15. Port facilities

15-1. Design criteria

Production:130,754 t/year=350 days ＝ 374 dry t/day
＝400 wet t/day Max

Maximum inventory on mill site: 2,000 wet tons

Maximum inventory on port site: 9,000 wet tons

Capacity of ship: 7,000 t

15-2 Shipping facilities

15-2-1. Concentrate yard

Maximum inventory on port site: 9,000 wet tons

Apparent specific gravity: 2.0t/ m^3

Stock volume: V＝9,000 t÷2.0t/ m^3 ＝4,500 m^3

Maximum height of pile: H ＝2.5 m

Required area: A＝V/H＝4,500 m^3 ÷2.5 m＝1,800m2 Min

Installed area: 32mW×64mL＝2,048m^2 ＞1,800m^2 OK

15-2-2. Loading equipment for conveyor

Loading for conveyor hoppers shall be done by wheel loaders and a bulldoze will do auxiliary work such as pile up of the concentrate.

Wheel loaders: Bucket capacity 2 m^3 × 2 sets

Bulldozer: 2.5t class 1 set

15-3. Ship loading conveyors

15-3-1. Design concept

Hauled concentrate will be damped at stock yard located near USKAN port. 7,000 ton cargo ships will be used to send the concentrate to Japanese smelters. 2 sets of wheel loaders will load the concentrate into 2 sets of chutes for No.1 and 2 belt feeders. They will discharge the load onto No.3 belt conveyor, then the concentrate will be conveyed by No.4 and No.5 belt conveyors to a ship loader with swiveling boom conveyor and loaded to hold continuously.

15-3-2. Calculations of minimum belt speeds

1] No.1 & No.2 belt feeder

Capacity : Q ＝250 mt/h

Belt width: b＝900 mm

Belt speed $v=Q/\{\gamma\cdot 60k1\cdot k2\cdot (0.9b-0.05)^2\}$ [m/min]

γ: apparent specific gravity 2.0

k_1: slope factor:1.0

k_2:　factor for trough and surcharge angles; 0.145

$=250/\{2\times60\times1\times0.145\times(0.9\times0.9-0.05)^2\}$

$=24.8$ m/min→25 m/min

2] No.3 belt conveyor

Capacity :　Q =450 mt/h

Belt width:　b=750 mm

Belt speed:　$v=Q/\{\gamma\cdot60k1\cdot k2\cdot(0.9b-0.05)^2\}$　[m/min]

γ: apparent specific gravity 2.0

k_1: 1.0

k_2: 0.075

$=400/\{2\times60\times1\times0.075\times(0.9\times0.75-0.05)^2\}$

$=113.8$ m/min→120 m/min

3] No.4 belt conveyor

Capacity :　Q =450 mt/h

Belt width:　b=750 mm

Belt speed:　$v=Q/\{\gamma\cdot60k1\cdot k2\cdot(0.9b-0.05)^2\}$　[m/min]

γ: apparent specific gravity 2.0

k_1:1.0

k_2:0.145

$=400/\{2\times60\times1\times0.075\times(0.9\times0.75-0.05)^2\}$

$=113.8$ m/min→120 m/min

4] No.5 belt conveyor

Capacity :　Q =450 mt/h

Belt width:　b=750 mm

Belt speed:　$v=Q/\{\gamma\cdot60k_1\cdot k_2\cdot(0.9b-0.05)^2\}$　[m/min]

γ: apparent specific gravity 2.0

k_1: 1.0

k_2: 0.145

$=400/\{2\times60\times1\times0.075\times(0.9\times0.75-0.05)^2\}$

$=113.8$ m/min→120 m/min

15-3-3. Calculations of power requirement

1] No.1 and No.2 belt feeders

Power for empty conveyor　$P_1=0.06fwv(l+l_0)/367$　[kw]

Power for horizontal live load $P_2=f\cdot Q_t\ (l+l_0)/367$　[kw]

Power for vertical live load　$P_3=\pm h\cdot Q_t/367$　[kw]

Total power requirement　$P = P_1 + P_2 + P_3$

$P_1=0.06\times0.03\times65\times25\times(5.5+49)/367=0.43$ kw

$P_2 = 0.03 \times 250 \times (5.5 + 49)/367 = 1.11$ kw

$P_3 = 0$

$P = 0.43 + 1.11 = 1.54$ kw

Installed power was determined to be 11 kw which is same with power for No.4 belt conveyor in order to save spare parts.

2] No.3 belt conveyor

$P_1 = 0.06 \times 0.03 \times 54 \times 120 \times (166 + 49)/367 = 6.83$ kw

$P_2 = 0.03 \times 400 \times (166 + 49)/367 = 7.03$ kw

$P_3 = 2.0 \times 400/367$ kw $= 2.17$ kw

$P = 6.83 + 7.03 + 2.17 = 15.5$ kw

Installed power: 22 kw

3] NO.4 belt conveyor

$P_1 = 0.06 \times 0.03 \times 54 \times 120 \times (49.5 + 49)/367 = 3.13$ kw

$P_2 = 0.03 \times 400 \times (49.5 + 49)/367 = 3.22$ kw

$P_3 = 3.0 \times 400/367$ kw $= 3.26$ kw

$P = 3.13 + 3.22 + 3.26 = 9.61$ kw

Installed power: 11 kw

4] No.5 belt conveyor

$P_1 = 0.06 \times 0.03 \times 54 \times 120 \times (232.95 + 49)/367 = 8.96$

$P_2 = 0.03 \times 400 \times (232.95 + 49)/367 = 9.21$ kw

$P_3 = 11.1 \times 400/367$ kw $= 12.0$ kw

$P = 8.96 + 9.21 + 12.0 = 130.21$kw

Installed power: 37 kw

15-4 Ship loader

15-4-1. Design concept

The concentrate will be load to ship by a belt conveyor type ship loader. In order to prevent loss due to wind, a telescopic bucket chain will be installed at discharge point and its length will be regulated by wire hanged from boom.

Manufacturer:	SANKI Engineering Co. Ltd
Capacity:	400 mt/h
Boom conveyor:	750 mmW×17 m×120 m/min×15kw
	Slope angle ±15°
	Tip speed 9 m/min×15 kw
Swiveling:	Right 35° ,Left 105°　Radius 15.8m
	Tip speed 30m/min×5.5kw
Shuttling:	Range 4.5m
	Speed 5 m/min×5.5kw
Tower dimension:	Total height;　19.3 m
	Width;　3.5 m
	Length;　4.0 m
	Counter weight; 35 tons
	Total weight; 38.5 tons excluding counter weight

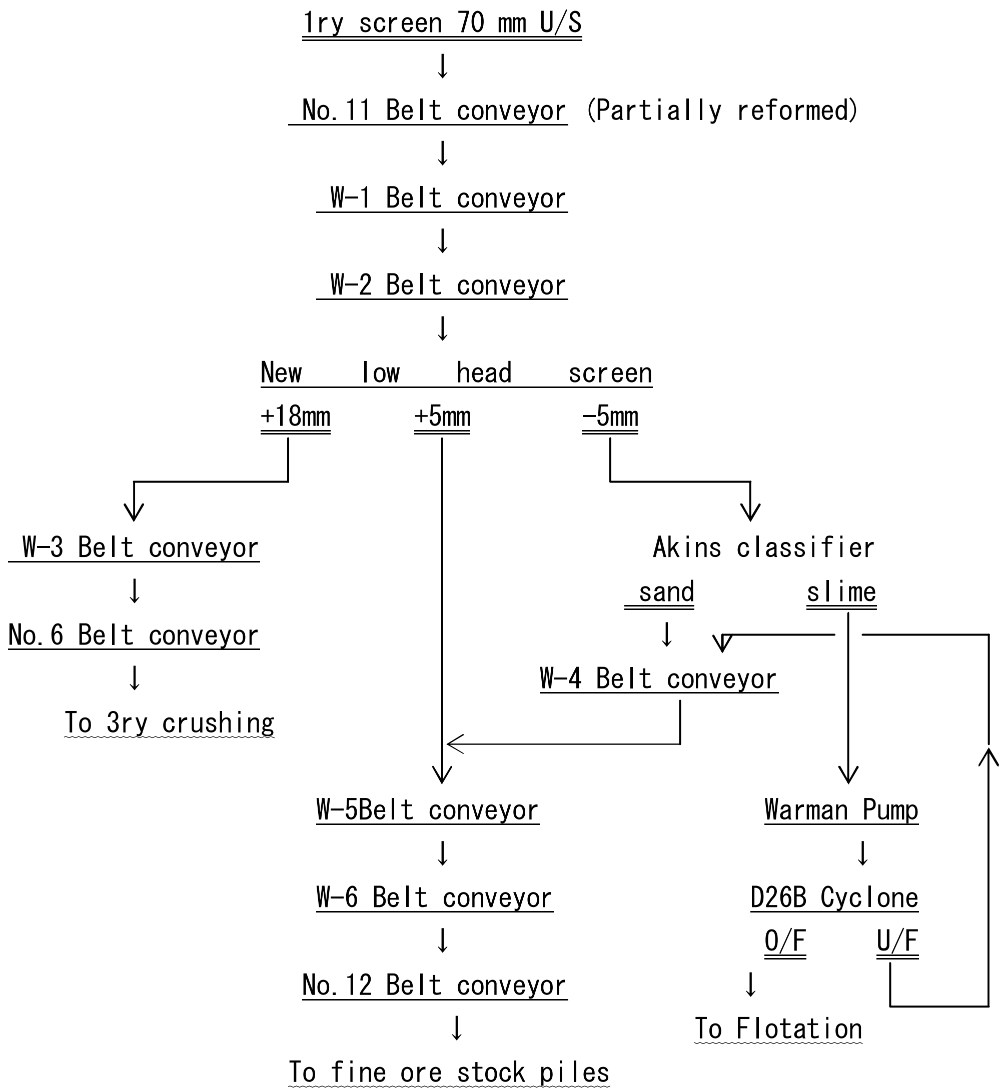
16. Washing facilities

16-1. Design concept

At initial start-up stage, extremely sticky ores were mined from near surface of deposit and many troubles due to choking of crushers and chutes occurred often and were one of the biggest causes of down time.

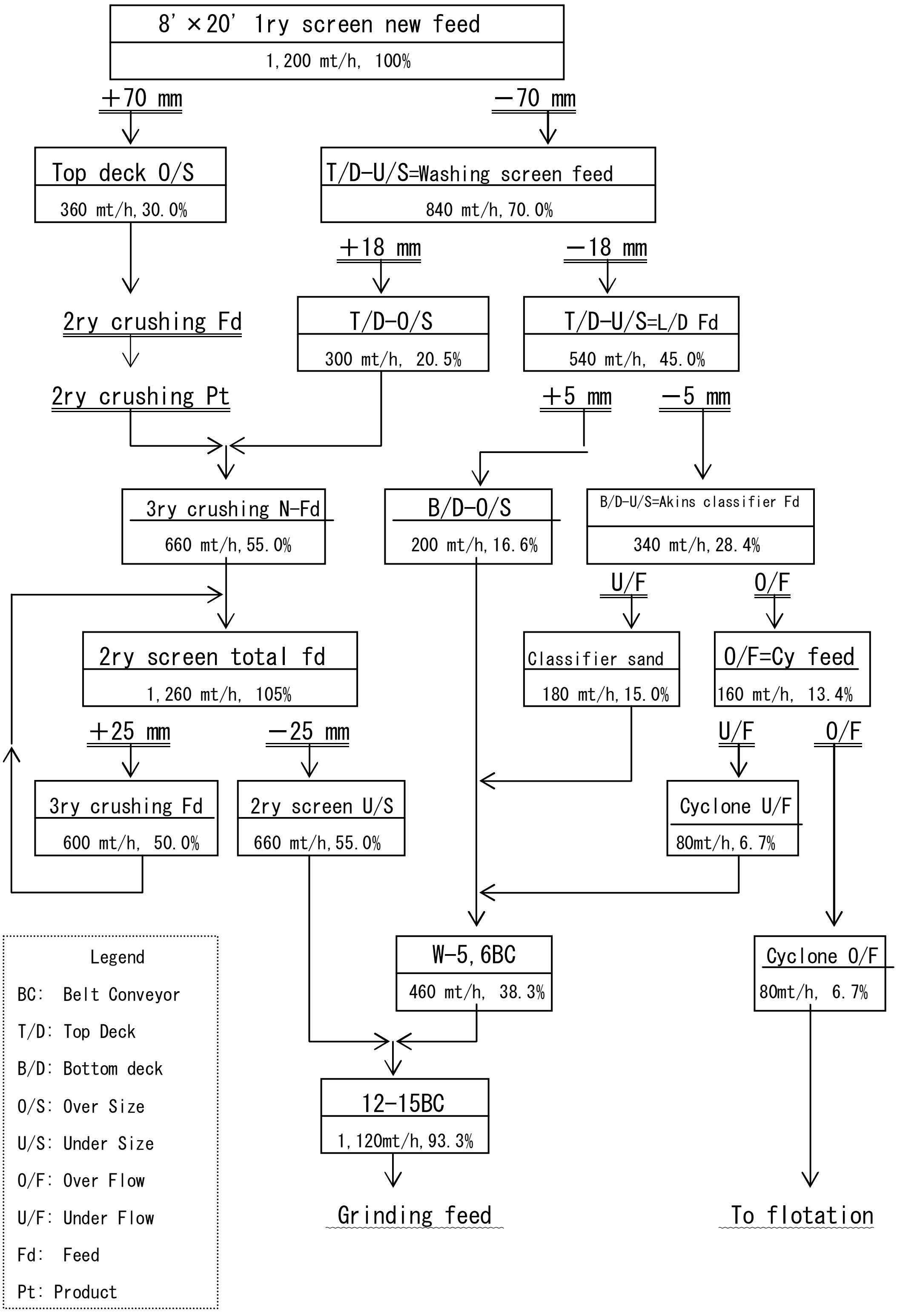
For this reason, we installed temporary washing facilities using a screen, mechanical classifier and cyclone.

Flow sheet



The bottom decks of 1ry screens will be removed and their under sizes will be washed by a double decked new low head screen. Washed over size product will be sent by belt conveyors to mix with the 2ry crushing product. The over size of bottom deck of the new low head screen will be sent directly to the fine ore stick pile. Undersize will be classified by an Akins classifier and Krebs cyclone and coarse fraction will be mixed with the middle size of the screen. Cyclone overflow will be treated by flotation process using a part of the existing rougher flotation circuit.

16-2. Estimated tonnage balance sheet for 2ry and 3ry crushing plant, including newly installed washing facilities



16-3 Calculation of minimum belt speed

16-3-1. W-1 belt conveyor

Capacity : $Q=1,200$ mt/h

Belt width: $b=1,200$ mm

$v=Q/\{\gamma\cdot 60k_1\cdot k_2\cdot(0.9b-0.05)^2\}$ [m/min]

γ: apparent specific gravity 2.0

k_1: 1.1

k_2: 0.075

$=1,200/\{2\times 60\times 1.1\times 0.075\times(0.9\times 1.2-0.05)^2\}$

$=114.3$ m/min→120 m/min

16-3-2. W-2 belt conveyor

Capacity : $Q=1,200$ mt/h

Belt width: $b=1,200$ mm

$v=Q/\{\gamma\cdot 60k_1\cdot k_2\cdot(0.9b-0.05)^2\}$ [m/min]

γ: apparent specific gravity 2.0

k_1: 1.1

k_2: 0.075

$=1,200/\{2\times 60\times 1.1\times 0.075\times(0.9\times 1.20-0.05)^2\}$

$=114.3$ m/min→120 m/min

16-3-3. W-3 belt conveyor

Capacity : $Q=400$ mt/h

Belt width: $b=900$ mm

$v=Q/\{\gamma\cdot 60k_1\cdot k_2\cdot(0.9b-0.05)^2\}$ [m/min]

γ: apparent specific gravity 2.0

k_1: 1.1

k_2: 0.075

$=400/\{2\times 60\times 1\times 0.075\times(0.9\times 0.90-0.05)^2\}$

$=76.9$ m/min→80 m/min

16-3-4. W-4 belt conveyor

Capacity : $Q=336$ mt/h

Belt width: $b=900$ mm

$v=Q/\{\gamma\cdot 60k_1\cdot k_2\cdot(0.9b-0.05)^2\}$ [m/min]

γ: apparent specific gravity 2.0

k_1: 1.1

k_2: 0.075

$=336/\{2\times 60\times 1.1\times 0.070\times(0.9\times 0.90-0.05)^2\}$

$=64.6$ m/min→80 m/min

16-3-5. W-5,6 belt conveyor

Capacity : $Q=768$ mt/h

Belt width: $b=1,200$mm

$v=Q/\{\gamma \cdot 60k_1 \cdot k_2 \cdot (0.9b-0.05)^2\}$ [m/min]

γ: apparent specific gravity 2.0

k_1: 1.1

k_2: 0.070

$=768/\{2\times60\times1.1\times0.070\times(0.9\times1.20-0.05)^2\}$

$=78.3$ m/min→80 m/min

16-4. Calculations of required power of belt conveyors

16-4-1. W-1 belt conveyor

Conveyor power without load P_1 : $P_1 = 0.06fWv(l+l_0)/367$ [kw]

Power by horizontal load P_2 : $P_2 = f \cdot Qt\ (l+l_0)/367b$ [kw]

Power by vertical load P_3 : $P_3 = \pm h \cdot Q_t/367$ downward－ [kw]

Required power P: $P = P_1 + P_2 \pm P_3 + P_t$ [kw]

$P_1 = 0.06\times0.03\times90\times120\times(14.7+49)/367=3.37$ kw

$P_2 = 0.03\times1,200\times(14.7+49)/367=6.25$ kw

$P_3 = +2.2\times1,200/367=7.19$ kw

$P = 3.37+6.25+7.19=16.81$ kw

$P_i = 16.81/0.8=21.01$→22kw

16-4-2.W-2 belt conveyor

$P_1 = 0.06\times0.03\times90\times120\times(46.2+49)/367=5.04$ kw

$P_2 = 0.03\times1,200\times(46.2+49)/367=9.33$ kw

$P_3 = +7.2\times1,200/367$ kw$=23.54$ kw

$P = 5.04+9.33+23.54=37.91$ kw

$P_i = 37.91/0.8=47.38$→55kw

16-4-3.W-3 belt conveyor

$P_1 = 0.06\times0.03\times63\times80\times(12.2+49)/367=1.51$ kw

$P_2 = 0.03\times336\times(12.2+49)/367=1.68$ kw

$P_3 = -0.3\times336/367$ kw$=-0.27$ kw

$P = 1.51+1.68-0.27=2.92$ kw

$P_i = 2.92/0.8=3.65$→5.5kw

16-4-4. W-4 belt conveyor

$P_1 = 0.06\times0.03\times63\times80\times(6.8+49)/367=1.37$kw

$P_2 = 0.03\times336\times(6.8+49)/367=1.53$ kw

$P_3 = 0$ kw

P ＝1.37＋1.53＝2.90 kw

P_i ＝2.90/0.8＝3.63→5.5kw

16-4-5. W-5 belt conveyor

P_1 ＝0.06×0.03×90×80×(33.2＋49)/367＝2.90 kw

P_2 ＝0.03×768×(33.2＋49)/367＝5.16 kw

P_3 ＝＋6.3×768/367 kw＝13.18 kw

P ＝2.90＋5.16＋13.18＝21.14 kw

P_i ＝21.14/0.8＝26.55→30kw

16-4-6. W-6 belt conveyor

P_1 ＝0.06×0.03×90×80×(7.0＋49)/367＝1.98 kw

P_2 ＝0.03×768×(7.0＋49)/367＝3.52 kw

P_3 ＝＋1.2×768/367 kw＝ 2.51kw

P ＝1.98＋3.52＋2.51＝8.01 kw

P_i ＝8.01/0.8＝10.01→11kw

16-5. New low-head screen

16-5-1.Design concept

Top deck under size of 1ry screens in the 2ry & 3ry crushing plant will be washed by additionally installed new low-head screen for separation of slime. In order to decrease load of Akins classifiers in the down stream, large particles will be separated by woven wire screen with 5mm aperture which is protected by punched steel plate with rubber lined 18 mm square steel plate for anti-abrasion.

16-5-2. Calculation of required screen area

Required screen area is given by the following equation.

$$A = \frac{Q}{CIDS_oS_hFEOWYMZ}$$

Where A: required screen area [ft^2]

Q :Tonnage of under size in feed

Top deck 540mt/h×1.102＝595.08 [st/h]

Bottom deck 340mt/h×1.102＝374.68 [st/h]

C : Basic capacity based on opening size 2.20 [$st/h/ft^2$]

Aperture mm	6.4	12.7	19.1	25.4	31.8	38.1	44.5	50.8	57.2	63.5
$St/h/ft^2$	1.05	1.70	2.20	2.65	3.05	3.42	3.74	4.02	4.23	4.40

C is determined by complementally method as C＝2.12 at 18mm.

I : Basic capacity based on opening size 1.0 at 0°, 0.95 at 20°

D : Deck factor; Top deck 1.00, second deck 0.90, bottom deck 0.80

So : Oversize factor; Factor due to bigger particles than opening. 1.0

10%	20	30	40	50	60	70	80	85	90	95
1.05	1.01	0.98	0.95	0.90	0.86	0.80	0.70	0.64	0.55	0.40

Assuming 70% is bigger than the aperture, S_o=0.8

S_h : Half size factor; % of material in the feed less than one half the size of opening;

0%	10%	20	30	40	50	60	70	80	85	90	95
0.44	0.55	0.70	0.80	1.00	1.20	1.40	1.80	2.20	2.50	3.00	3.75

Assuming 50% is smaller than the aperture, S_h=0.8

F : Factor due to shape of the opening Square;1.0, circle; 0.8, rectangular: L/S=2～３ ;1.6, L/S=3～6;1.4, L/S>6; 1.1

E: Efficiency factor; in the case where smaller size than half of the aperture takes more than 70%, efficiency is improved.

Ratio %	70	80	85	90	95
E	2.25	1.75	1.50	1.25	1.00

O : Open area factor;＝1－0,02(50－opening%)

Top deck; 18mm square staggered, O＝1－0,02(50－40)＝0.8

Bottom deck; 5×11mm 6mmφ woven wire O＝1－0,02(50－30)＝0.6

W : Factor depending on bulk density＝1.7/1.6＝1.06

Y : Shape factor due to shape of particles which varies by percentage of particles in total feed where major axis/minor axis ratio is bigger than 3, besides minor axis ranges from 1/2 to 2/3.

(5%; 1.00, 10%; 0.95, 20%; 0.85) →1.0

M: Wet screening factor

Dry;1.0、

Wet (In the case where water is sprayed 25～50ℓ per m³/h of feed)

Aperture	25.4mm	19.1	12.7	9.5	7.9	4.8	3.2	1.6	0.8
M	2.9	2.71	2.5	2.25	2.1	1.9	1.75	1.5	1.25

Z: Moisture and cohesion factor

Wet muddy or sticky gravel, gypsum, apatite etc. ; 0.75

Ore with wet surfaces, Moisture＞6% and not water absorpivet materials ; 0.85

Dry limp materials, Moisture＜4%;1.0

	Q	C	I	D	So	Sh	F	E	O	W	Y	M	Z
T/D	595.08	2.12	1.0	1.0	0.96	0.8	1.0	1.25	0.8	1.06	0.95	2.55	0.85
B/D	374.68	1.05	1.0	0.9	0.86	1.0	1.6	2.0	0.6	1.06	0.95	2.1	0.85

Top deck $A=\dfrac{595.08}{2.12\times1\times1\times0.96\times0.8\times1\times1.25\times0.8\times1.06\times0.95\times2.55\times0.85}=167\ ft^2$

Assuming screen width as 8 ft, length L will be

$L=167\ ft^2/8\ ft=20.9\ ft$

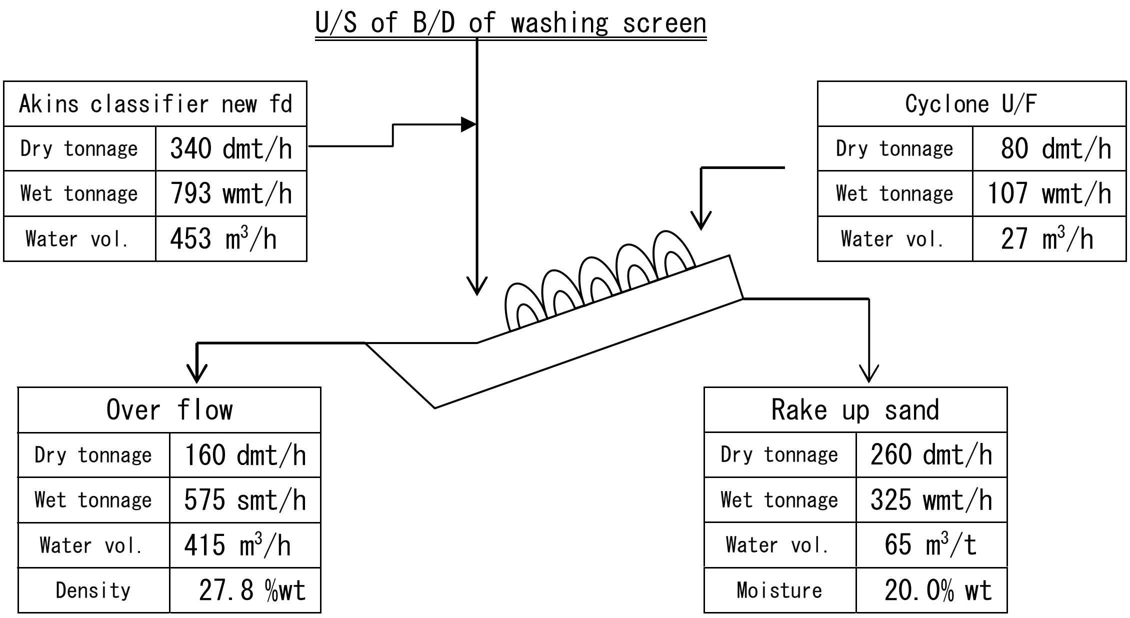
Since 22 ft is standard next to 20 ft 8 ftW × 22 ftL model should be adopted.

Bottom deck $A=\dfrac{374.68}{1.05\times1\times0.9\times0.86\times1\times1.6\times2\times0.6\times1.06\times0.95\times2.1\times0.85}=134\ ft^2$

$A=134<8\times22=176\ ft^2$…OK

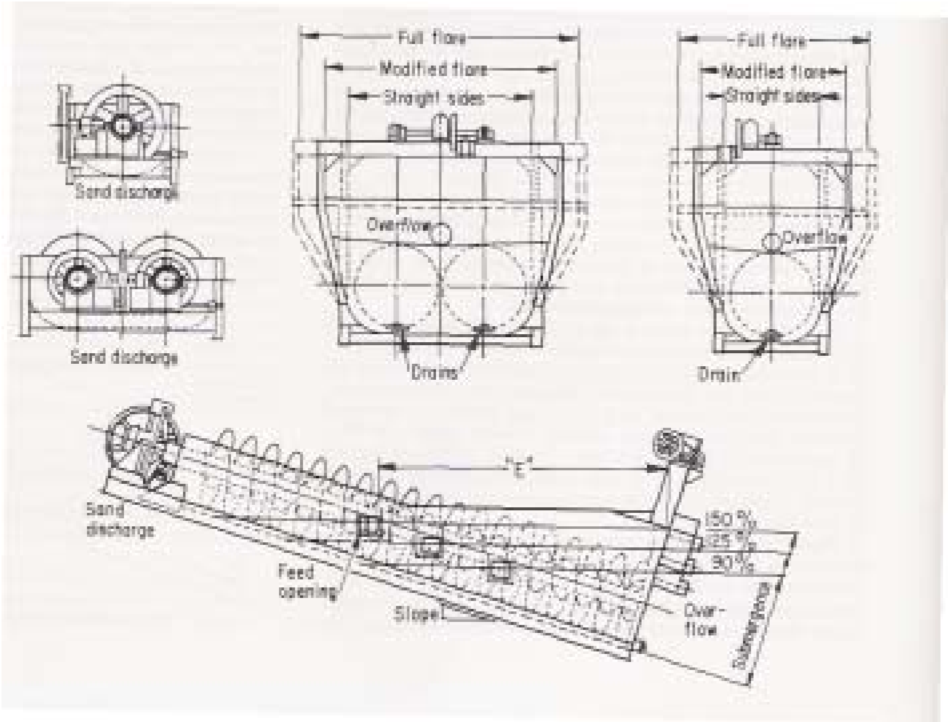
16-6. Akins classifier

16-6-1. Material balance

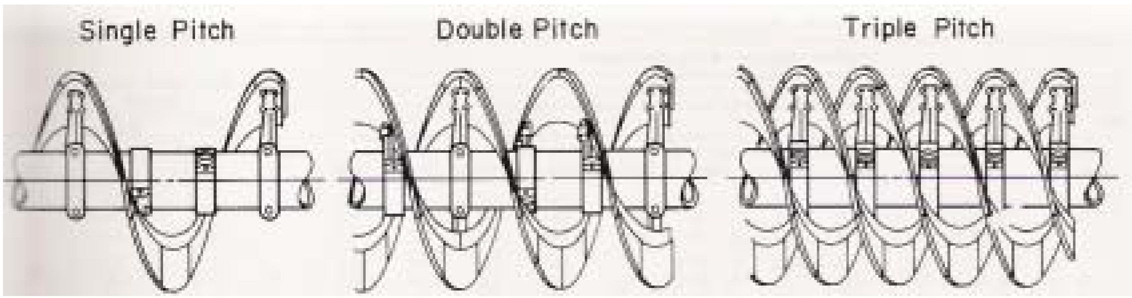


16-6-2. Design concept

The slime which gives many troubles for crushing or transportation, finally is separated by cyclone. Since when many coarse particles are contained, severe abrasion problem may be occurred, they are removed in advance by mechanical classifiers. The mechanical classifiers can be roughly classified into rake classifier and spiral classifier. The former has rather excellent classifying performance but requires much attention for operation and is expensive. The latter has simple structure and bigger capacity for unit floor area and less troubles due to sedimentation. Troubles of its submerged bearing have been improved by progress of seals. Hence we should adopt Akins classifier as a model of the spiral classifier.



There are two types of the spiral classifiers, namely simplex with single raking mechanism and duplex with double ones, as shown in above figures. Each type has Straight side, Modified flare and Full flare based on pool type. Besides, helices of the mechanism with single, double and triple pitch can be available to increase raking capacity as shown in the following. Submergence of the spiral can be manufactured in three styles with 90%, 125% and 150%. There are also differences in the pitches of helices, revolutionary speeds and tank slope among the manufacturers.



We should select two sets of simplex type for maintenance.

After technical bulletin of TOHOKU Kikai MFG Co. Ltd, we should adopt the helices of doubled 1,800ϕ ×900 pitch×7.5kw base on the tonnage of rake up sand. Tank type should be full flare based on the tonnage of over flow.

16-7. Warman pump

16-7-1. Design concept

Required flow rate : dry volume;160 mt/h×1/2.7t/m^3×1/60 min/h=0.99m^3/min
water;　　415 m^3/h×1/60 min/h=6.91m^3/min
Pulp volume; 0.99m^3/min+6.91m^3/min=7.90 m^3/min

Flow velocity :　　Assuming pipe diameter as 250A,
V=7.90m^3/min×1/60sec/min×1/{π/4×(0.25m)^2}=2.68m/sec
V<3.0m/sec, so there will not be trouble due to abrasion.

16-7-2. Calculation of friction loss after Darcy's equation

$$hs = f \cdot \frac{L \cdot V^2}{D \cdot 2g}$$

Where	hs	: friction head loss		[m]
	L	: piping length	20.0	[m]
	D	: Inner diameter of pipe	0.25	[m]
	V	: averaging flow velocity	2.68	[m/sec]
	g	: acceleration of gravity	9.80	[m/sec^2]
	f	: friction loss coefficient	0.02	

Then

$$hs = 0.02 \times \frac{20.0 \times 2.68^2}{0.25 \times 2 \times 9.8} = 0.59m$$

Total head=actual head+pressure head+head loss
=10.00m+10.0m+0.59=20.59m

This total head should be revised by multiplication of correction factor.
Final total head=20.59m/0.69=30.0m

16-7-3 Calculations of pump speed & required power

1] Revolutionary pump speed N_2

$$N_2 = N_1 \sqrt{\frac{H_2}{H_1}}$$

Where	N_1	: standard rpm at standard delivery head	[rpm]
	H_1	: standard delivery head	[m]
	H_2	: Required delivery head	[m]

In the case of Warman 10/8 pump,　N_1 =703 rpm at H_1 =22.6mH,

Then $N_2 = 703 \times \sqrt{30/22.60} = 810$ rpm

2] Require shaft power P_2

$$P_2 = P_1 \left(N_2 / N_1 \right)^3 = 52.8 \times (810/703)^3 = 78.0\,\text{kw}$$

Where P_1 : standard power at standard delivery head [kw]

N_1 : standard revolutionary speed [rpm]

N_2 : required revolutionary speed [rpm]

3] Installed power P

P=(Required shaft power)/(pump efficiency×mechanical eff. of V-belts)

=78.0×1/0.76×1/0.95=108.0kw→round up to 110kw.

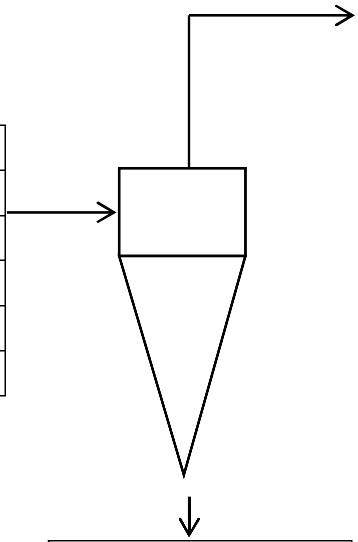
16-7-4. Selection of pump type

We should select 10-8FAH EL 4VM VL×110 kw model manufactured by Pacific Metals Co. Ltd.

16-8. Cyclone

16-8-1. Material balance

Cyclone feed	
Dry tonnage	160 dmt/h
Wet tonnage	575 wmt/h
Water vol.	415 m^3/h
Density	27.8 %wt
Wet volume	474 m^3/h



Over flow	
Dry tonnage	80 dmt/h
Wet tonnage	468 wmt/h
Water vol.	388 m^3/h
Density	17.1 %wt

Under flow	
Dry tonnage	80 dmt/h
Wet tonnage	107 smt/h
Water vol.	27 m^3/h
Density	74.8 %wt

16-8-2. Design concept

We should select same type with grinding operation and the largest model and less number of sets as possible as we can to minimize space and costs for construction.

16-8-3. Selection of cyclone

D26B model of Krebs Engineers has capacity of about 250 st/h＝226.9mt/h at inlet pressure of 11 psi (0.8kg/cm^2) as dry solid. D15B model has capacity of 1.9m^3/min as feed pulp. Since the required feed flow rate is 7.9m^3/min, 4 sets will be needed. So we should prefer one set of D26B.

End