

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

Innovative Utility of 3 - D Mixer as a Mass Finishing Equipment

Vandan K. Gundale

Workshop Superintendent, Dept. of Mechanical Engineering, B. & B. Institute of Technology, V.V.Nagar, Gujarat, India

ABSTRACT: Mixing machine based on Schatz mechanism uses a highly ordered form of three dimensional motion that brings centrifugal and centripetal forces to dynamic balance. Such Mixers are ideal for mixing of powders or liquids. However motion of particles in this type of mixture can also be ideal for mass finishing or deburring of tiny, fragile metal parts. In this paper innovative utility of 3D mixer is suggested. The paper also includes the experimental work that finds significance of different control parameters on finishing performance.

KEYWORDS: Schatz Mechanism, 3D Mixer, Deburring, Mass Finishing, DOE

I. INTRODUCTION

Deburring is, to put it simply, a finishing method used in industrial settings and manufacturing environments. Metal is frequently machined using many processes in order to create pieces of specific shape and size. For example, metal may be welded, molded, cast, trimmed, slit or sheared. These procedures often create ragged edges or protrusions. The raised particles and shavings that appear when metal blanks are machined are referred to as burrs, and the process by which they are removed is known as deburring [1].

For small machined components or press parts where deburring of each individual component, either on machine or manually, may not be possible due to delicate & fragile structure of component or due to time consuming operation which may not justify productivity requirement. In such cases Mass Finishing Operation like tumbling or use of vibratory bins can prove very effective solution.

In Mass Finishing Operation components [3] are mixed with deburring media & tumbling or vibratory action causes the rubbing action of part surfaces against the media. Intricate surfaces on the parts can also be finished effectively with these actions. Mass finishing equipment can be divided into four major categories[2]:

- 1) Barrel Tumblers;
- 2) Vibratory finishers;
- 3) High Energy Centrifugal Finishers; and
- 4) Drag Finishing machines.

The size and operating intensity are major considerations when selecting media.

II. 3 DIMENSIONAL MIXING MACHINE

Mixing machine based on Schatz mechanism [8] uses a highly ordered form of three dimensional motion that brings centrifugal and centripetal forces to dynamic balance. This results in ideal mixing environment. However these types of mixers are still not much known to Indian industry. The wonderful spatial movement of drum of 3-D Mixer provides ideal environment for mixing. In 3D mixer particles inside the drum moves smoothly in a cyclic ordered form regardless of their specific weights and regardless of their size and shape. This type of motion of particles inside the drum is also ideal for the mass finishing of tiny, light weight and delicate components. Deburring and / polishing of such components can be carried out by using proper media without damaging or deforming them.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

III. MASS FINISHING EXPERIMENT IN 3D MIXING MACHINE

In this research work, based on the principles of Design of Experiments (DOE) [5] [6] Mass Finishing Experiments are conducted on selected tiny parts using 3D Mixing Machine.

EXPERIMENT DETAIL:

Component Selected for Experiment (From S. B. Enterprise, G. I. D. C., Makarpura, Vadodara – 390010)	:	Threaded Lug
Material of the Component	:	Brass
Overall Size of the Component	:	20 X 17 X 0.8 mm
Weight of one component	:	1.28 gms. (Average weight)
Quantity loaded for deburring during each set of experiment	:	25 Nos.
Media type and size	:	Ceramic 6 X 12 mm angle cut triangle, brown color (Al ₂ O ₃ 75 – 80%) [4]

IV. CONTROL AND RESPONSE PARAMETERS SELECTION

Control Parameter:

Since media selection is finalized for the selected component, the other parameters which can be controlled are Speed of Rotation, % Filling Volume of Container and Cycle Time. Performance of deburring operation will be dictated by these parameters. Three levels of each of these factors selected are as below:

Table 1 Levels of Factors

Speed of Rotation R. P. M.	Filling Volume %	Cycle Time Minutes
30	60	15
70	75	30
130	90	60

Response Parameters:

Since it was difficult to quantify the quality of deburring performance, deciding about the response parameters was also difficult. One way to quantify the quality of deburring process is to note the weight loss of component after deburring. Since burrs are loosely attached particles to the component, hence if we weigh the component before and after deburring process, difference of these weights will directly give the amount of material removed by the process.

Since weight loss in deburring operation will be a very small amount, therefore it was necessary to weigh the component precisely. For weighing the components, a weighing scale with least count of 10 micro gram is to be used. Thus there are three control factors & each factor has three different levels. Hence we have 33, means 27 combinations of control parameters. To eliminate the directional trend effects of the independent parameters and parametric combinations, the entire experiment was performed in random order manner. All 27 combinations were first listed in the serial order, preferred and random numbers were drawn from random number table and were assigned to each combination, and their sequence was rearranged in the ascending order of random numbers. Thus the entire observations sequence was randomized.

Combinations of these parameters, their standard order and run order are listed in Table 2.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

V. EXPERIMENTAL PROCESS

Components to be deburred are marked with vibro marker & weighed precisely. Container of 3 Dimensional Mixer is loaded according to the required volume ensuring even distribution of media & components. Closed the lid of container tightly & adjusted the speed of rotation as per required R. P. M. for each run. Ensured the cycle time of each run precisely, using stop watch. After completion of each run components are separated from media & are washed & dried out. Components are then weighed & noted the weight.

The run order of components, with the levels of control parameters & response parameter is listed in Table 2.

Table 2: DOE

Std Order	Run Order	Blocks	Speed RPM	% Filling Volume	Time in Minutes	Weight Before in gms	Weight After in gms	Weight loss in gms
12	1	1	70	60	60	32.28390	32.13514	0.14876
2	2	1	40	60	15	32.17908	32.11456	0.06452
9	3	1	70	75	60	32.17988	32.07628	0.10360
25	4	1	130	90	15	32.36952	32.26125	0.10827
11	5	1	70	60	30	32.52388	32.42793	0.09595
24	6	1	130	75	60	32.15358	31.77374	0.37984
14	7	1	70	75	30	32.39923	32.30208	0.09715
6	8	1	70	60	15	32.33706	32.22583	0.11123
18	9	1	70	90	60	32.15372	32.03159	0.12213
10	10	1	40	75	60	32.12144	32.02757	0.09387
21	11	1	130	60	60	32.27994	31.97822	0.30172
23	12	1	130	75	30	32.42778	32.26029	0.16749
26	13	1	130	90	30	32.04676	31.91445	0.13231
13	14	1	70	75	15	32.23806	32.07979	0.15827
15	15	1	40	90	60	32.45358	32.39442	0.05916
4	16	1	40	75	15	32.32208	32.27490	0.04718
3	17	1	40	60	60	32.16216	32.10752	0.05464
27	18	1	130	90	60	32.23367	32.05387	0.17980
17	19	1	70	90	30	32.21239	32.14927	0.06312
1	20	1	40	60	30	32.33055	32.28298	0.04757
5	21	1	40	75	30	31.97896	31.93687	0.04209
20	22	1	130	60	30	32.19461	32.02690	0.16771
22	23	1	130	75	15	32.29194	32.18896	0.10298
8	24	1	40	90	30	32.01178	31.96460	0.04718

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

16	25	1	70	90	15	32.08349	31.99494	0.08855
7	26	1	40	90	15	32.19874	32.14265	0.05609
19	27	1	130	60	15	32.20772	32.08547	0.12225

VI. RESULTS AND DISCUSSION

Since removal of burr will reduce the weight of the part, Weight Loss of the part will indirectly indicate the effectiveness of the deburring process. Hence, Weight loss of part after deburring is the response parameter for our experiment.

Analysis of Variance Using (ANOVA) MINITAB Release 13.20

Table 3. ANOVA for Weight Loss

Two-way ANOVA: Weight loss in gms versus Speed in RPM, % Filling Volume

Source	Degree of freedom (DOF)	Sum of Squares (SS)	Mean Square Value MSV = SS/ DOF	F	P Value	Significance
Speed in RPM	2	0.07420	0.03710	9.63	0.001	>99 %
% Filling Volume	2	0.00686	0.00343	0.89	0.428	83 %
Interaction	4	0.00429	0.00107	0.28	0.888	76 %
Error	18	0.06937	0.00385			
Total	26	0.15472				

Table 4 :ANOVA for Weight Loss

Two-way ANOVA: Weight loss in gms versus Speed in RPM, Cycle Time in Minutes

Source	Degree of freedom (DOF)	Sum of Squares (SS)	Mean Square Value MSV = SS/ DOF	F	P Value	Significance
Speed in RPM	2	0.07420	0.03710	24.96	0.000	>99 %
Cycle Time in minutes	2	0.02523	0.01261	8.49	0.003	>99 %
Interaction	4	0.02854	0.00714	4.80	0.008	>99 %
Error	18	0.02675	0.00149			
Total	26	0.15472				

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

Table 5: ANOVA for Weight Loss
Two-Way ANOVA: Weight Loss versus % Filling Volume, Cycle Time in Minutes

Source	Degree of freedom (DOF)	Sum of Squares (SS)	Mean Square Value MSV = SS/ DOF	F	P Value	Significance
% Filling Volume	2	0.00686	0.00343	0.52	0.606	80 %
Cycle Time in minutes	2	0.02523	0.01261	1.89	0.179	89 %
Interaction	4	0.00278	0.00069	0.10	0.980	<75 %
Error	18	0.11985	0.00666			
Total	26	0.15472				

Effect of Speed of Rotation on Weight Loss



Figure 1: Threaded Lug Used for Deburring Experiment

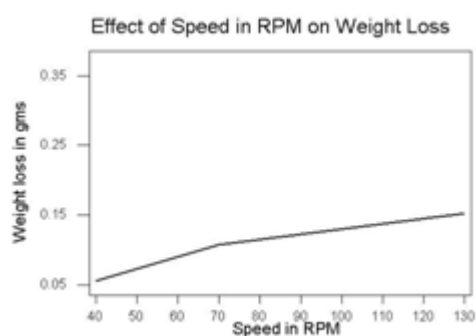


Figure 2: Graph Speed v/s Weight Loss

It is clear from the graph (Fig. 2) that as we increase the speed of rotation, the weight loss also increases. However the rate of increase of weight loss for the speed ranges from 70-130 is less than that for the speed range 40-70. With the increased rotation per unit time, the contents of the drum undergo increased repetition of movement patterns and hence with increased repetition of abrasion of parts against media, weight loss increases. Increment in the rate of weight loss will continue till all the burrs get removed and there after rate of material removal from part will decrease and hence the weight loss rate will decrease.

Effect of % Filling Volume on Weight Loss

It is seen from the figure 3 that there is no much more effect of % Filling Volume on the Weight Loss. However looking to graphs in Fig. 4 and main effects plot in Fig. 5 it is seen that weight loss is found increased when %

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

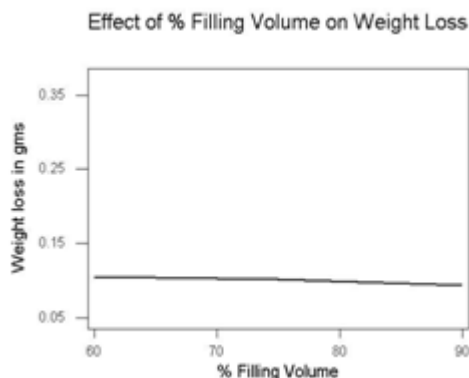


Figure 3: Graph % Filling Volume v/s Weight Loss

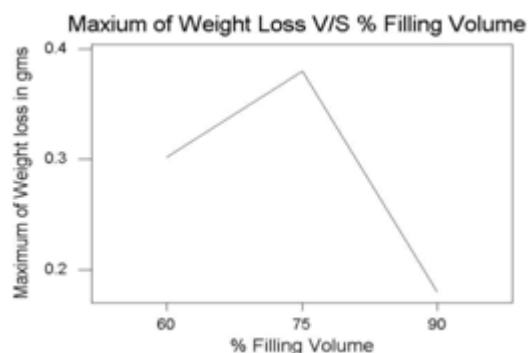


Figure 4: Graph % Filling Volume v/s Maximum of Weight Loss

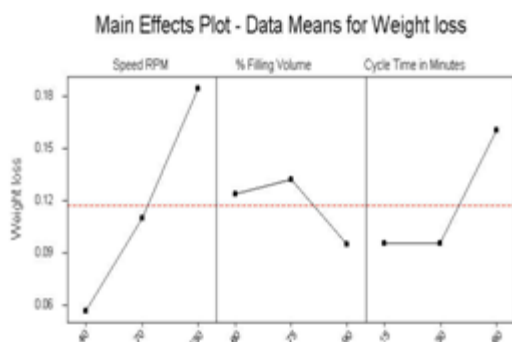


Figure 5: Main Effects Plot-Data Means for Weight Loss

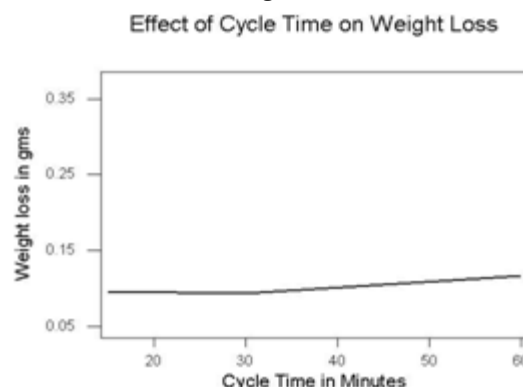


Figure 6: Graph Cycle Time v/s Weight Loss

Filling Volume is changed from 60 % to 75 % and same is found to be decreased when % Filling Volume is increased to 90 %. In our experiment, for each run the part quantity is same irrespective of media quantity. Therefore the quantity of media is less at 60 % Filling Volume than that at 75 % Filling volume. Perhaps, this reduced media quantity is responsible for less weight loss at 60 % Filling Volume than at 75 % Filling Volume. But at 90 % Filling Volume Weight Loss is again reduced. This reduction in Weight Loss is due to the less unfilled space in drum which is available for the movement of Drum contents.

Effect of Cycle Time on Weight Loss

Weight loss is almost same for Cycle Time range from 15 to 30 minutes and found increased for Cycle Time range 30-60 minutes. This is clear from graphs in fig nos. 6, 7 and 5. The effect is quite obvious as more is the time allowed for part media interaction more will be the weight loss.

Effect of Interaction of Speed of Rotation and % Filling Volume on Response Factor (Weight Loss)

From interaction plot (Fig. 8) it is seen that for all the three levels of speed, the weight loss is increased with initial increase in % Filling Volume but with further increase in % Filling Volume Weight loss is decreased. Similar outcome can be drawn from graph in Fig. 9, which shows the response surface of Weight Loss as function of design factors of Speed of Rotation and %Filling Volume.

Speed is most significant factor as compared to other two factors. This is evident from ANOVA table 3. Level of significance for the factor; Speed of Rotation is above 99 %. % filling Volume has no significance on Weight Loss as

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

its confidence level is 83% only. Hence interaction of speed of Rotation and % Filling Volume has no significance on Weight Loss as its confidence level is 76 % only.

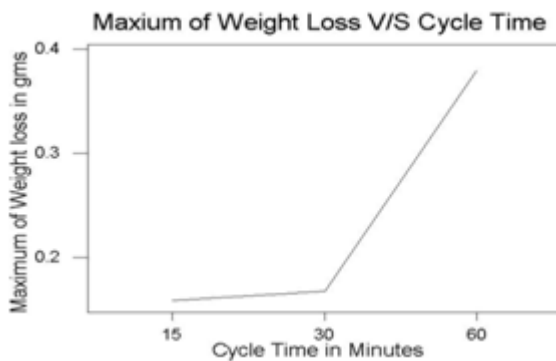


Figure 7: Graph Cycle Time v/s Maximum of Weight Loss

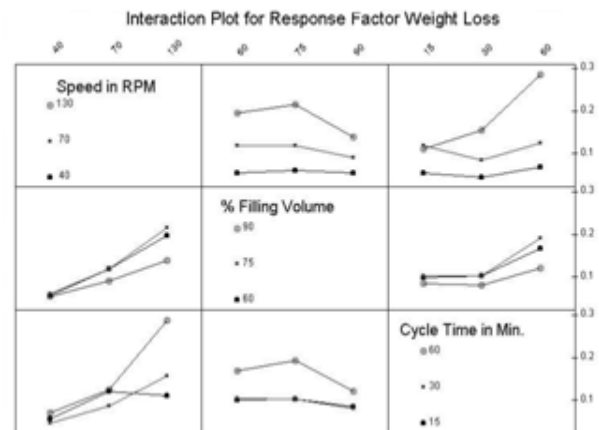


Figure 8: Interaction Plot for Weight Loss

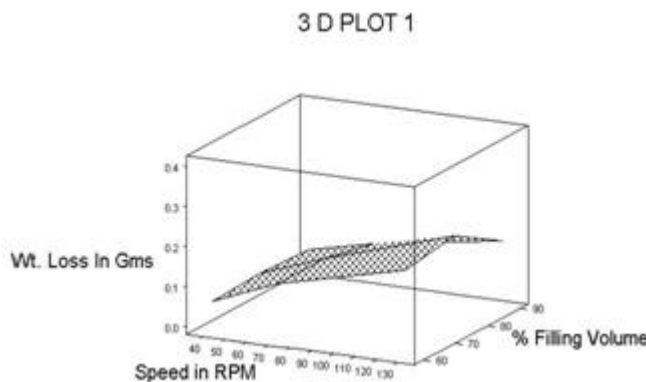


Figure 9: 3 D Plot 1

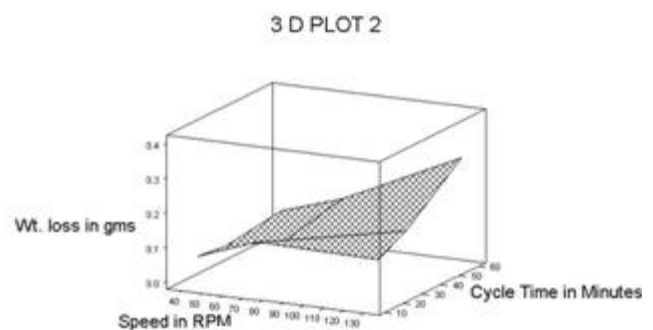


Figure 10: 3 D Plot 2

Effect of Interaction of Speed of Rotation and Cycle Time on Response Factor (Weight Loss)

From interaction plot (Fig. 8) it is seen that, the weight loss is increased with increase in Cycle Time for all the three levels of Speed of rotation. From graph in Fig. 10 which shows the response surface of Weight Loss as function of design factors of Speed of Rotation and Cycle Time it can be seen that at all three levels of Cycle Time, with the increase in speed of rotation Weight Loss is also increased.

ANOVA table 4 indicates that factors Speed of Rotation, Cycle Time and interaction of both have most significant effect on response factor Weight Loss. All these sources are significant with more than 99% confidence level.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

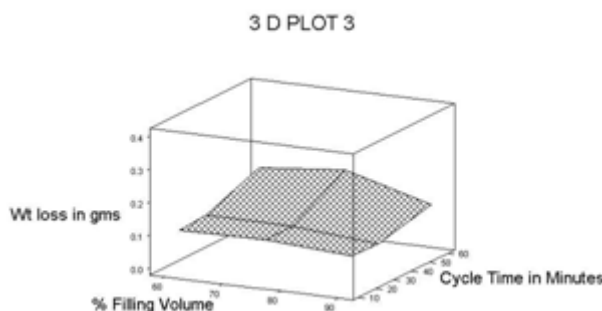


Figure 11: 3 D Plot 3

Effect of Interaction of % Filling Volume and Cycle Time on Response Factor (Weight Loss)

From interaction plot (Fig. 8) it is seen that for all the three levels of % Filling Volume, the weight loss is increased with increase in Cycle Time but 75 % Filling Volume has highest Weight Loss and 90 % Filling Volume has lowest Weight Loss.. Similar outcome can be drawn from graph in Fig. 11 which shows the response surface of Weight Loss as function of design factors of %Filling Volume and Cycle Time. However this graph shows almost decreased Weight Loss with increase in % Filling Volume for initial levels of Cycle Time. But at higher level of Cycle Time, Weight Loss is increased with initial increase in % Filling Volume and after that it decreases with increase in % Filling Volume. From ANOVA table 5, it can be said that % Filling Volume, Cycle Time and interaction of both of these factors have no Significant effect on Weight Loss as none of these factors is significant with level of confidence even more than 90 %.

VII. CONCLUSION

Innovative idea of utilizing the 3-D Mixing Machine as Deburring Equipment seems successful. Deburring of tiny, fragile components can be safely done in this machine. An effect of control parameters on deburring performance is verified. Speed of rotation & % filling volume are two significant parameters affecting deburring performance. However as compared to Tumbling Mill or Vibratory Bins, in 3D mixers speed of rotation can be kept comparatively very low and also comparatively higher filling volume can be used hence the operation is fast. For deburring few components in Tumbling Mill or Vibratory Bins, cycle time is same as it is for the full capacity of machine. In such cases small sized 3-D Mixing machine can prove its superiority. The finishing operation of this machine does not only save the time but due to its special movements ensures thorough removal of burrs from every corners and edges.

Efforts of this work can prove very useful for gaining popularity for such 3-D Mixing Machine especially for mass finishing of tiny parts apart from efficient mixing.

REFERENCES

- [1] <http://www.vibrafinish.com/deburring.html>
- [2] <http://www.pfonline.com/articles/fundamentals-of-mass-finishing>
- [3] <http://www.advancedfinish.com/vibe101.asp>
- [4] <http://www.advancedfinish.com/media.asp>
- [5] "Design of Experiments for Engineers And Scientists" By Jiju Antony, Butterworth Heinemann.
- [6] "Design Analysis of Experiments" Douglas C. Montgomery, Jhon Wiley & Sons Inc.
- [7] A Spatial Over-Constrained Mechanism That Can Be Used In Practical Applications, Constantinos Mavroidis, Assistant Professor, Michael Beddows, Research Assistant
- [8] Design Of Structural Mechanisms By Yan CHEN -A Dissertation Submitted For The Degree Of Doctor Of Philosophy In The Department Of Engineering Science At The University Of Oxford St Hugh's College Trinity Term 2003