International Journal of Emerging Engineering Research and Technology
Volume 3, Issue 3, March 2015, PP 6-12
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

Designing of Silo in Batching System

Amol Shroff, UlkeshSolanki, Prashant Waghmare, Tejas Kulkarni, K.P. Agte

Mechanical Department of Smt. Kashibai Navale College of Engineering, Sinhgad Institutes, Pune, India

ABSTRACT

This document gives a brief ideology about designing of silos in batching system for glass manufacturing. Four major constituents which are free flowing and granular are considered. Capacity of silo, batch size, numbers of batches are taken into account. Percentage wise weight of each component is calculated. Volumes of silos and hoppers are computed. Calculations of heights and diameters of each section of silo and collection hopper are involved. Working drawings of silo design are included.

Keywords: Silo, Collection hopper, Capacity, Batch size, Refilling Time, Flowability, Abrasiveness, Angle of Repose, Back up time

INTRODUCTION

The manufacturing of any product mainly involves steps of transferring and weighing or batching of individual ingredients based upon their weight percentage in a product. We are designing silos for storage of the materials during batching system based on gain in weight principle.[3]

Silos are cylindrical towers used for storing silage. They are used in industry for protection and storage of powdered materials. It must be designed such that it is easy to load. More importantly, easy unloading of silos is desirable. The impact of silo design is on rate of flow of the powder out of the silo, if it flows at all. Also, the way in which the silo is designed affects how much of the stored material can discharge and mixing of solid sizes or dead space that reduces the effective holding capacity of the silo.

Major constituents of the product similar to Silica (SiO_2), Boric acid (B_2O_3), Aluminum Oxide (Al_2O_3), Soda (Na_2O) which are free flowing and fine powder are considered and their different properties required for the designing of Silos and collection hopper are studied. Designing of silos and collection hopper should be such that perfectly metered quantities of materials are available.

BACKGROUND

Design a batching system for production of glass.

Batch Size-500 kg

Plant Capacity for each day - 50 Tone

Working Time for each day – 8 hours

Number of batches to be produced each day – 100

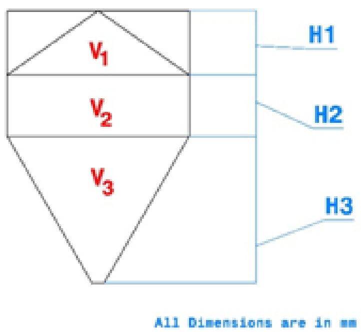

Fig1. *Basic Silo Geometry*

**Address for correspondence*

priyajshinde17@gmail.com

Table1. *Major constituents and their properties [2]*

Material	Material A	Material B	Material C	Material D
Percent Composition (%)	34	25	22	19
Particle Size	B	A	A	B
Density (gm./cc)	2.2	2.46	3.69	2.27
Flowability	1	2	1	2
Abrasiveness	8	8	8	7
Angle of Repose	34^0	34^0	33^0	31^0

Table2. *Material classification*

	Material Characteristic	Class
Size	Very fine – 100 mesh and under	A
	Fine – 3 mm and under	B
	Granular – 12mm and under	C
Flowability	Very free flowing	1
	Free Flowing	2
	Sluggish	3

DESIGNING OF SILO

Silo Designing for the Given Problem

- Four silos are to be designed for handling the major products.
- The silos are designed according to the percent composition of each constituent.
- The capacity of silo is calculated according to the batch size and number of batches per day.
- To achieve mass flow and considering the ease of fabrication, we will design for the type – Conical Silo[2]

Percentage Wise Weight of Each Component

1. Material A (34%) – 170 kg;
   For 100 batches – 170*100 = 17000kg = 17 ton
2. Material B (25%) – 125 kg;
   For 100 batches – 125*100=12500kg=12.5 ton
3. Material C (22%) – 110kg;
   For 100 batches – 110*100= 11000kg= 11 ton
4. Material D (19%) – 95 kg;
   For 100 batches – 95*100 = 9500 kg = 9.5 ton

Calculation of Total Volume Required to be Handled

- Although each silo has to be designed with different volume handling capacity, it is comparatively easy and cheap to fabricate four silos of same volume than fabricating all four silos of different volumes. So the volume of silos containing material of less percent composition is increased by increasing its back up (i.e. increasing its refilling period).

1. Material A – V= m/ρ; Where m = Weight of
   The Constituent for 1 day; 17 ton
   ρ = Density of the material; 2200kg/m^3
   V = Corresponding Volume;
   Taking 2 days backup in the Silo; m = 17*2 =
   34 ton
   Therefore, V = 34000/2200 = 15.45m^3 [4]
2. Material B – V = m/ρ; m = 12.5 ton;
   ρ = 2460 kg/m^3;
   As mass of this component is less than

Previous component we take
3 days backup of this component in the Silo;
m = 12.5*3 = 37.5ton
Therefore, V = 37500/2460 = 15.24 m^3

3. Material C – V = m/ρ; m = 11 ton;
   ρ = 3690 kg/m^3;
   As Density of this material is much higher
   Than previous materials for
   Obtaining the same volume we take 5 days
   Backup of this component
   In the Silo; m = 11*5 = 55 ton
   Therefore, V = 55000/3690 = 14.90 m^3
4. Material D – V = m/ρ; m = 9.5 ton;
   ρ = 2270 kg/m^3;
   Taking 3 days backup of this component in
   The Silo;
   m = 9.5*3 = 28.5 ton
   Therefore, V = 28500/2270 = 13 m

Table3. *Materials and their required volume*

MATERIAL	WEIGHT (tons)	VOLUME (m^3)	REFILLING TIME (Days)	SILO TYPE
Material A	34	15.45	2	Major
Material B	37.5	15.24	3	Major
Material C	55	14.90	5	Major
Material D	28.5	13	3	Major

From the above table we conclude that, the Silo is to be designed having storage capacity of 16 m^3. Hence we considered all the 4 silos are of same size but refilling time of each component is different.

Calculation of Height and Diameter of the Silo

Section I [4]

Height of the 1st section is;

H_1 = 1.5*tan (34^0);

H_1 =1.01176 m;

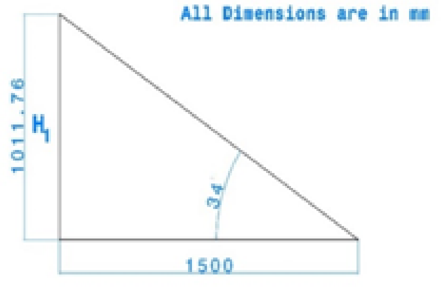

Fig2. *Height of second section*

According to industrial considerations for the given volume; diameter of the silo d = 3 m; [2]

Volume handling capacity of section I is –

$V_1 = (1/3) * A * H_I$;

$V_1 = (1/3) * (\pi/4) * d^2 * 1.01176$;

$V_1 = (1/3) * (\pi/4) * 3^2 * 1.01176$;

$V_1 = 2.3839\ m^3$

Section 3: [4]

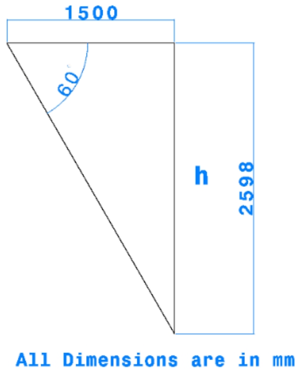

Fig3. *Height h*

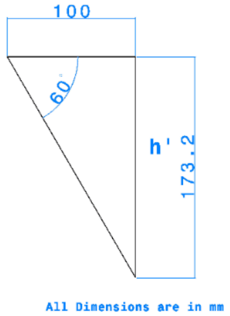

Fig4. *Height h'*

Height of the 3rd section is;

$H_3 = h - h'$;

$h = 1.5 * \tan(60^0) = 2.5980$ m;

$h' = 0.1 * \tan(60^0) = 0.17320$ m;

$H_3 = 2.5980 - 0.17320 = 2.4247$ m;

Volume handling capacity of section 3 is -

$V_3 = (1/3) * (\pi/4) * ((d_1^2 * h) - (d_2^2 * h'))$;

According to industrial considerations for required flow rate; opening d_2 = 200 mm diam.; [2]

$V_3 = (1/3) * (\pi/4) * ((3^2 * 2.5980) - (0.2^2 * 0.17320))$;

$V_3 = 6.119\ m^3$

Section 2:

Out of total volume, volume handling capacity of 2nd section is to be

$V_2 = V_T - (V_1 + V_3)$;

$V_2 = 16 - (2.3839 + 6.119)$;

$V_2 = 7.4971\ m^3$;

Height of 2nd section is;

$V_2 = A * H_2$;

$7.4971 = (\pi/4) * 3^2 * H_2$;

$H_2 = 1.0607$ m;

Therefore total height of the silo is =

$H_1 + H_2 + H_3$;

$H_S = 1.01176 + 1.0607 + 2.4247$;

$H_S = 4.49$ m;

Height to diameter ratio is = $H_S/d = 4.49/3 = 1.49 \approx 1.5$

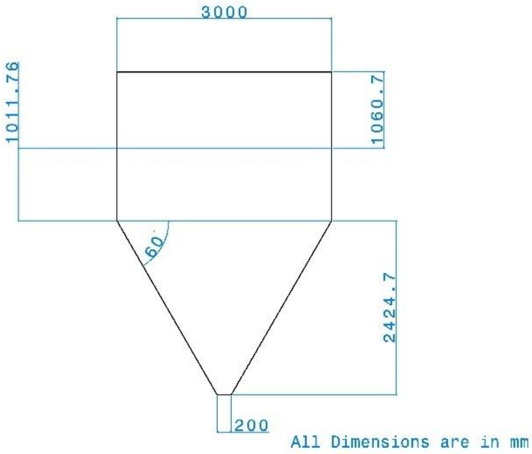

Fig5. *Final geometry of the silo*

DESIGNING OF COLLECTION HOPPER

Collection hopper is used for collecting material forming one batch by taking metered quantity of different materials from each Silo.

Collection hopper is designed same as main silos; only material handling capacity of the collection hopper will change.

Weight to be handled by the collection hopper is – 500 kg;

Volume to be handled by the collection hopper can be calculated as below;

Table4. *Volume of the materials in each batch*

MATERIAL	WEIGHT IN 1 BATCH (kg)	DENSITY (kg/m^3)	VOLUME IN 1 BATCH (m^3)
Material A	170	2200	0.07727
Material B	125	2460	0.05081
Material C	110	3690	0.02981
Material D	95	2270	0.04185

Total volume to be handled is;

$V_T = 0.07727 + 0.05081 + 0.02981 + 0.04185 = 0.19974\ m^3 \approx 0.2\ m^3$

Assuming Industrial factor of safety we considered it as 0.3 m^3

Doing similar calculations as done in silo designing;

Section 1:

According to the industrial considerations for given volume; diameter of hopper d = 800mm; [2]

Height of 1st section is;

$H_1 = 0.4 * \tan(34^0)$;

$H_1 = 0.26980$ m;

Therefore volume handling capacity of section 1 is;

$V_1 = (1/3) * (\pi/4) * d^2 * H_{I;}$

$V_1 = (1/3) * (\pi/4) * 0.8^2 * 0.26980$;

$V_1 = 0.045205\ m^3$;

Section 3:

Height of 3rd section is;

$H_3 = h - h'$;

$h = 0.4 * \tan(60^0) = 0.69282$ m;

$h' = 0.075 * \tan(60^0) = 0.1299$ m;

$H_3 = 0.69282 – 0.1299 = 0.56291$ m;

Volume handling capacity of 3rd section is -

$V_3 = (1/3) * (\pi/4) * ((d_1^2 * h) – (d_2^2 * h'))$;

According to the industrial considerations for required flow rate; opening d = 150 mm; [2]

$V_3 = (1/3) * (\pi/4) * ((0.8^2 * 0.69282) – (0.075^2 * 0.1299))$;

$V_3 = 0.1158\ m^3$

Section 2:

Volume to be handled by section 2 is –

$V_2 = V_T – (V_1 + V_3)$;
$V_2 = 0.3 – (0.045205 + 0.1158)$;
$V_2 = 0.13890\ m^3$;
Height of 2nd section is;
$V_2 = A * H_2$;
$0.13890 = (\pi/4) * 0.8^2 * H_2$;
$H_2 = 0.27633$ m;
Therefore total height of the collection hopper is =
$H_1 + H_2 + H_3$;
$H_{ch} = 0.27633 + 0.26980 + 0.56291$;
$H_{ch} = 1.1$ m;
Height to diameter ratio is = $H_{ch}/d = 1.1/0.8 = 1.37$

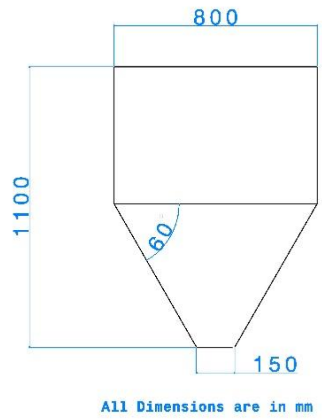

Fig6. *Final geometry of collection hopper*

CONCLUSION

Four different silos are designed for major constituents using standard codes and different standard charts. Collection hopper is also designed in the same way. Working drawing of design of silo and collection hopper is proposed using calculation data. A standard design of silo which is required for batching system is done.

REFERENCES

[1] Indian Standard: 9178 (Part 1) – 1979, pp. 8-11
[2] Indian Standard: 9178 (Part 1) – 1980, pp.8-18
[3] Jenike, A.W., "Storage and Flow of Solids", Bulletin123, Utah Engineering Experiment Station, Univ. of Utah, Salt Lake, UT (1964)
[4] Bhandari V.B., Chapter No. 22. "Cylinders and PressureVessels", 1994, pp. 783-794

AUTHORS' BIOGRAPHY

Amol Shroff – Final year student inMechanical Engineering at SKNCOE, Pune

Ulkesh Solanki – Final year student in Mechanical Engineering at SKNCOE, Pune

Tejas Kulkarni – Final year student in Mechanical Engineering at SKNCOE, Pune

Prashant Waghmare – Final year student in Mechanical Engineering at SKNCOE, Pune

K.P. Agte – Asst. professor in Mechanical Engineering Dept. at SKNCOE, Pune