Batch mixing study of granular agro-food materials in an innovative mixer: the T ○

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Materials and Methods

✓ Particulate system used

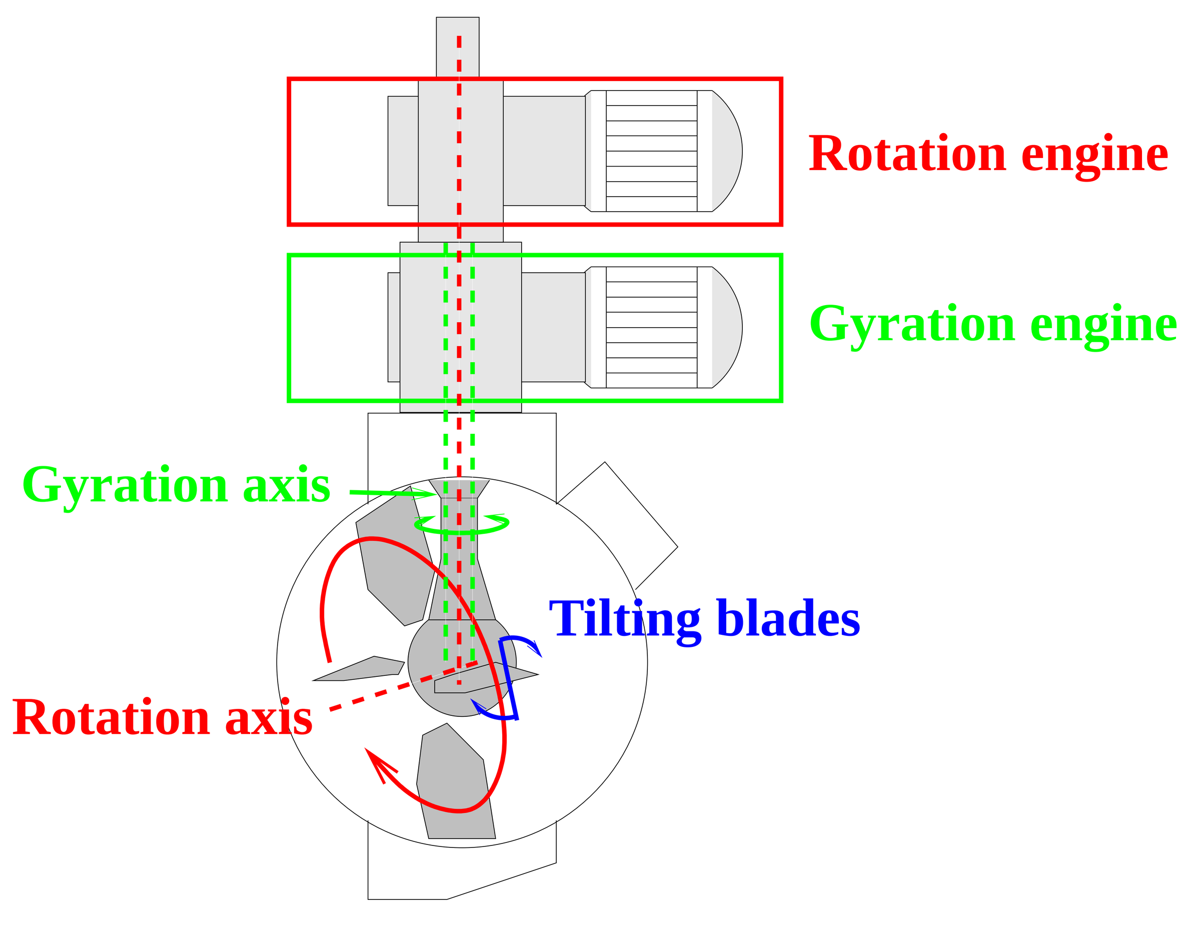
The solids used are agro-food products of different flow properties: free flowing powders as well as a cohesive powder.

Density $\left[\,g \cdot cm^{-3}\,\right]$	Lactose	Semolina	Couscous
True	1.54	1.47	1.44
Aerated	0.63	0.76	0.72
packed (500 taps)	0.90	0.82	0.76

Various densities of the products

Diameter $[\,\mu m\,]$	Lactose	Semolina	Couscous
d_{10}	20	200	1100
d_{50}	70	340	1400
d_{90}	140	840	1800
$Span = \frac{d_{90} - d_{10}}{d_{50}}$	1.71	1.88	0.5

Characteristic particle diameters



The T ○

✓ The T ○ an innovative mixing system:

→ We fill the spherical tank with a volume of powder of 48 L,

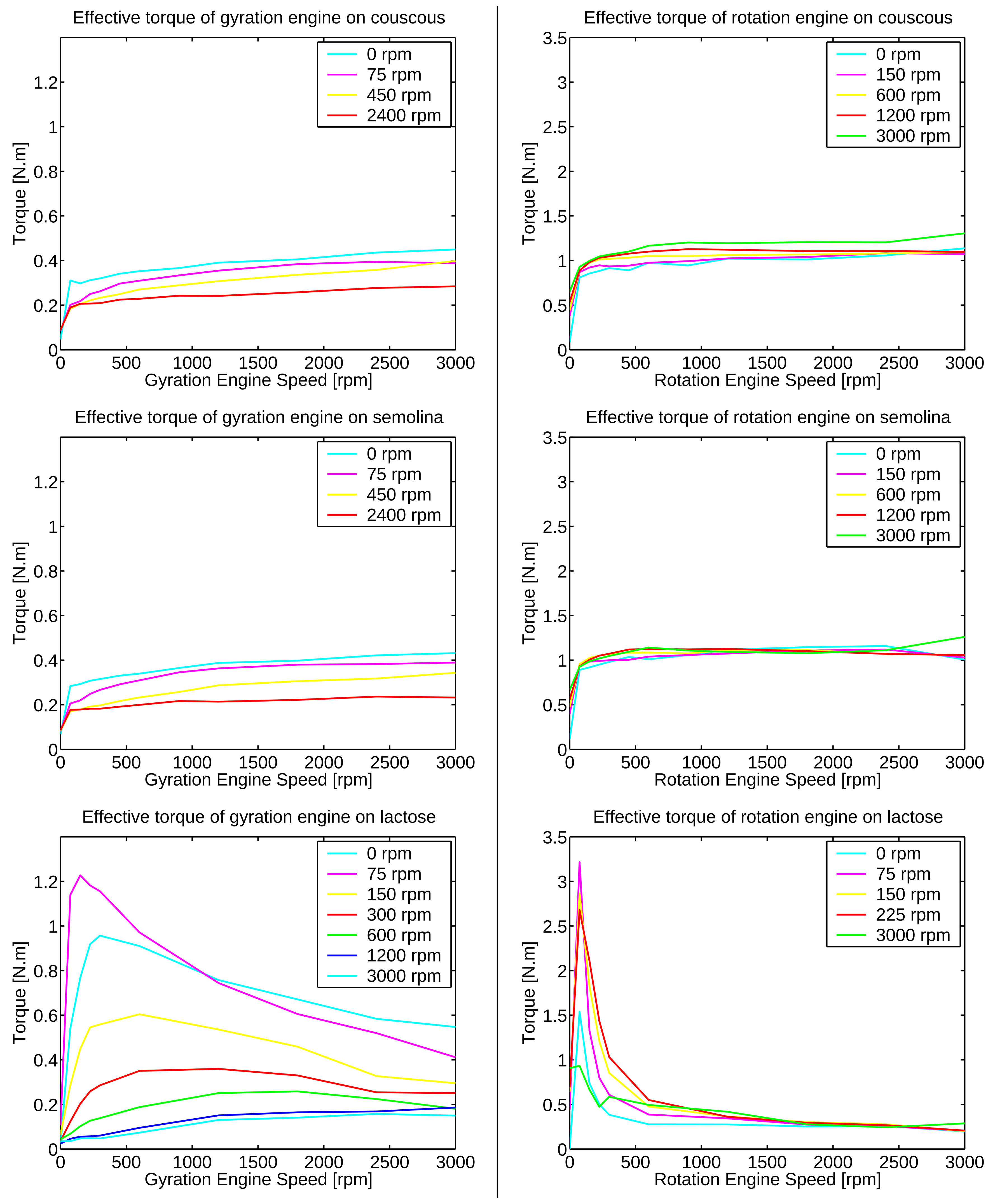
→ The 2 S U ○ engines of 375 Watts controlled by 2 turntables M ○ allow us to use differents combination of stirring velocities – rotation from 0 to 90 rpm and gyration from 0 to 21 rpm,

→ We measured the torque developped by the engines with 2 S ○ rotary torquemeters placed between the engines and the axis of revolution,

→ The acquisition is carried out with a N I ○ card PCI-6023E and a software developped with LabVIEW○,

→ We test clockwise direction for the gyration, and we fix the angle of the tilting blades to 45°,

Results and discussion



Torque measured on a driving shaft according to its speed. Each series corresponds to a speed of the other engine. Each graph corresponds to a couple product/engine.

We get free from the mechanical losses by cutting off the values of torque from no-load test with those under loads:

$T = T_{in\,load} - T_{no\,load}$

Then we calculate the power consumption (N_{GE} and N_{RE} the speed of the engine of gyration and rotation): $P_C = P_G + P_R$ with

$P_G = (T_G - T_{G_{nl}}) \cdot 2\pi \cdot N_{GE}$ and

$P_R = (T_R - T_{R_{nl}}) \cdot 2\pi \cdot N_{RE}$

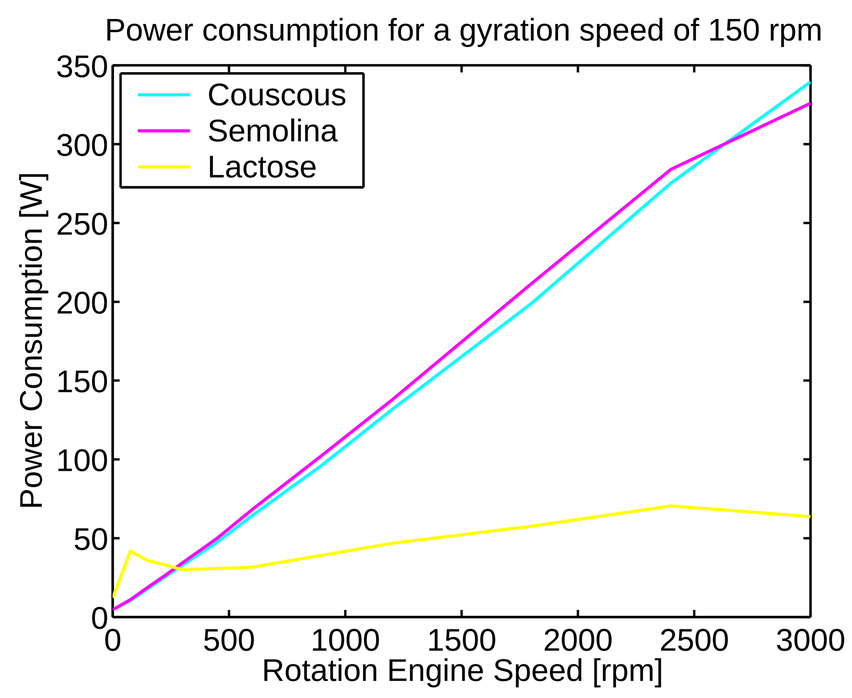
Each graphics describes, for a couple Product/Engine, the useful torque developed by the engine according to its speed. The different series correspond to various speed of the other engine.

The effective torque is mainly brought by the rotational movement.

In rotation or gyration, we always observe a phase of growth of torque with speed, and a plateau phase. For the cohesive powder, there exists a maximum between these two phases, corresponding to a "critical" speed.

Once the lactose is in motion, it seems to be slightly fluidised, which decreases the interparticle cohesion forces. The torque required is therefore less important.

The torque developed by the engine of gyration depends on the speed of the engine of rotation. It may be argued that the torque brought by the engine of rotation facilitates the displacement of the axes of gyration within the product. On the other hand, for each speed of the engine of gyration, the torque developed by the engine of rotation is appreciably the same one.



Comparison of the power consumption for the 3 products for a speed of gyration of 150 rpm

The power consumption for lactose is lower than for couscous or semolina after the "critical" speed of 300 rpm. Moreover, it is interesting to note that the mixer never consumed more than 450 W to put 48 L of product into motion. We can estimate the specific power to 15.6 $W.kg^{-1}$ for couscous, 13.2 $W.kg^{-1}$ for semolina and 5 $W.kg^{-1}$ for lactose.

Conclusions and Perspectives

⇛ This mixing system is very interesting in term of power consumption: the T ○ has never consumed more than 450 W for 48 L of free flowing powder and 100 W for 48 L of cohesive powders.

⇛ The use of adimensionnal numbers as Reynolds, and Power Number will improve the comprehension of phenomena of mixture in the T ○.

⇛ We will characterize the quality of the mixture in term of homogeneity with an online image analysis method. And we'll try to connect the results to the operating conditions.