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Design of Belt Conveyor to Reduce Loss Batch-Cullet

[1]saikat Deb, [2]smrutiranjan Panda,
Gandhi Institute of Excellent Technocrats, Bhubaneswar, Bhubaneswar
Orissa Engineering College, Bhubaneswar, Odisha, India

ABSTRACT
In a glass-making production process, the quality of the rawmaterialisveryimporttanttoproducegoodqualityofglass.Butsometimes not all of material have a good quality, there mustbe foreign object contamination in the raw materials so that donotmatchwiththeexpectedmaterialqualityandhasanimpactonrejectedmaterialandcaninterferewitht heproductionprocess or the glass quality. The purpose of this paper is toreducemetalcontamination,sothatbatch-culletmaterialisnotwastedbydesigningandrealizingabatch-culletrejectconveyor which consists of two conveyors. Conveyor A has atotallengthof7.5meterswithaheightof3.5meters,aslopeof20^0, has a power of 2.62 kW with a suspended magnet andmetaldetector.ConveyorBhasatotallengthof4.5meters,hasa power of 1.29 kW and both conveyors can accommodate aproductioncapacityof620000kg/day.Fromthedesignofthetwoconveyors,itwasfoundthattheamountof batch-culletlossper day was reduced by 87.92% from 7890 kg/ day to 952.6kg/day
Keywords:batch-cullet,beltconveyor,metal,contaminant**.**

INTRODUCTION

The word of glass comes from Teutonic word "Glaza" whichmeansyellow.Theoldestblueprintthatisfoundandprintedonclay in 669-627 BC which describe the initial composition ofglass making, there is 60 parts of sand, 180 parts of ash frommarine plants and 5 parts of [1]. The properties of glass areuniqueandvariedforchemicalofglass,andcanbeadjustedbychanging the composition or production technique of the glass[2].Alongwiththedevelopmentoftheera,themethodofglassmaking is growing [3]. The current most popular sheet glassproductionprocessisthefloatprocessmethod.[1].Theflowoftheglassproductionprocesswiththefloatprocessisill ustratedinFigure 1

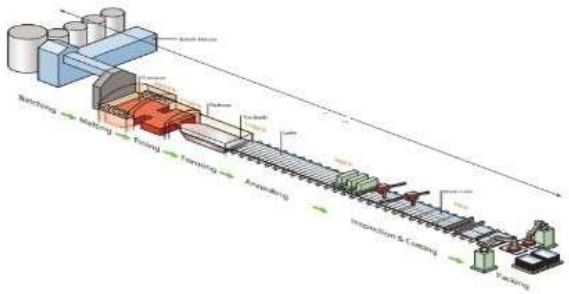

Figure1. Flowproductionof floatprocess[4].

One of the companies that produce flat glass is PT MuliaglassFloatDivisioninIndonesia.Figure2describestherawmaterialbatchingprocess:

Figure2. Batchingprocess[5].

The problem that often occurs in the batching process is theamount of material that is discarded due contamination in theraw material, one of the sources of contamination in the glassraw material is from foreign objects [6]. According to Sugito,Head Section of The Batch Plan Department at PT MuliaglassFloatDivisionFloat3,thereareseveraltypesofcontaminationthatcannotpassintothemeltingprocesssuchas metal,aluminium, and rock. Figure 3 shows the contamination thatcanbe filteredout:

Figure3. Examplesofcontaminations.

The wasted material of batch-cullet by metal contaminationcausesnewproblem.Theproblemisthewastebatch-culletthatincrease every day by metal contamination in the batch-culletmaterial. Figure 4 show that the one of flow process in BatchPlan:

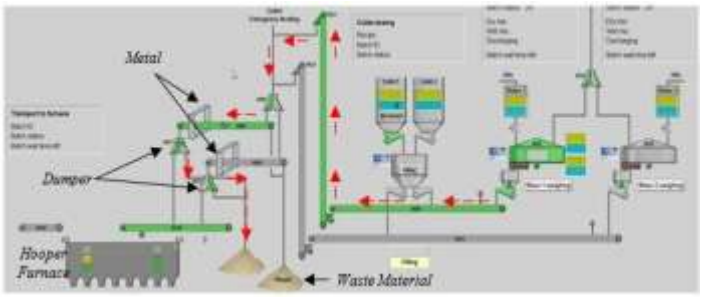

Figure4. Flowprocessofbatching-plan

Observation of the area becomes a reference for designing aconveyor that can distribute batch-culet material and reducemetalcontaminationinthematerial.Beltconveyorsystemisaneconomicalequipmentfortransportinglargequantitiesofmaterial [7]. The addition of this belt conveyor system is aninnovation in the Batch Plan Department that is consideredeffective,becauseithasfunctiontodistributeandmovematerial from one place to another place by adding a magnetwhichfunctionistoattractmetalcontaminationinthematerialand metal detector to detect metal contamination. Figure 5showstheexample ofconveyorsupportstructure:

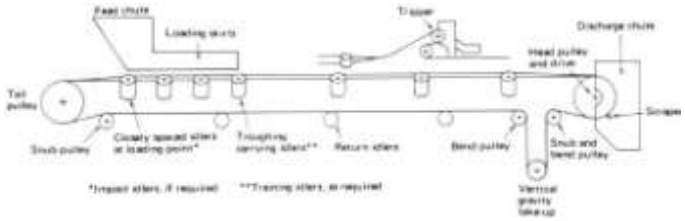

Figure5. Supportstructureofbeltconveyor[7].

1. METHOD OF DESIGN

The flow chart design of batch-cullet reject conveyor is showninFigure6:

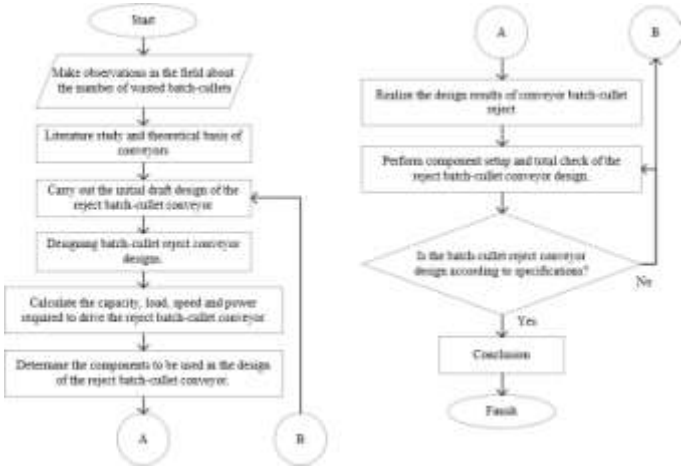

Figure6. Flowchartofconveyorbatch-culletrejectdesign.

The belt conveyor can be characterized by a belt or steel wirethat rotates around a driving pulley supported by several rollwithastructure[7]. Theuseofbeltconveyorsinseveralindustries is different according to needs of each industry. Indesigning a conveyor batch-cullet reject there are several stepsthat need to be done. The first thing to do is conduct a fieldstudy on the wasted batch-cullet material, and then looking forliterature on conveyor design [8-10], make the initial design ofbatch-cullet reject conveyor, determine what components willbeused,thenproceedwithcalculatingthecapacity,tensionandpower required, after that realize the conveyor of batch-
culletrejectandthenmakeadjustmentofcomponentandtotalcheckingallofcomponents.Ifthedesignissuccessful,

conclusions will be drawn. However, if it is not fit, it can bereset several components or make another priority design. Toget more detailed technical data such as the capacity used, beltspeed,tensionandpowerrequired,andthisisseveralequationscanbe usedto calculate them[11]:

1. Capacityand beltspeed:

Q_t=3,6$xAx\gamma xkxv$… (1)Where,

Qt=Beltconveyorcapacity(ton/hr)A=Crosssectionarea(m^2)

γ=Materialdensity(kg/m^3)v= Beltspeed(m/s)

k=Inclineordeclinefactor.

Table1. MaterialDensity[12].

Material	Density (kg/m3)	Angle of repose	Angle of surcharge
Chips, paper mill - *softwood*	190-480	"	25°
- *yellow pine*	320-400	"	25°
Clay - dry, loose	1010-1440	40°- 45°	15°- 25°
- *brick, gravmd fine*	1760	35°	15°
Coal - *150mm domestic sizes*	830-900	"	25°
- *run-of-mine*	720-880	35°	25°
- *slack*	690-800	37°	25°
- *pulverized for coking*	480-590	"	10°
- *lignite, broken*	720-880	"	25°
Cocoa	480-560	"	"
Coke - run of oven	400-480	30°	25°
- breeze	380-560	30°- 45°	20°
Concrete, wet, on conveyor	1760-2400	"	5°
Copper ores, crushed	2080-2400	"	25°
Copra	350	"	"
Corn grits	670	"	"
Cryolite - *50-75mm lumps*	1600-1680	"	20°
- *15mm screenings*	1440-1600	"	15°
- *dust*	1200-1440	"	5°
Dolomite - *lump*	1440-1600	See limestone	"
Earth - *as excavated, dry*	1120-1280	30°- 45°	20°- 25°
- *wet, mud*	1600-1760	"	5°
Foundry refuse, old sand, cores, etc.	960-1280	"	15°
Garbage - *household*	800	"	"
Glass - *batch*	1680	"	"
- broken	1280-1600	"	"
Granite - *40-80mm lumps*	1360-1440	25°	"
- *15mm screenings*	1280-1440	"	"
- *broken*	1520-1600	"	"
Gravel -*dry, sharp*	1440-1600	30°- 45°	25°
- *wet*	1600-1920	32°	25°
Gutta percha	960	"	"
Gypsum - *50-75mm lumps*	1200-1280	30°	20°

Table2. Crosssectionofload[11].

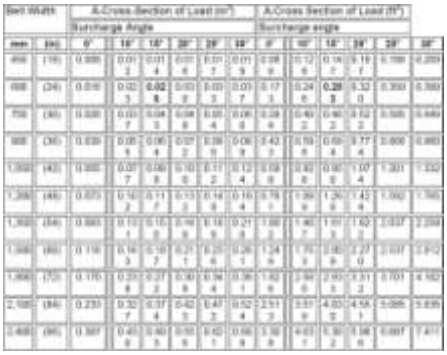

Table3."k"factorforinclineanddeclineconveyor.

Belt Slope	5°	10°	15°	17,5°	20°
Cos φ	0.996	0.985	0.954	0.940	0.906

2. Effectivetensionandpowerrequirment

T_e=$LxK_t(K_x+K_{yc}xW_b+ 0{,}015W_b)$
$+W_m(LxK_{yr}\pm H) +T_x+T_y+T_z+T_{ac}$ …(2)Where,

Te=Effectivetension(kg).

T_X=TheTensionto movetheemptybelt(kg).

=Gxf_xxL_c …(3)

T_Y =Thetensiontomovetheloadhorizontally(kg).

=$W_m x\ f_yxL_c$ …(4)

T_Z =Thetensiontoliftthe load(kg).

=HxW_m …(5)

Tac=The tensionasaresultofaddingaccessories(kg).

Tabel5: Massofmovingparts[12].

Belt Width (mm)	Belt Width (in)	Mass of Moving Parts (kg/m) (lb/ft)			
		Light Duty 4" Idlers Light Belt	Medium Duty 5" Idlers Moderate Belt	Heavy Duty 6" Idlers Heavy Belt	Extra Heavy Duty 6" Idlers Steel Cord Belt
450	18	23 (15.4)	25 (16.8)	33 (22.2)	
600	20	29 (19.5)	36 (24.2)	45 (30.2)	49 (33.0)
750	24	37 (25.0)	46 (31.0)	57 (38.3)	63 (42.3)
900	30	45 (30.0)	55 (37.0)	70 (47.0)	79 (53.0)
1050	36	52 (35.0)	64 (43.0)	82 (55.0)	94 (63.2)
1200	42	63 (42.3)	71 (47.7)	95 (63.8)	110 (74.0)
1350	48	70 (47.0)	82 (55.0)	107 (72.0)	127 (85.3)
1500	54		91 (61.2)	121 (81.3)	143 (96.0)
1650	60		100 (67.2)	132 (88.7)	160 (107.5)
1800	66			144 (96.7)	178 (119.6)
2100	72			168 (112.8)	205 (137.7)
2200	84			177 (119.0)	219 (147.2)

$\underline{\ f_SxW_mxL_S}$

$vx\ b$

L =Horizontallengthofconveyor(m)Lc=Correctedlengthofconveyor(m).

Kt =TemperatureambientcorrectedfactorKx =Idler frictionfactor(kg/m).

…(6)

Symbol	Description	Value of the friction factor		
		Normal operating conditions. Horizontal length up to 250 m (820 ft)	Normal operating conditions. Horizontal length more than 250 m (820 ft)	Very well aligned structure. No tilted idlers. Horizontal length more than 500 m (1640 ft)
f_C	Friction coefficient for scrapers	0.600	0.600	0.600
f_S	Friction coefficient for skirtboards	0.650	0.650	0.650
f_X	Friction coefficient for empty belt	0.022	0.020	0.020
f_Y	Friction coefficient for loaded belt	0.027	0.022	0.020

Table6: Frictionfactor[12].

Kyc =Factorsforcalculatingthebeltforceandflexureloadonthe idler roll. (0,022).
Kyr =Factorsforcalculatingthebeltforceandflexureloanonthe returnroll(0,015).
W_m =Materialweight(kg/m)W_b =Beltweight(kg/m)
G =Massofmovingparts(kg/m)(Table5)
f_s= friction coefficient for skirt board (Table 6)f_y = friction coefficient for loaded belt (Table 6)f_x=frictioncoefficientforemptybelt(Table6)

Table4: Beltweight[12].

Belt Width (mm)	Belt Width (in)	Operating Conditions		
		Light Duty kg/m (lb/ft)	Medium Duty kg/m (lb/ft)	Heavy Duty kg/m (lb/ft)
500	20	4.1 (2.75)	6.2 (4.16)	10.3 (6.92)
600	24	5.0 (3.36)	7.4 (4.97)	12.3 (8.26)
750	30	6.2 (4.16)	9.3 (6.25)	15.5 (10.41)
900	36	7.4 (4.97)	11.1 (7.46)	18.5 (12.43)
1050	42	8.6 (5.78)	13.0 (8.73)	21.6 (14.51)
1200	48	9.8 (6.58)	14.8 (9.94)	24.7 (16.60)
1350	54	11.0 (7.39)	16.7 (11.22)	27.8 (18.68)
1500	60	12.3 (8.26)	18.6 (12.50)	30.9 (20.76)
1650	66	13.5 (9.07)	20.5 (13.77)	33.9 (22.78)
1800	72	14.7 (9,88)	22.3 (14.98)	37.0 (24.86)

3. Powerofconveyor:

$P=(T_e xv)/75$ …(7)

Where,
P=Beltpower (HP).
T_e= Effective tension (kg).v=Kecepatanbelt(m/min)

2. DESIGNOFCONVEYORBATCH-CULLETREJECT

Conveyordesignspecificationsareplannedbasedonfieldconditionsorinstallationareaswhicharealsoadjustedtoproduction,sothatitfitstotheproductionprocessintheBatchPlanarea,Table7describestherequiredconveyorspecifications:

Table7: Productdesignspesification

No	Item	Spesification	Wish / Demand
1	General Function	Capable to transport batch-cullet materials.	D
2	Performance	1. Transport capacity 620 tons/day or 150 times of mixing process.	D
		2. Capable to filtering metal contamination in batch-cullet reject.	W
3	Dimension	1. Conveyor A: maximal length of 8 meters with angle inclined 30^0 dan maximal height of 5 meters.	W
		2. Conveyor B: maximal length of 5 meters.	W

Theconceptualdesignofconveyorbatch-culletrejectisarrangedbasedonallthesub-functionslistedinTable 8:
Table8: Sub-functionofconveyorbatch-culletreject**.**

No	Sub-function	1ST Solution	2ND Solution	3RD Solution	4TH Solution	5TH Solution	6TH Solution
1	Drive Arrangemnts	Single drive without snub pulley	Single drive with snub pulley	Tandem type single drive	Tandem drive	Dual drive	Multiple drive
2	Belt tension adjustment	*Screw take-up*	*Gravity take-up*	*Horizontal gravity type*	*Power sistem type*	-	-
3	Belt support	*2 Idler roll*	*3 Idler roll*	*5 Idler roll*	-	-	-
4	Contamination filter	*Suspended magnet*	*Suspended electro magnetic*	-	-	-	-
5	Contamination detector	Metal *detector*	-	-	-	-	-
6	Dumper drive	Motor	Pneumatic	-	-	-	-

consist of two types of conveyor, first conveyor is conveyor A(inclinedconveyor)andthesecondoneisconveyorB(horizontalconveyor).

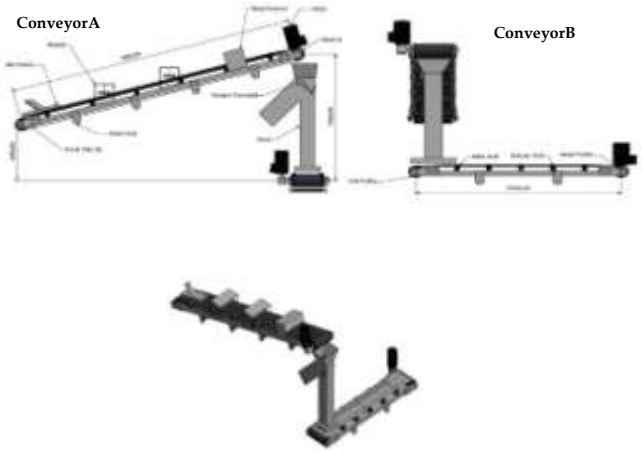

Figure7: Designofbatch-culletrejectconveyor.

Figure7showsthedetaileddesignofbatch-culletrejectconveyorthathasbeenadjustedtothespecificationneededandwiththeconceptualdesignthathasbeendetermined.Thetechnicaldataforconveyorbatch-culletrejectwillbedescribedbased on the equation used to calculate the conveyor capacity,belt speed, the tension generate by the belt and the powerrequired ofbatch-culletrejectconveyor.

1. ConveyorA

- Theconveyorcapacitytobeusedisbasedonproduction

Thecombinedresultsofall functionwillformoverallfunctionthat qualify the design product specification. There are severalvariants of solutions, design priority is given based on technicalandfieldsneed.Thefirstoptionisconsideredtobethefirst

capacity= $\frac{620ton/day}{150mixingx60}$

- Beltspeed:

$x1000$=68.83 kg/s

priority that will lead to the selection of a conceptual design.Here is a combination of solutions with sub-function as thebasisfor conceptual design:

v= $\frac{Qt}{3,6xAx\gamma xk}$ = $\frac{68,83}{3,6x0,043x1680x0,906}$

- Teganganefektif:

=0.292m/s…(1)

1. 1ST conceptualdesign:1-1,2-1,3-2,4-1,5-1and6-2.
2. 2ND conceptualdesign:1-2,2-1,3-3,4-2,5-1and6-1.
3. 3RD conceptualdesign:1-1,2-1,3-3,4-1,5-1and6-2.
4. 4TH conceptualdesign:1-2,2-1,3-2,4-1,5-1and6-2.

The conceptual design is determined based on the assessmentofeachalternativesolutionbasedonthetechnicalrequirementsand operational conditions in the area and the first conceptualdesign variant is the main priority. Based on the specificationin Table 1, the drive system uses a single drive without a snubpulley, belt tension adjustment using screw take-up [13], beltsupport using 3 idler-roll [14], contaminant catcher using asuspended magnet [15], contamination detector using a metaldetectorand dumperdriver usingapneumaticsystem[16-17].

3. DETAILDESIGNOFCONVEYORBATCH-CULLETREJECT

Figure7showsthedesignofbatch-culletrejectconveyorwhich

$T_e=LxK_t(K_x+K_{yc}xW_b+0,015W_b)+$
$W_m(LxK_{yr}\pm H)+T_x+T_y+T_z+T_{ac}$
…(2)

Where,
Tx= 67.62 kg …(3)
Ty=137.10kg …(4)
Tz =229.32kg …(5)
Tac=217.68kg …(6)
L = 7.5 meters Wm =65.52kg/m Wb=9.9kg/m
G = 39.66 kg/m Kyc= 0.022

Kyr =0.015
Kt=1
Kx=1.96kg/m

Then,
$T_e=LxK_t(K_x+K_{yc}xW_b+0,015\ W_b)+$
$W_m(L\ xK_{yr}\pm H)+T_x+T_y+T_z+T_{ac}$
=7.5x1(1.96+0.022x9.9+0.015x9.9)+
65.52(7.5x0.015+3.5)+67.62+137.10+
229.32 +217.68
=905.81 kg

Then,
$T_e=LxK_t(K_x+K_{yc}xW_b+0,015W_b)$
$+W_m(LxK_{yr}\pm H)+T_x+T_y$

$+T_z+T_{ac}$
=4.5x1(1.97+0.022x9,9+0.015x9.9)+
72.48(4.5x0.015+0)+65+145.79+0+
266.35
=492.54kg

- PowerofConveyor

$P=\frac{Texv}{75}=\frac{492.54_x0,264}{75}$=1.73HP=1.29kW

- Powerofconveyor:

$P=\frac{Texv}{75}=\frac{905.81_x0.292}{75}$=3.52HP =2.62kW
…(7)

2. ConveyorB

- Theconveyorcapacitytobeusedisbasedon

Thedetaildesignofbatch-culletrejectconveyorproducestechnical specification for conveyor A and conveyor B whicharedescribedinTable9basedonthecalculationthathavebeencarried out

Table9: Technicalspesification

production capacity= $\frac{620_{ton/day}}{150mixingx60}$

Conveyor A		Conveyor B	
Technical Spesification		**Technical Spesification**	
1. General Data Conveyor		**1. General Data Conveyor**	
Length	: 7.5 meter	Length	: 4.5 meter
Height	: 3.5 meter	Height	: -
Max Inclined	: 20^0	Max Inclined	: -
Capacity	: 68.83 kg/s	Capacity	: 68.83 kg/s
Belt Speed	: 0.292 m/s	Belt Speed	: 0.264 m/s
Belt Width	: 800 mm	Belt Width	: 800 mm
Effective Tension	: 905.81 kg	Effective Tension	: 492.54 kg
Conveyor Power	: 2.62 kW	Conveyor Power	: 1.29 kW
2. Pulley Diameter		**2. Pulley Diameter**	
Head Puley Diameter	: 406 mm	Head Puley Diameter	: 406 mm
Tail Pulley Diameter	: 318 mm	Tail Pulley Diameter	: 318 mm
3. Carry Roll		**3. Carry Roll**	
Idler Roll Diameter	: 101,6 mm	Idler Roll Diameter	: 101,6 mm
Idler Roll Length	: 200 mm	Idler Roll Length	: 200 mm
Idler Roll Spacing	: 1200 mm	Idler Roll Spacing	: 1200 mm
Troughing Angle	: 20^0	Troughing Angle	: 20^0
4. Return Roll		**4. Return Roll**	
Return Roll Diameter	: 106,68 mm	Return Roll Diameter	: 106,68 mm
Return Roll Spacing	: 1800 mm	Return Roll Spacing	
5. Skirt Board		**5. Skirt Board**	
Length	: 1000 mm	Length	: 1000 mm
Width	: 670 mm	Width	: 670 mm
6. Material Data		**6. Material Data**	
Material Density	: 1680 kg/m^3	Material Density	: 1680 kg/m^3
Surcharge Angle	: 10^0	Surcharge Angle	: 10^0
Cross section of load	: 0.043 m^2	Cross section of load	: 0.043 m^2

x1000=

68.83kg/s

- Beltspeed:

v=$\frac{Qt}{}$=$\frac{68,83}{}$

=0.264 m/s

3,6 $xAx\gamma$ 3,6 x0,043x1680

- Teganganefektif:

T_e=LxK_t(K_x+$K_{yc}xW_b$+0,015 W_b)+ W_m(L xK_{yr}±H) +T_x+T_y+T_z+T_{ac} …(2)

Where,
Tx=65kg …(3)
Ty=145,79 kg …(4)
Tz=229.32kg …(5)
Tac=266.35kg …(6)
L= 4.5 metersWm = 72.48 kg/mWb =9.9 kg/m
G = 39.66 kg/mKyc=0.022
Kyr=0.015
Kt= 1
Kx=1.96 kg/m

3. RESULTS

Aftergettingthetechnicalspesificationofthebatch-culletreject conveyor which is show in Table 9. The next thing to dois to realize the design and evaluate the results of the batch-culletrejectconveyortoreducelossbatch.Figure8istheresult

fromdesignofbatch-culletrejectconveyorbasedonconceptualdesignanddetaildesignofbatch-culletrejectconveyor

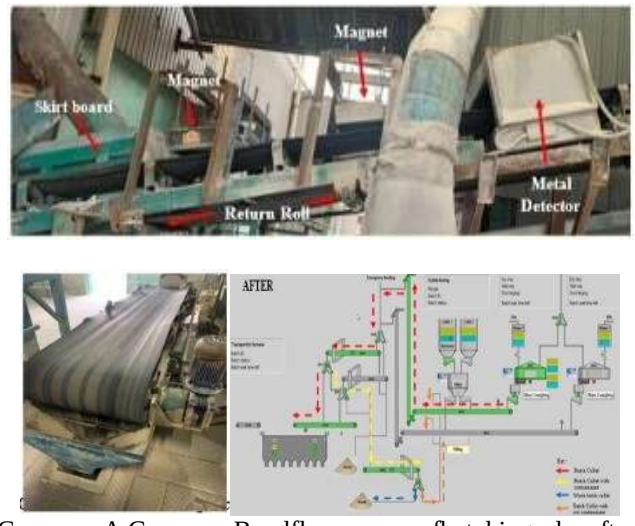

Figure8: ConveyorA,ConveyorBandflowprocessofbatching-planafterdesigning

Thedesignofthisbatch-culletrejectconveyoraffecttheamount of batch-cullet loss produced per day, where the lossbatch-cullet per day is 7890 kg. After the batch cullet rejectconveyor realize, loss batch-cullet decreased by 87% or 952.6kg per day. Figure 9 shows the difference in the number ofbatch-culletrejectproducedperdaybeforeandafterdesigning.

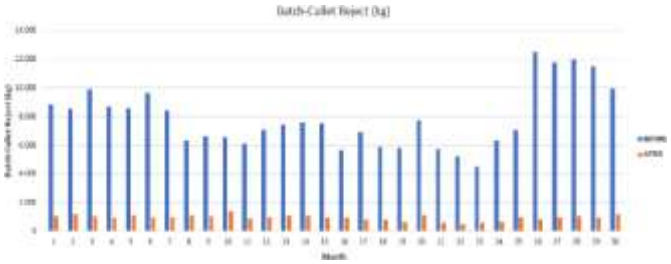

Figure9: Lossbatch-cullet.

Basedontheresults,thatbatch-culletrejectconveyorisabletoreducelossbatch-culletcausedbymetalcontaminationandthedesignresultisqualifywithspecificationwhichcanaccommodateaproductioncapacityaround620000kgperdayand can split contamination in batch-cullet. Where the lengthoftheconveyorAis7.5meters,3.4metersofconveyor height,slope angle is 20^0 and suspended permanent magnet and metaldetector. The conveyor B has a 4.5 meters of conveyor lengthwithoutmagnet andmetal detector

SUMMARY AND CONCLUSION

This paper describes the innovation of batch cullet recyclingdesignthatiscontaminatedbymetal.Designofabeltconveyorusing a single drive system without snub pulley, adjusting beltwith screw take-up, belt support with 3 idler rolls, metal catcherwithsuspendedpermanentmagnet,contaminationdetector withmetaldetectorsanddrivingdumperwithpneumaticsystemhavebeensuccessfullyandaccordingtospecifications. ThetotallengthoftheconveyorAis7.5meters,theheightis
3.5 meters, conveyor angle is 20^0, and power generate by theconveyor is 2.62 kW with suspended permanent magnet as acontaminantcatcherandmetaldetectorasacontaminantdetector. The total length of the conveyor B is 4.5 meters andpower generate by conveyor B is 1.29 kW. The application ofthis conveyor batch-cullet reject is effective in reducing batch-cullet reject affected by metal contamination. The number ofbatch-culletrejectisreducedfrom7890kg/dayto952.6kg/daysor around87.92%of7890 kg/day

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