



Project no.043386

TRIGS

TRIGGERING INSTABILITIES IN MATERIALS AND GEOSYSTEMS

Sixth Framework Programme (FP6) - STREP

New and Emerging Science and Technology Pathfinder (NEST)

Deliverable n. 4.2.2

The experimental datasets on granular size effects and a synthesis report will be provided for the general community via the Web, to assist with theory and model validation, and for comparisons with other experiments

Due date of deliverable: 31-12-2008

Actual submission date:

Start date of project: 1-1-2007

Duration: 36 months

Organisation name of lead contractor for this deliverable: CNR

Diffusion Level: PU

Revision: 1

Author: Fergal Dalton, ISC/CNR.

Introduction

For introduction, please see deliverable D4.2.1.

The principal data sets relevant to this deliverable are:

- Tests of the (granular) solid-on-solid experiment
 - <http://trigs.artov.isc.cnr.it/twiki/bin/view/TRIGS/Task12Expts070808>
- to investigate the effect of different GM - 2mm and 1.5mm glass beads
 - <http://trigs.artov.isc.cnr.it/twiki/bin/view/TRIGS/Task12Expts0804>
- 'granular' solid-on-solid experiments
 - <http://trigs.artov.isc.cnr.it/twiki/bin/view/TRIGS/Task42Expts070927A>
- to investigate the effect of changing the height of the granular bed
 - <http://trigs.artov.isc.cnr.it/twiki/bin/view/TRIGS/Task42Expts071002>

In addition a synthesis report has been published on the Twiki platform [???AND ON THE MAIN TRIGS WEBSITE???] at:

- PLEASE INSERT APPROPRIATE TWIKI ADDRESS
- ???PLEASE INSERT APPROPRIATE MAIN TRIGS WEBSITE ADDRESS???

Both the synthesis reports and the experimental datasets are public, freely available for comparison with existing literature. The synthesis report is reproduced below.

Synthesis Report on experiments in Granular Size Effects conducted by CNR

The experiments conducted in this section are an attempt to establish what, if any, finite-size effects are present when a granular medium is sheared by an external force. We have attempted two different approaches to the argument:

1. By changing the depth of the granular bed
 - o 0, 1.5, 2, 3, 4, 5, 7, 9, 13 layers of material
 - o Drive velocity = 0.01, 0.1, 1, 10 rad/s.
2. By changing the size of the constituent granular particles
 - o 080401AA: 1kg 2mm glass beads
 - o 080401AB: 1kg in ratio 2:1 by weight of 2mm and 1.5mm glass beads
 - o 080401AC: 1kg in ratio 2:1 by weight of 2mm and 1.5mm glass beads

1. Changing the depth of the granular bed

The former approach varied the quantity of granular material in the channel, adjusting the height of the false floor as necessary. The quantities of GM used corresponded to approximately 0, 1.5, 2, 3, 4, 5, 7, 9 and 13 layers of GM, and the drive velocity was also varied from 0.01 to 10 rad/s. Here we find a clear alteration in behaviour as material is added, moving from a solid-on-solid state (0 layers), through what seems to be a lubricated phase, to a granular shear phase. As GM is added at a given driving velocity, the device tends from stick-slip motion to a steady-sliding state in which more energy is dissipated by particle collisions and the torsion spring unwinds less. A selection of illustrative graphs are shown below, and further results are available at <http://trigs.artov.isc.cnr.it/twiki/bin/view/TRIGS/Task42Results071002>

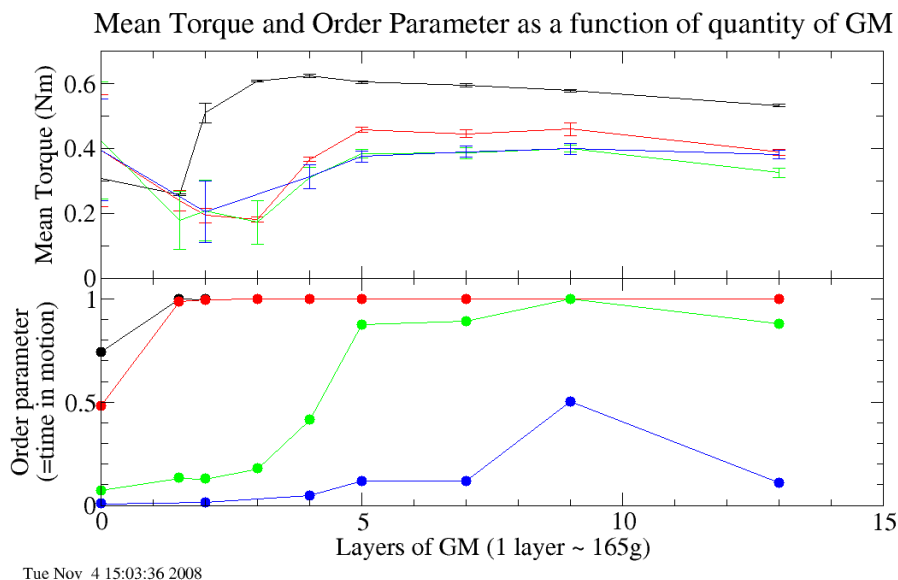
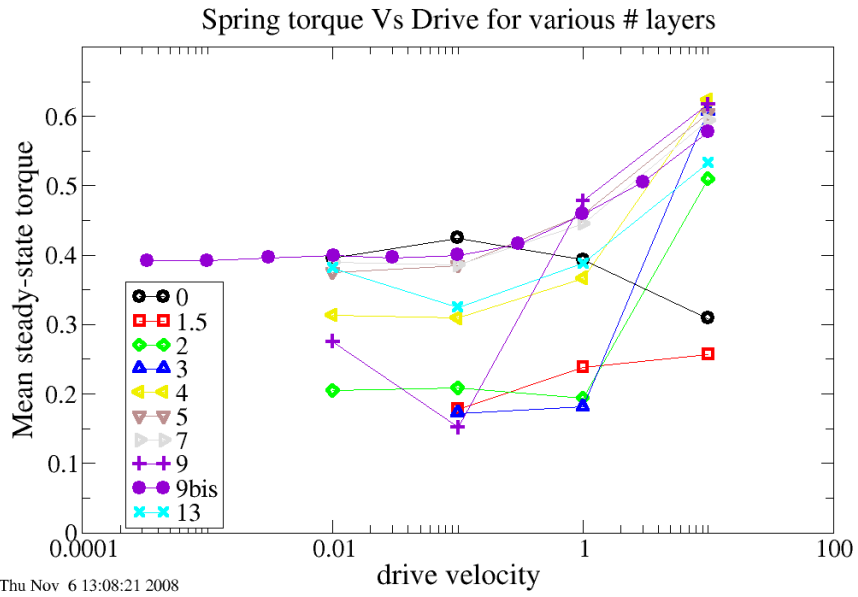


Fig. 1: This graph illustrates the general behaviour of the device as layers of GM are added (x-axis). The torque initially reduces (lubrication) before increasing again at 5 layers as granular dissipation comes into effect. The Order Parameter (measured as the fraction of time in motion) always increases to an asymptote which depends on the driving velocity (except for some anomalous points).



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Fig. 2: The same data as before is presented as a function of the drive velocity for varying number of layer of GM. The solid-on-solid (0 layers) is a decreasing function, followed by an intermediate state with low friction at low velocity, reaching a final (almost) constant regime at 5 layers with a high low-velocity torque which increases further at high velocity.

Duration distribution, considering velocities $\omega > 1$ mrad/s or $\omega > \omega_D$ rad/s
 $\omega > \omega_D$ (drive)

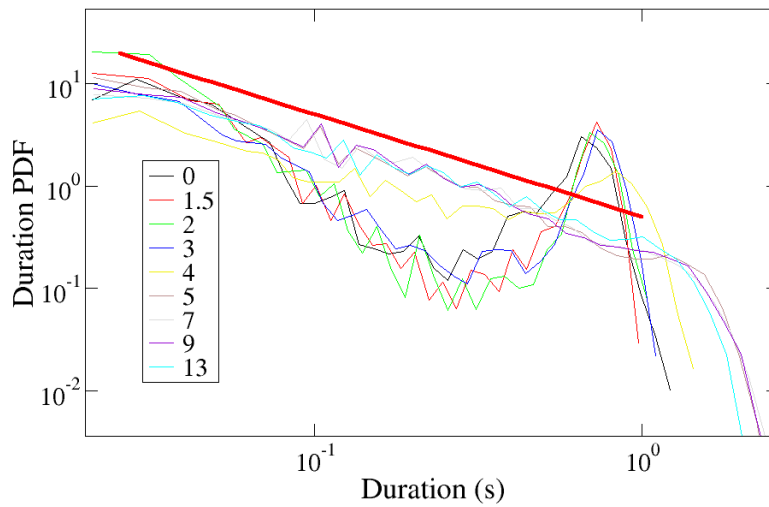


Fig. 3: The distribution of slip-event durations as GM is added. The resonant peak due to the inertia of the Top Plate is replaced by a power-law distribution of events.

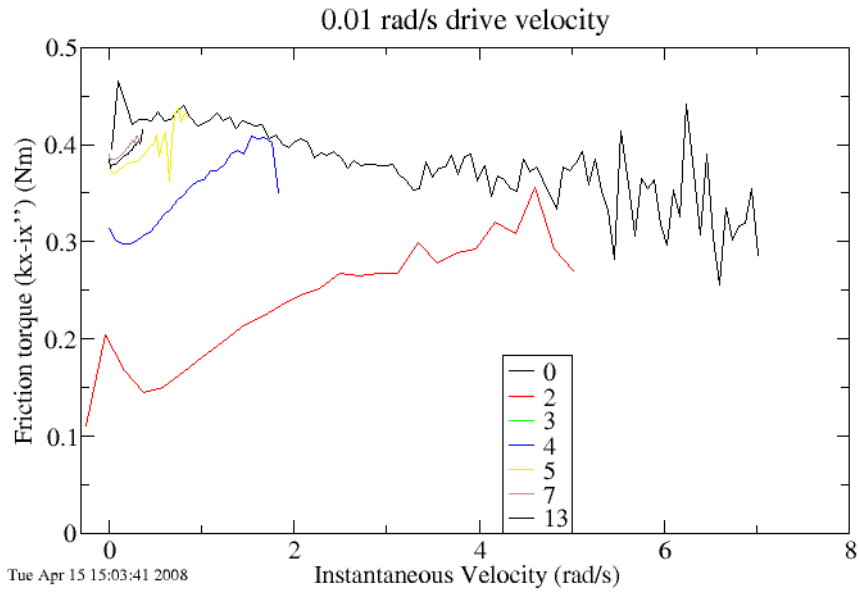


Fig. 4: For drive velocity $\omega D=0.01$ rad/s, the solid-on-solid friction force is a decreasing function of velocity (but with almost constant negative 'viscosity'), while granular friction shows first a decrease then an increase in the force; i.e. is shear-strengthening.

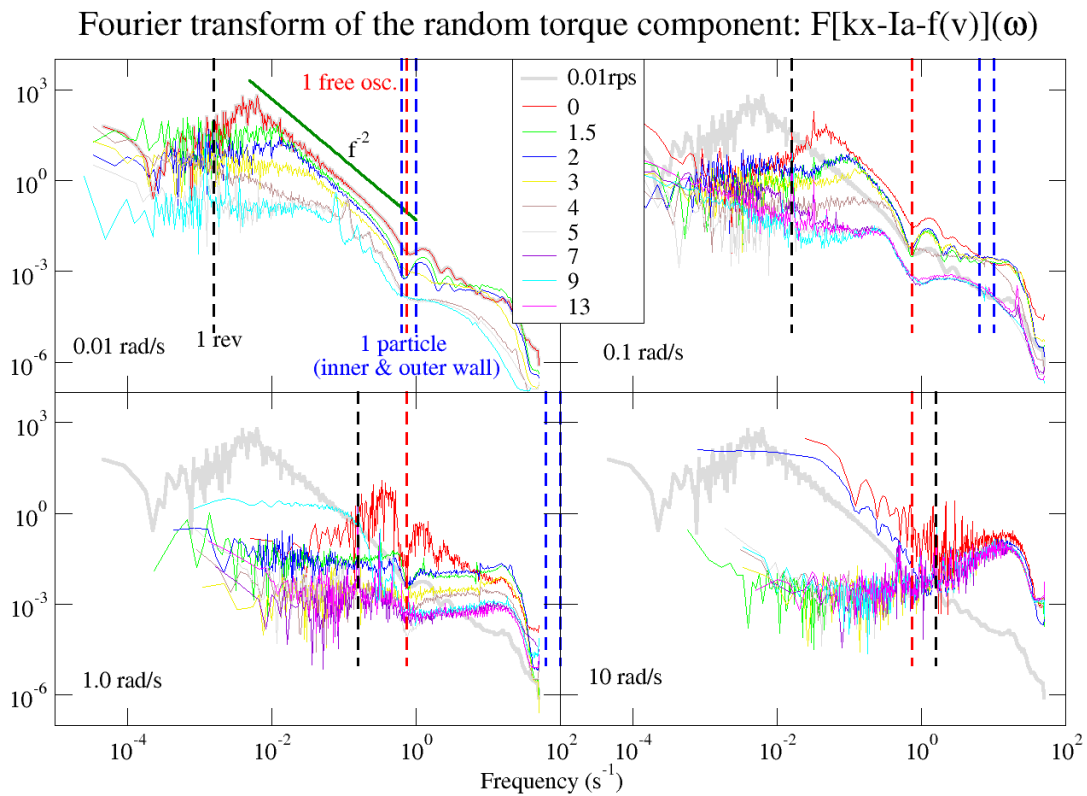


Fig. 5: The power-spectrum of the random torque component for various drive velocities and layers. The thick dashed vertical lines correspond to (black) the frequency of a single revolution at the given drive, (red) the frequency of a natural oscillation of the top plate and (blue) the frequency at which the top plate passes single particles positioned at the inner and outer walls. The curve for 0 layers & 0.01rps is reproduced in all graphs for comparison (grey). The device seems to display a $1/f^2$ spectrum principally between the revolution & natural oscillation frequencies of the top plate, though there are some anomalous results. At 1 rad/s the device is fully fluidised (with the exception of solid-on-solid) and displays either a white or blue spectrum.

2. Changing the size of the granular particles

The latter approach consisted of the alteration of the mix of granular medium over which the top plate sheared. All experiments consisted in cycling the drive velocity with a triangular signal, and observing the torque subtended at the different velocities. Surprisingly, the second experiment exhibited a torque curve almost 50% higher than the first, which result was initially attributed to the finer particles filling more voids and creating more contact points, however a repeat of the experiment returned the torque curve to its original position.

Further analysis revealed that some anomalous sources of friction had developed, believed to originate in channel asperities and/or ball bearing dirt. For this reason the experiments were not pursued in greater detail, choosing instead to focus on analysis of the former approach. Though there are some differences between the curves, for example, the friction increases more from the zero-velocity point for the mixture than for the mono-disperse material, it is not possible to obtain qualitative or quantitative results without additional data. Through the acquisition of a torque-meter, it is hoped that such experiments will be possible, and avoid the complication of the oscillating torsion spring.