run at a constant frequency, thereby generating a constant force

- The rotating eccentric weights on a shale shaker are used to vibrate the screen.

- Screen motion in this shaker has elliptical model

- Masses on the two motors are rotating in opposite direction (clockwise-counter clockwise), the net force on the shaker channel is zero except along a line passing through the gravity center.

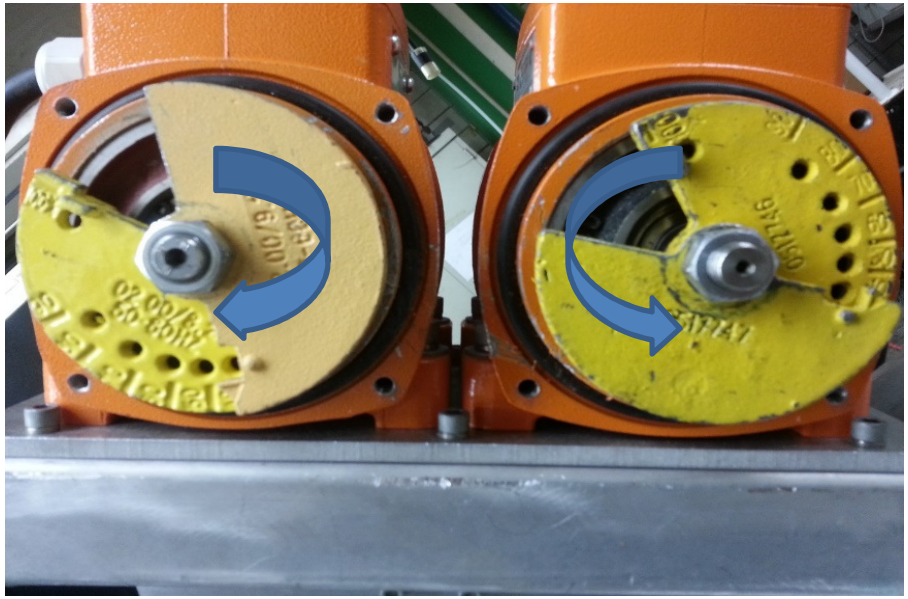


Fig.2) Meaning of motor weight

- These Rotating masses offset are referred as motor weights.

- Weights are two rotating eccentric mass inside two motors. These two weights is spinning in two different directions to keep motor balances and neutralize forces generated by two motors.

- For each motor rotating masses offset, acceleration in three directions, Ax ,Ay, and Az, are measured for each frequency.

- Fig.3 shows the example of meaning of motor weight. Each motor weight is representative of the range of acceleration for different frequencies.

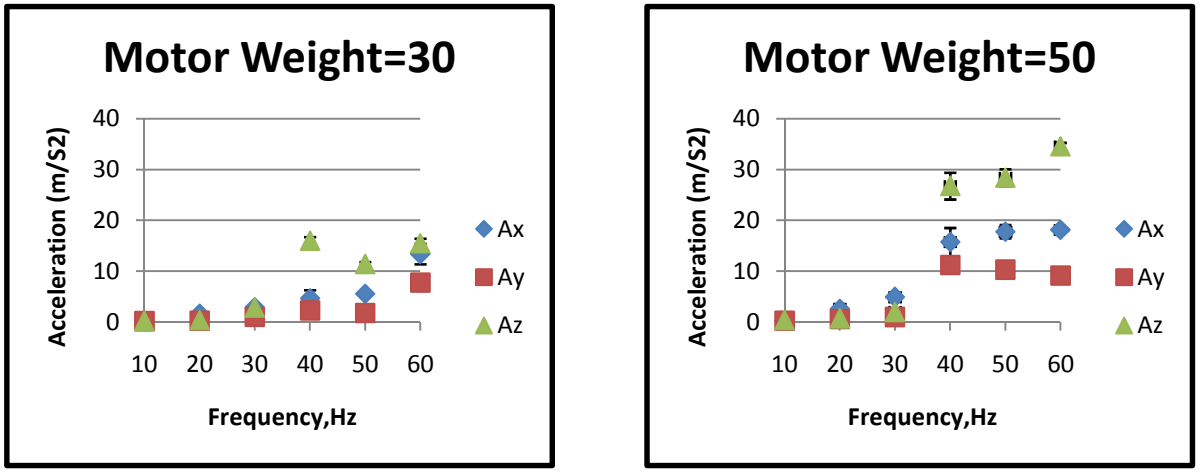


Fig.3. Example of acceleration and frequencies range

- Each motor weight should accompany a graph to clear acceleration and frequency range.

Experiments Procedure

- The screen used in this research is XR 120. Number shows mesh number.

- The experiments were done with sand concentrations 2, 4, and 6%. In each sand concentration, the motor weights 40, 60, 80, and 100 were tested.

- For each motor weight, deck angles 3, 5, 7, and 10 degree were investigated. In all tests, the frequency changed from 10 through 60Hz (working frequency was 60 Hz).

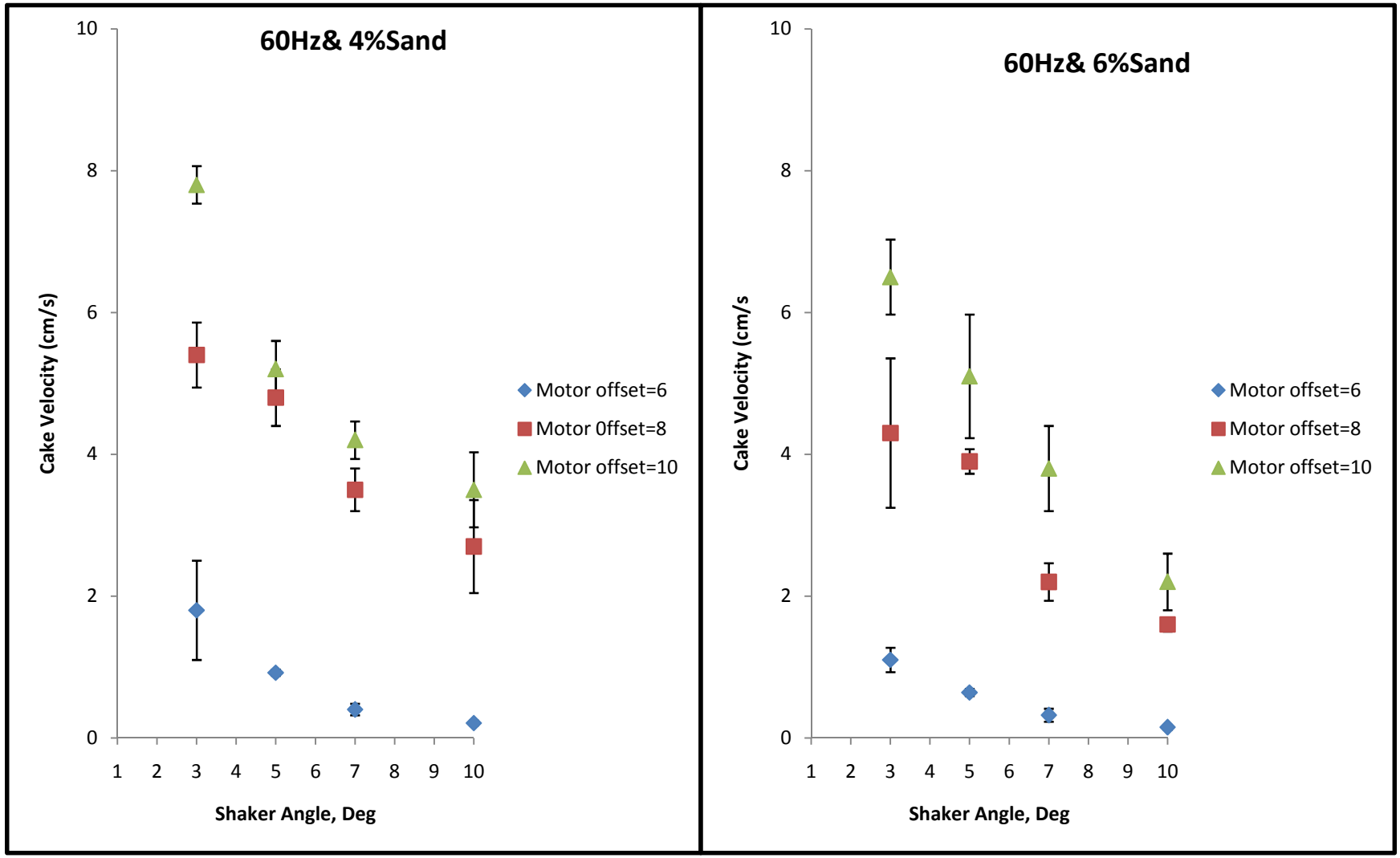


Fig.4) cake velocity of sand leaving out channel for 4 and 6 % sand

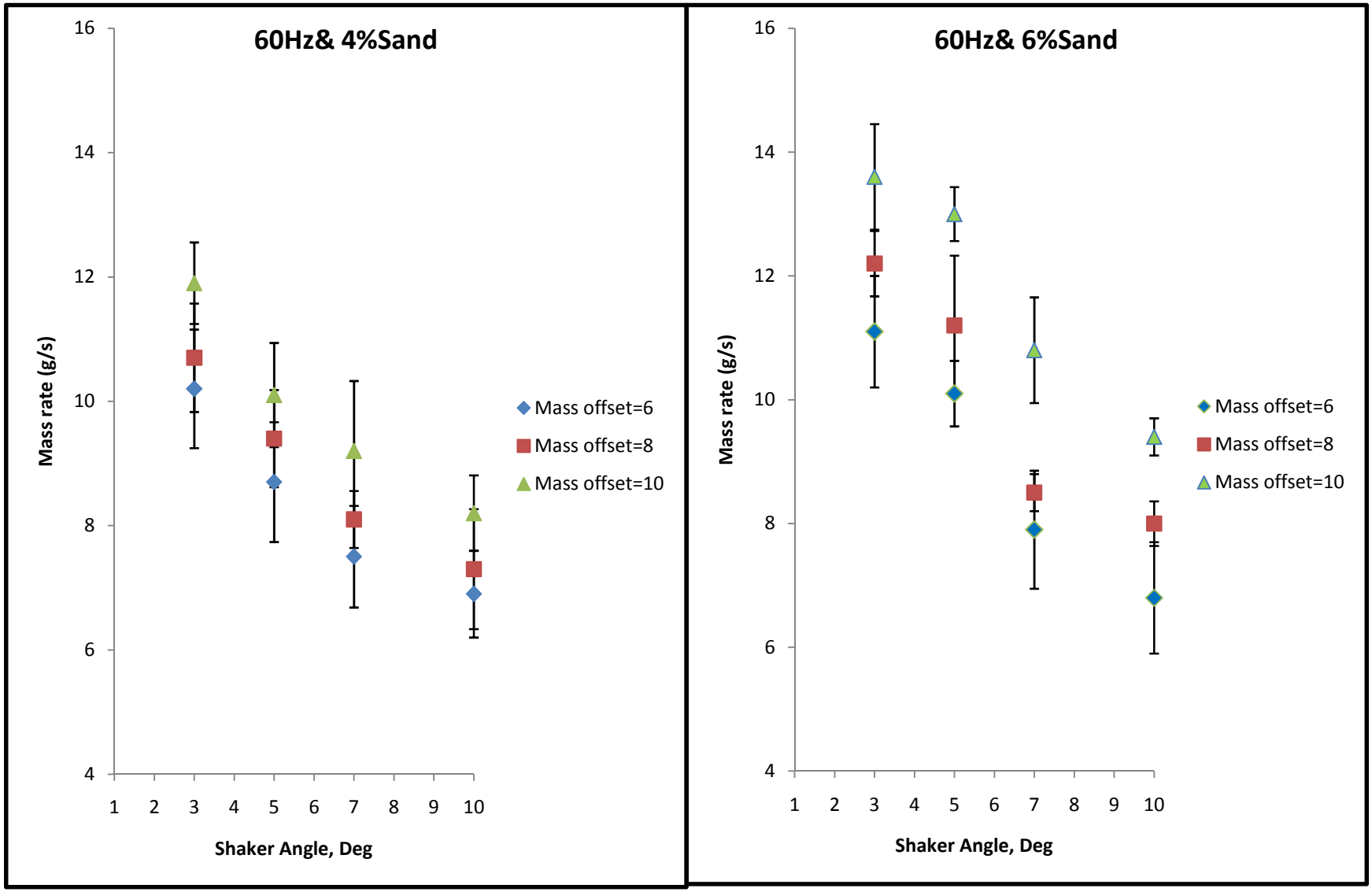


Fig.5. Mass flow rate of sand leaving out channel for 4 and 6 %

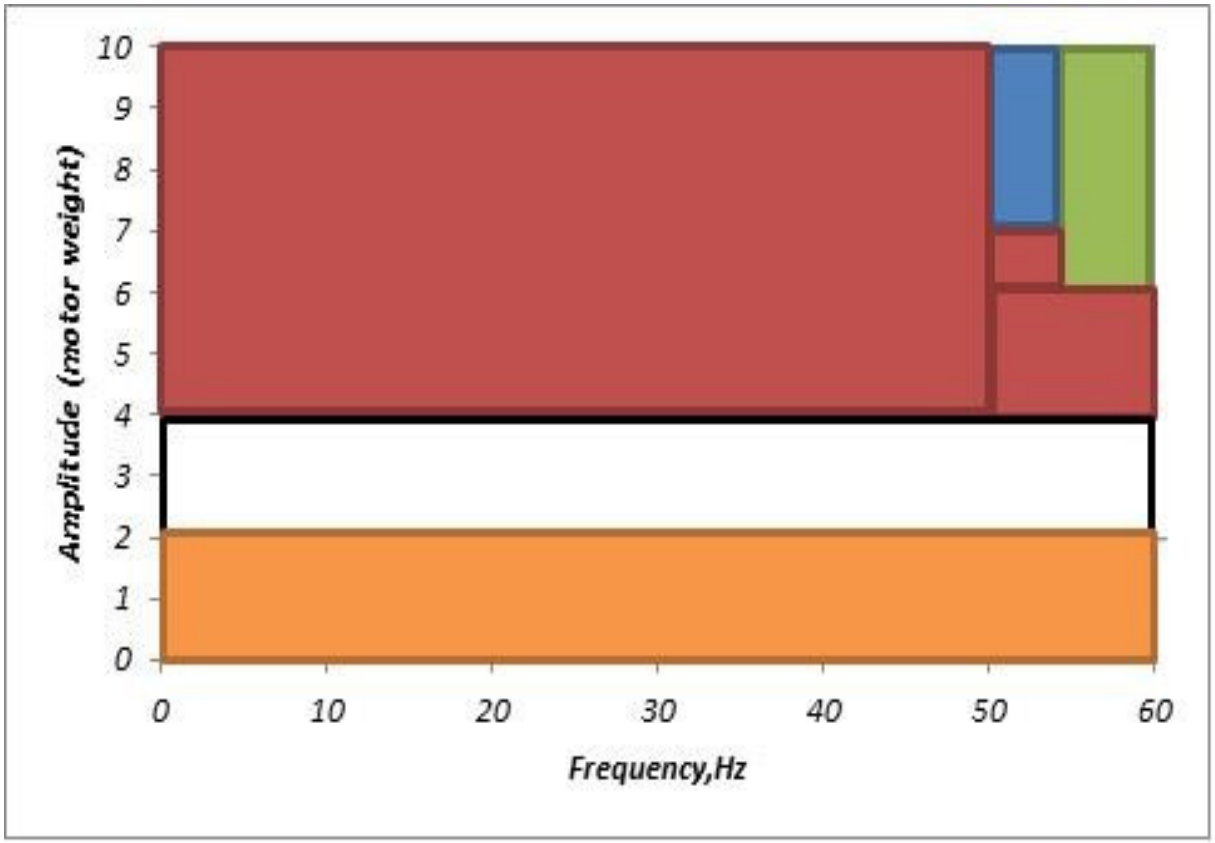


Fig.6. Operating envelope of shale shaker

Did Not Attempt Experiments

Channel Flooded

Plugs



Clumps



Flat Cake



Results

- Frequency 40Hz is a resonance frequency. The shaker is not stable in this frequency.
- In an shale shaker , vibration acceleration depends on frequency of vibration
- The shaker did not separate in the frequencies less than 60Hz
- The shale shaker works best with slurry concentrations of 2%
- For 2%,sand leaving out the channel is in form of clumps rather than flat cake.
- Results for 4 and 6% sand concentration showed that the shaker is more sensitive to amplitude than for 2% sand concentration.
- Tests results for angles 3 and 5 deg showed that frequency had great effect on the filter cake form.

Thank you for your attention

Questions?