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Install Variable Speed Drives (VSD) on 12 fans to reduce electricity use by motors

SUMMARY OF THE OPTION

PT Indocement is one of the largest cement producers in Indonesia, established in 1985 and currently operates 12 plants, nine of which are located in Citeureup, Bogor, West Java; two in Palimanan, Cirebon, West Java; and one in Tarjun, Kotabaru, South Kalimantan.

There are over 90 fans used throughout Plant #6 for a variety of tasks in the cement making process. Many of the fans used on site are controlled and monitored from the Central Control Room (CCR). Whilst looking at the controls for some of these fans the Team observed that many of them have Inlet Guide Vane (IGV) or damper controls that were closed to some extent and are not operating at their best efficiency. The fans in Plant #6 have the best potential for energy savings.

The option implemented was optimization of fan use is by installing Variable Speed Drives **(**VSD) to control fans with fluctuation load. The original investment for this project is Rp 1,250,000,000 or approximately US$136,000 (1US $ = Rp 9,200). The feasibility study shows that the electricity saving can achieve 5.530 MWh per year, annual cash inflow per year to be Rp , or approximately US$ 266,463 with a payback period of five months, GHG emission reductions are at least 3,336 tCO_2/yr.

The installation of six inverters was completed in March 2005 in in grate 2 and 3, while the other six inverters in grate 1 were installed by December 2005. VSD panel will be placed in MCC location.

KEY WORDS

Indonesia, Cement, Fans & Blowers, Variable Speed Drive (VSD)

OBSERVATIONS

There are over 90 fans used throughout Plant #6 for a variety of tasks in the cement making process. The sizes of the fans varies considerably from <5 kW up to >400kW applications. Optimization of fans performance represents a good opportunity to reduce the specific power consumption of the plant as many of the fans observed run at constant speed with damper or inlet guide vane (IGV) flow regulation. Many of the fans used on site are controlled and monitored from the Central Control Room (CCR). Whilst looking at the controls for some of these fans the Team observed that many of them have inlet guide vane (IGV) or damper controls that were closed to some extent and are not operating at their best efficiency. The fan load varies in each of these applications hence the need for adjustable IGV's or dampers. In each case the controls for the IGV's or dampers are tied to a process parameter that allows the fan load to be adjusted to meet the process requirements. In the following table, a list with the best potential for energy savings was compiled along with some available field-data from all the fans in Plant #6:

Table 1: Best potential for energy savings from the Plant # 6

Equipment No.	% Open of IGV / Damper	Motor Size (kW)	Actual Power Consumed (kW)	Actual Flow Rate (m^3/min)
422-FN1	71	375	227	-
423-FN1	70	375	222	-
426-FN1	68	470	350	-
426-FN2	60	470	369	-
451-FN1	53	2000	-	-
452-FN1	47	2000	-	-
471-FN4	60	110	58	41,312
471-FN5	55	110	58	39,262
471-FN6	55	110	50	41,452
471-FN7	70	110	50	44,125
471-FN8	57	110	-	32,748
471-FN9	40	55	-	27,697
471-FN10	45	45	-	24,835
471-FND	52	-	-	688
471-FNE	52	-	-	380
471-FNF	30	-	-	200
471-FNG	52	-	-	455
471-FNH	44	-	-	446
471-FNI	24	-	-	171
471-FNJ	46	-	-	320
471-FNK	36	-	-	300
521-FN1	60	-	75	-
522-FN1	65	-	75	-

OPTIONS

The options from the above observations are as follows:

- The volumetric flow rate from a fan is directly proportional to the motor speed, hence, the most efficient method to control the fan output is by controlling the speed of the fan.
- Additionally, power consumed by the fan motor is proportional to the motor speed cubed i.e. a small reduction in motor speed results in a large reduction in power.
- It is estimated that power savings of up to 59% can be achieved by moving from IGV to variable speed control and up to 69% by moving from damper to variable speed control.
- It is therefore recommended that where investigations deem it to be feasible, the fans have variable speed drives (VSD's) installed on their motors to control fan speed. This will allow the inlet guide fans or dampers to be left 100% open and regulate the motor speed to match load requirements and therefore achieve significant power savings. This should only be applied where there are large changes in the fan load i.e. fans where the IGV or damper setting changes continuously or regularly. If the IGV setting is normally constant under all operating conditions then other options should be explored including changing pulley ratio or using multi-speed motors.
- On fans for which it is feasible to install a VSD, additional benefits may be gained by directly coupling the motor to the fan. Many of the fans are currently belt driven which results in 2-3% power losses through belt slippage.

RESULTS

Below are the results of inverter test on cooling fan 1R 75 kW:

Table 2: Data of Inverter Test

Trade mark of "Hitachi"
The comparison before and after using inverter in cooling fan
(Cooling Fan 1R 75 KW)

No.	Before					After				Difference	
	Damper (%)	Flow (m^3/m)	Current (A)	Cos j	Daya (KW)	Current (A)	Cos j	Frequency (Hz)	Daya (KW)	Daya (KW)	%
1	0	40	62	0,53	22,74	3	0,18	8,00	0,37	**22,37**	**98,4**
2	20	164	78	0,71	38,32	13	0,20	25,61	1,80	**36,52**	**95,3**
3	40	265	100	0,81	56,05	63	0,63	43,80	27,47	**28,59**	**51,0**
4	60	295	111	0,83	63,75	81	0,76	47,84	42,60	**21,15**	**33,2**
5	80	300	116	0,84	67,43	86	0,80	48,94	47,61	**19,82**	**29,4**
6	100	300	119	0,84	69,17	97	0,80	50,00	53,70	**15,47**	**22,4**

Test was done in 19/05/2003
P6 Electrical party and Hitachi

The GP Team did not come across technical difficulties with installing VSD's on the fans.

Table 3. Energy Saving Vs Opening Damper Interpolation (Data Result)

Table 3 a: Interpolation energy saving From data fan 1R 75 kW

Open Damper (%)	Energy saving (%)
0	98,400
5	97,625
10	96,850
15	96,075
20	95,300
25	84,225
30	73,150
35	62,075
40	51,000
45	46,550
50	42,100
55	37,650
60	33,200
65	32,250
70	31,300
75	30,350
80	29,400
85	27,650
90	25,900
95	24,150
100	22,400

Table 3 b: Energy saving if make VSD's and use real % open damper

Equipment Number	Opening Damper Real (%)	Energy saving (%)	Energy use after make VSD's
471FN8MO1	68	31,680	0,683
471FN9MO1	25	84.225	0,158
471FNFMO1	26	82.010	0,180
471FNIMO1	20	95.300	0,047
471FN4MO1	65	32.250	0,678
471FN5MO1	65	32.250	0,678
471FN6MO1	65	32.250	0,678
471FN7MO1	75	30.350	0,697
471FNEMO1	33	66.505	0,335
471FNHMO1	41	50.110	0,499
471FNKMO1	43	48.330	0,517
471FNGMO1	37	57.645	0,424
471FNJMO1	38	55.430	0,446

Table 4: Saving Energy Calculation for Cooling Fan at Grate Cooler Plant-6

Assumption:

1. (%) saving energy : based on table 3b
2. Power Factor: 0.8 (PF varied with load, range 0.3~0.95)
3. Voltage: 400 V
4. Running hour: 300 days in 1 year
5. **Energy rate: IDR 532 / KWH**

NO	EQP.NO	RATING		OPERATING			% DAMPER OPENING	WITH INVERTER		POWER SAVING (KW)	ENERGY SAVING			SAVING MONEY Yearly (IDR)
		POWER (kW)	Current (Amp.)	Current (Amp.)	Current % Oper.	POWER (kW)		POWER (kW)	Current (Amp.)		Daily (KWH)	Monthly (KWH)	Yearly (KWH)	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	471FN8MO1	55	98	54	55,102	29,8944	68	36,89	20,42	9,47	227,29	6.818,79	81.826	43.531.174,91
2	471FN9MO1	55	98	48	48,980	26,5728	25	7,73	4,28	22,30	535,09	16.052,68	192.632	102.480.326,42
3	471FNFMO1	75	140	132	94,286	73,0752	26	16,96	9,39	63,69	1528,44	45.853,23	550.239	292.726.997,95
4	471FNIMO1	75	140	90	64,286	49,824	20	3,02	1,67	48,15	1155,63	34.668,96	416.028	221.326.658,15
5	471FN4MO1	110	195	123	63,077	68,0928	65	42,73	23,66	44,43	1066,44	31.993,14	383.918	204.244.206,94
6	471FN5MO1	110	195	123	63,077	68,0928	65	42,73	23,66	44,43	1066,44	31.993,14	383.918	204.244.206,94
7	471FN6MO1	110	195	100	51,282	55,36	65	34,74	19,23	36,13	867,02	26.010,68	312.128	166.052.200,76
8	471FN7MO1	110	195	85	43,590	47,056	75	30,36	16,81	30,25	725,97	21.778,96	261.348	139.036.910,50
9	471FNEMO1	110	195	140	71,795	77,504	33	24,05	13,31	64,19	1540,59	46.217,66	554.612	295.053.555,66
10	471FNHMO1	132	242	132	54,545	73,0752	41	27,21	15,06	58,01	1392,25	41.767,37	501.208	266.642.881,21
11	471FNKMO1	132	242	138	57,025	76,3968	43	29,46	16,31	60,09	1442,04	43.261,30	519.136	276.180.126,53
12	471FNGMO1	160	294	155	52,721	85,808	37	22,33	12,36	73,45	1762,71	52.881,19	634.574	337.593.541,61
13	471FNJMO1	160	294	182	61,905	100,7552	38	27,59	15,27	85,48	2051,54	61.546,21	738.555	392.911.011,72
		1.394							**191**	**640**	**15.361**	**460.843**	**5.530.120**	**2.942.023.799**

<u>METHOD of CALCULATION</u>

Column F: % operating = (Amp. Operating / Amp. rating) X 100% = (Column E / Column D) X 100%
Column G: Power operating (kW) = (v3 x V x I x PF)/1000 = 1.73 x 400 x Column E x 0.8)/1000
Column I: Current with Inverter = (100-% energy saving) x Operating Current = (100-% energy saving) x Column E
Column H: Data Open Damper
Column J: Power with Inverter (kW) = (v3 x V x I x PF)/1000 = (1.73 x 400 x Column I x 0.8)/1000
Column K: Power Saving (kW) = Power Operating – Power with Inverter = Column G – Column J
Column N: Yearly Energy Saving (kWH) = 24 x 25 x 12 x Power Saving = 24 x 25 x 12 x Column K
Column O: Saving Money (IDR) – Yearly = Yearly Energy Saving x IDR 532 = 532 x Column N

Some assumptions the rational measures are as follows:

- Energy Cost: Rp 532.05 per kWh
- Plant Operation: 300 days
- Energy Saving Factor (%): See Table. 3
  (Assumption from the result of average calculation)
- Power consumption: 1394 kW, and 640 savings

Financial benefits

- Investment: Rp 1,250,000 or US$ 136,000 (1US$ = Rp 9,200)
- Annual cost savings:
  - Rp 2,942,023,799 or US$ 360,000, calculated as shown in table 4.
  - Rp 2,451,456,000 or US$ 266,463 if calculated as follows: 640 kW reduction X Rp 532.05/kWh X 24 h = Rp 8,172,288 X 300 operating days = Rp 2,451,456,000
- Payback period: 5 months

Environmental benefits

- Annual electricity savings: 5530 as shown in Table 4, or 4608 MWh if calculated (= 640 kW X 24 h X 300 days)
- Annual GHG emission reduction:
  - Based on data from Table 4: 5530 X 0.724* = 4004 tCO2
  - Calculated: 4,608 MWh X 0.724* = 3,336 tCO_2

*sourced from UNEP GHG calculator: www.uneptie.org/energy/tools/ghgin/

FOR MORE INFORMATION

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