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Analysis Of Locus Of Point On Rotating Disc In The Proposed Mechanism For Delivering Sago Granules

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Abstract

In a novel mechanism for delivering sago granules in a disc rotating about an inclined axis plays the vital role. It is observed that the locus of a point on the rotating circular plate tends to move away from the centre, which confirms the delivery of sago granules from the plate when system of force applied in that point. This study is carried out through analytically as well as numerical simulation using ADAMS package. These results will provide some insight into the scaling transformation analysis and fabrication of the automatic simple granulation machine which enhances the granular production minimizes the granulation difficulty and labour requirement.

***Keywords**: Sago, Granulation, Point*

1. Introduction

Granulation is one of the methods of processing powder materials into granulated products which are more suitable for storage, transport and further processing. The process consist the formation and growth of particles in a rotating drum or in a disc. This study will focus on the granulation of powder particle using a disc granulator as this equipment gives a product with high density and high sphericity. The efficiency of wet granulation process using disc granulator depends on many factors including binder content, rotational speed, surface roughness, size of plate, starch content of the raw material. This study provides analytical and numerical solutions for locus of particle in granulator mechanism. Several analytical as well as experimental studies have been performed for particle trajectories. Nakagawa [1] performed DEM simulation and checked against MRI result for granules flows in a rotating cylinder. From the Heim [2] observation the value of reduced torques are higher for big diameter disk in the disk granulation process and also the angle of disk inclination on the reduced Torque was observed significantly. Heim [3] proposed the model for bed dynamics during the drum granulation by dimensionless equations and presenting the relation between power number Froude number and dimensionless parameters. Also he [4] showed a significant effect of bed wetting parameters on the kinetics of wet drum granulation and presents the effect of jet break up on the granule related to surface tension. Grift [5] analysis showed that the friction coefficient can be measured using a single radial velocity measurement of particle at a distance of 4m from the edge of the disc. The data showed that the larger particles attained slightly higher velocities than the smaller ones, and the friction coefficients showed a moderate inverse relationship with the particle diameter. Rioul [6] presented a dynamical transition between a rolling and sliding at the regime and also the purely sliding regime as function of the friction coefficient and elongation of the particle.

Vilketel [7] demonstrates that the every velocity component can be deduced from the horizontal outlet angle measurement and the rotational speed. Rioul [8] studies the trajectory of solid spherical particle bouncing at high velocity along the rotating plate with accurate statistical analysis of the trajectory for both radical and angular velocity. Montira [9] experiment results indicated that the growth of cassava pearl was very sensitive to binder content. At the initial stage to granulation stage (after 4 minute), cassava peal obtained from all treatments exhibited the maximum growth rate. Also showed that particle size enlargement decreased as the binder content increased. The result of drum filling degree indicated that growth behaviour of cassava pearl is dependent on drum filling degree. Alexadru [10] studied that the functional optimization of wiper mechanism was made by using virtual model

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which was realized with ADAMS software. The optimization will be described as parametrizing the model, defining the design variables, performing studies to identify the main design variables and constraints. SitiMazlina [11] replacing the method of extracting sago starch by integration of both blending and mechanized squeezing into one unit operation aided by controlled amount of water. Labour and energy requirements could also be reduced reasonably owing to the fact that a few separate steps are combined into a single unit operation.

2. Present process & Innovative concepts

Traditionally wet starch is agglomerated in a cloth cradle which is used as a generator until larger granules are formed. Use of cloth cradle as a granulator can cause many problems because quality and productivity of granules produced from cloth cradle depend entirely on human skill. Additionally it makes it difficult to follow Good Manufacturing Practice (GMP) guidelines and regulations. In order to overcome these problems and achieve higher productivity, a new type of granulator need to be developed for powder granulation. In this new mechanism, delivery of various dimensions of granules can be obtained by varying rotational speed of circular plate. When sago powder is spilt on the rotating circular plate, the spherical shaped sago balls are formed by the addition of sprinkling water. The formed sago granules are in globules size and are roll over the edge of the circular plate and finally pushed out of the circular plate due to the centrifugal force.

3. Analytical Models

In analyzing motion the first and most basic problem encountered is that of defining and dealing with the concept of position and displacement. So the position of the point must be defined in terms of some reference coordinate system.

- Origin provides a location from which to measure the location of point.
- Coordinate axes provide the direction along the measurement are to be made and also provides the lines and planes for measurement of angle.
- Unit distance along the axes provides a scale for quantifying distances.

The coordinate of a point P (x, y, z) in the XYZ coordinate reference frame which is rotated θ radians around the ZZ axis. The coordinates and new position of the point P*(x', y', z') can be expressed as in the equation (1) are only considering the rotational transformation and its position can be investigated by numerical iterative approach and initially substituting the values as follows, Initial coordinate conditions: X=Y=Z=1, transformation angle: 30^0

$$x' = x.\cos\theta - y.\sin\theta.$$
$$y' = x.\sin\theta + y.\cos\theta. \quad (1)$$
$$z' = z.$$

From the positional results obtained from the equation (1) is shown in figure 1 it can be concluded that the rotational motion of the point is deviated from its circular path as the displacement range of 7.17958 $x10^{-9}$ units for one complete rotation in the X coordinates.

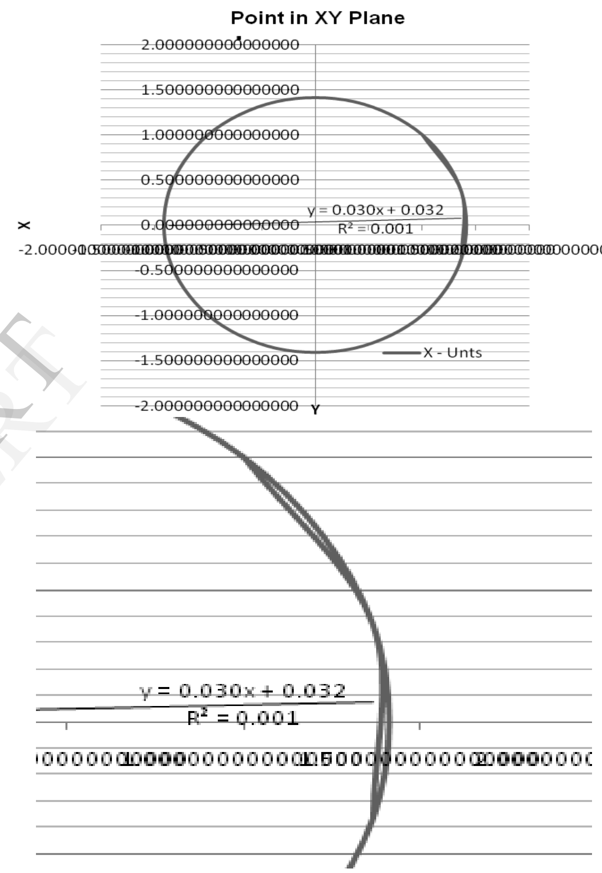

Figure 1 Graphical plot for moving point deviation in XY plane

4. Software Models and Simulation

The virtual model of the sago sizing mechanism has been made using ADAMS package and the simulation of this model consists of modelling the prototype, defining variables, solving the model, running simulation, post processing and determining the position of point. The mechanism modelling consists of creating settings, creating points, creating parts, creating variables, creating constrains and adding motion using the ADAMS software. The major components are ground, cylindrical rod, circular plate and revolute joints and after performing all the modeling procedure using the required specification, the three dimensional model was developed in ADAMS/View 12.0.0 shown in figure 2. The motion added to the model with ground is shown in figure 3. The important dimensions are,

- Length of the Cylindrical Rod 1500.0 mm,
- Radius of the Cylindrical Rod 25.0 mm,
- Diameter of the circular Plate 500 mm,
- Thickness of the circular Plate 15 mm.

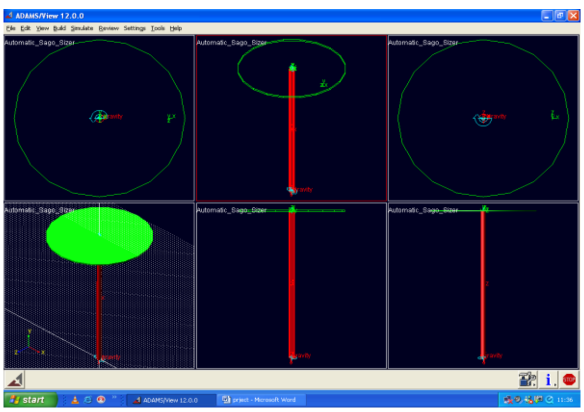

Figure 2 Views of the model

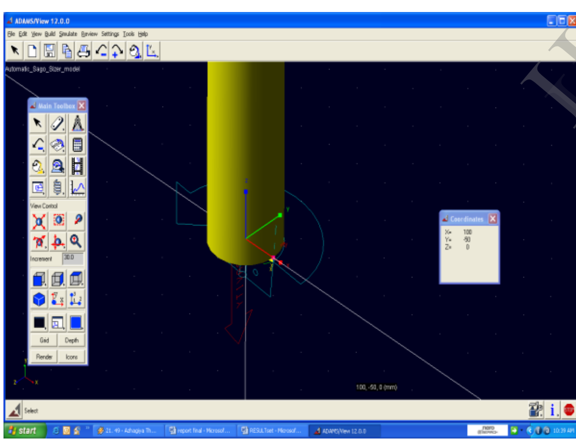

Figure 3 Motion of 3D model with ground

The analysis of the mechanism can be done by the sequence operations are, setting up the simulations, running and animating a simulation and solving the model for displacement analysis of point. The running time for complete rotation is 6.283 s and steps are 100. The figure 4 shows the recorded results of simulation view in ADAMS 12.0.0. Analyzing of point on the circular plate with respect to origin, the translational displacement of the point with respect to the global XY axes in the X, Y and Z directions are shown in figure 5.

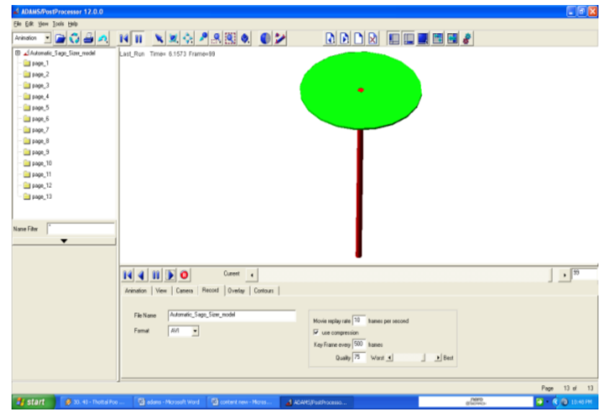

Figure 4 Recorded simulation results

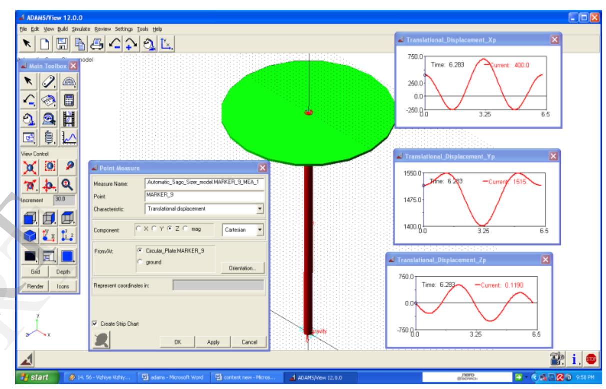

Figure 5 Translational displacement

5. Results and Discussion

The position analysis results of the point on the model are plotted graphically. All the plots are obtained by the last run simulation during the time of 12.566 s and corresponding value of displacement. The following figure and table show the translational displacement of the point at the speed of 1 rad/s in the X Y Z direction.

The figure 6 shows the maximum translational displacement length of the point is at the every half rotation of the model and minimum translational displacement length of the point is at the every quarter rotation of the model in the X axis direction and the maximum translational displacement length of the point is at the every quarter rotation of the model and minimum translational displacement length of the point is at the every half rotation of the model in the Y axis direction. From the table 1 it is clear that the point will move outward from its centre as it displaced away by 0.0331mm in one complete rotation of the model in time period of 6.4087 seconds in the X axis direction and the point is deviate as the displacement range of -

0.0025 mm. in one complete rotation of the model in time period of 6.4087 seconds in the X axis direction.

The force on the point at the speed of 1 rad/sec in the X Y Z direction is Zero. No force is acting on the point in the mechanism as shown in Table 1.

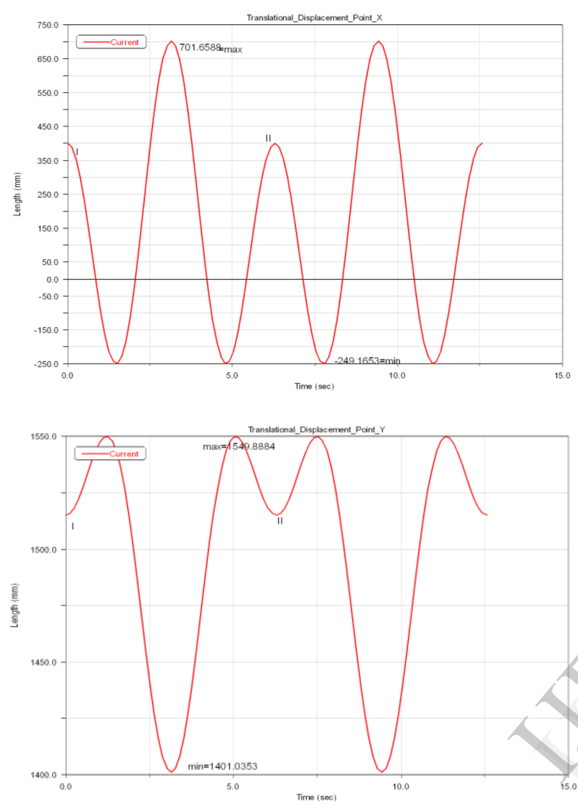

Figure 6 Translational displacement of the point in the X and Y component

S. No	Time	Displacement X	Displacement Y	Force
1	0.0	400.0	1515.0	0.0
2	0.1257	388.7231	1515.8403	0.0
3	6.283	400.0	1515.0	0.0
4	6.4087	388.7562	1515.8378	0.0

Table 1 Translational displacement of the point in the X and Y component

6. Conclusion

Results from the analytical solution, the rotational motion of the point is deviated from its circular path as the displacement range of 7.18×10^{-9} units for one complete rotation and from the software solution also the point will move outward from its centre as the displacement range of 0.0331 units in one complete rotation. This is clear that these deviations are accumulation of numerical error since the particle on that specified point in the plate will not deviate without action of force, but the system of force is added to particle in that particular point it will deviate from its path when rolling and automatically delivered from the plate. It is used to conclude that the rotational motion of the particle will move outward from the centre of the plate due to centrifugal force, $mr\omega^2$ with respect to the angular velocities of the circular plate.

7. References

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Appendix A. Analytical solution:

Sl.No	X - Unts	Y - Units	Z - Units	θ Rotation (Radian)		Difference	
1	1.000000000000000	1.000000000000000	1.000000000000000	0	0	After One rotation for XY plane	
2	0.366025404601730	1.366025403565440	1.000000000000000	30	0.52333		
3	-0.366025402149855	1.366025404222420	1.000000000000000	60	1.04667		
4	-0.999999998205103	1.000000001794890	1.000000000000000	90	1.57		
5	-1.366025402908460	0.366025407053604	1.000000000000000	120	2.09333		
6	-1.366025404879400	-0.366025399697980	1.000000000000000	150	2.61667		
7	-1.000000003589790	-0.999999996410206	1.000000000000000	180	3.14		
8	-0.366025409505479	-1.366025402251490	1.000000000000000	210	3.66333		
9	0.366025397246106	-1.366025405536370	1.000000000000000	240	4.18667		
10	0.999999994615309	-1.000000005384680	1.000000000000000	270	4.71		
11	1.366025401594510	-0.366025411957353	1.000000000000000	300	5.23333		
12	1.366025406193350	0.366025394794231	1.000000000000000	330	5.75667		
13	1.000000007179580	0.999999992820412	1.000000000000000	360	6.28	0.000000007179580	7.17958E-09
14	0.366025414409228	1.366025400937530	1.000000000000000	30	0.52333	0.000000009807498	9.8075E-09
15	-0.366025392342357	1.366025406850330	1.000000000000000	60	1.04667	0.000000009807498	9.8075E-09
16	-0.999999991025515	1.000000008974480	1.000000000000000	90	1.57	0.000000007179588	7.17959E-09
17	-1.366025400280550	0.366025416861103	1.000000000000000	120	2.09333	0.000000002627910	2.62791E-09
18	-1.366025407507310	-0.366025389890482	1.000000000000000	150	2.61667	-0.000000002627910	-2.62791E-09
19	-1.000000010769380	-0.999999989230618	1.000000000000000	180	3.14	-0.000000007179590	-7.17959E-09
20	-0.366025419312977	-1.366025399623570	1.000000000000000	210	3.66333	-0.000000009807498	-9.8075E-09
21	0.366025387438607	-1.366025408164290	1.000000000000000	240	4.18667	-0.000000009807499	-9.8075E-09
22	0.999999987435721	-1.000000012564270	1.000000000000000	270	4.71	-0.000000007179588	-7.17959E-09
23	1.366025398966600	-0.366025421764852	1.000000000000000	300	5.23333	-0.000000002627910	-2.62791E-09
24	1.366025408821260	0.366025384986732	1.000000000000000	330	5.75667	0.000000002627910	2.62791E-09
25	1.000000014359170	0.999999985640824	1.000000000000000	360	6.28	0.000000014359170	1.43592E-08
26	0.366025424216726	1.366025398309620	1.000000000000000	30	0.52333	0.000000019614996	1.9615E-08
27	-0.366025382534858	1.366025409478240	1.000000000000000	60	1.04667	0.000000019614997	1.9615E-08

Appendix B. Software Solution:

Translational Displacement Point in XYZ			
Time	Current X	Current Y	Current Z
0.0	400.0	1515.0	0.0
0.1257	388.7231	1515.8403	-79.6712
0.2513	355.657	1518.2873	-153.4172
0.377	303.0462	1522.1241	-215.6997
0.5026	234.4705	1527.0057	-261.7297
0.6283	154.6218	1532.4817	-287.7795
0.754	68.9905	1538.0279	-291.437
0.8796	-16.4731	1543.0811	-271.7615
1.0053	-95.7502	1547.0784	-229.3586
1.1309	-163.1385	1549.4961	-166.351
1.2566	-213.6229	1549.8873	-86.2535
1.3823	-243.2026	1547.9143	6.2405
1.5079	-249.1559	1543.3748	105.5487
1.6336	-230.2243	1536.2201	205.5472
1.7592	-186.7061	1526.5628	299.953
1.8849	-120.4511	1514.6757	382.7192
2.0106	-34.7587	1500.9795	448.4166
2.1362	65.8158	1486.0215	492.5782
2.2619	175.7344	1470.4466	511.9857
2.3875	288.8121	1454.9607	504.8782
2.5132	398.5941	1440.2914	471.0717
2.6389	498.7509	1427.1458	411.9803
2.7645	583.4674	1416.169	330.5391
2.8902	647.7999	1407.9078	231.0322
3.0158	687.9834	1402.7767	118.8331
3.1415	701.6588	1401.0353	0.0884
3.2672	688.0235	1402.7716	-118.661
3.3928	647.8781	1407.8978	-230.8738
3.5185	583.5782	1416.1548	-330.4046
3.6441	498.8871	1427.1279	-411.8767
3.7698	398.7504	1440.2707	-471.0026
3.8955	288.9779	1454.9383	-504.8479
4.0211	175.9005	1470.4234	-511.995
4.1468	65.9725	1485.9988	-492.6257
4.2724	-34.62	1500.9582	-448.4985
4.3981	-120.338	1514.6567	-382.8299
4.5238	-186.6245	1526.5468	-300.085
4.6494	-230.178	1536.2076	-205.692
4.7751	-249.1464	1543.3662	-105.6972
4.9007	-243.2293	1547.9095	-6.3834
5.0264	-213.6827	1549.8862	86.1249
5.1521	-163.2266	1549.4983	166.2444
5.2777	-95.8597	1547.0832	229.2802

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11.4351	-163.3145	1549.5004	166.1378
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