Modification of a clinker cooler to increase its capacity

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Summary

Describes modifications to a clinker cooler, including installation of an additional cooling fan, a separate pulsating device, and re-use of part of the waste hot air. The modifications were made necessary by changes to the kiln plant which had increased clinker production by more than 40%. The discharged clinker temperature is now about 130°C, but had reached 230° to 260°C.

Reason for modifications

The Polysius Recupol clinker cooler Type P1613 which was installed with the No. 1 kiln plant at the Ipoh works of Tasek Cement Limited in 1964 has now been in use for more than five years and has handled more than one million tons of clinker. The performance of the cooler, both in cooling effect and mechanical durability, was in the early years satisfactory, but as a result of an increase in kiln output following several modifications made to the plant in the last two years, the average daily clinker production has exceeded 700 tons, which is more than 40% greater than the cooler's designed capacity. In consequence the cooler was found to be too small to cope with the extra demand made upon it under these rather forced-production conditions. Consequently, a considerable amount of heat was being carried way by the insufficiently cooled clinker discharged from the cooler. This, besides being uneconomical, also caused difficulties for the cement grinding department in controlling the setting time, and also because more power was required due to the poor grindability of the ineffectively cooled clinker.

After lengthy observations made on the cooler, the decision was taken to install an additional fan to ensure the supply of sufficient air to meet the extra requirements for clinker cooling as well as for combustion in the kiln. Furthermore, a separate pulsating device was installed in order to improve the clinker bed spread; the air-entraining effect of the pulsator also permitted more cooling air to pass through for greater heat exchange. Lastly, a hot-air returning duct was installed between the cooler waste-air fan and the additional cooling fan, to re-use part of the waste hot air, thereby reducing the amount of heat being carried away.

These modifications have now been completed, and the modified cooler is now able to maintain the temperature of discharged clinker at around 130°C, which is excellent compared to the previous 230° to 260°C.

2. Description of modifications

Cooling fan

Original fan capacity = 14 m³/sec at 30°C.

Increased cooling air requirement when clinker production was targeted at 650 tons per day

$$= 14 \times \frac{650}{500} = 18{\cdot}2 \text{ m}^3\text{/sec at } 30^\circ\text{C}.$$

Figure 1: Auxiliary cooling fan.

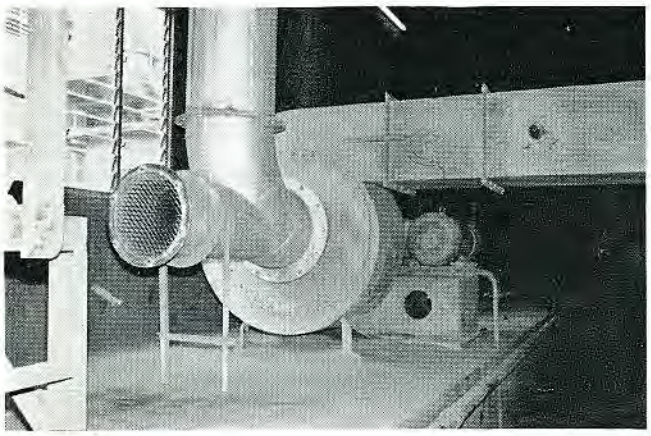
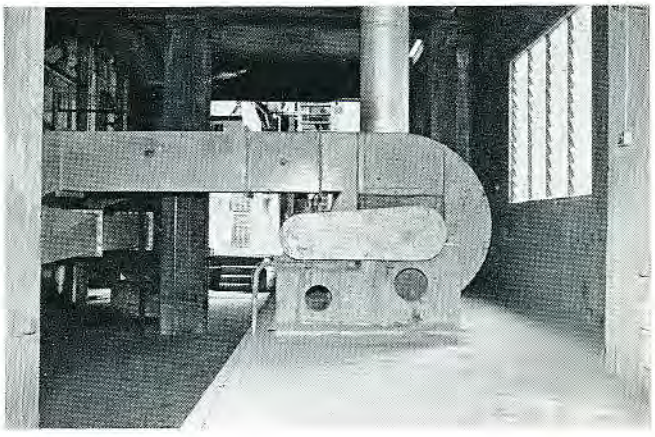
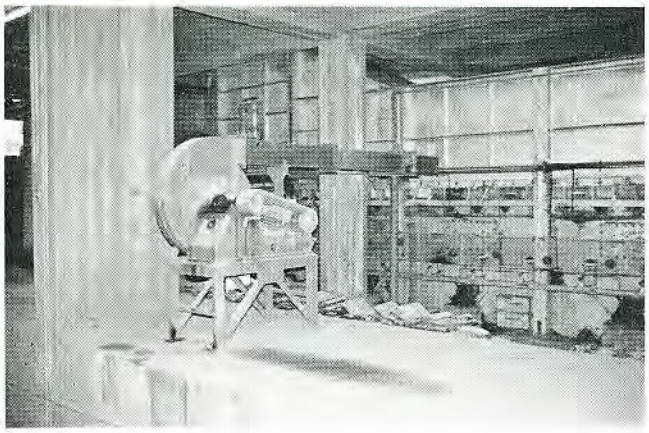


Figure 2: Ducting to auxiliary cooling fan.





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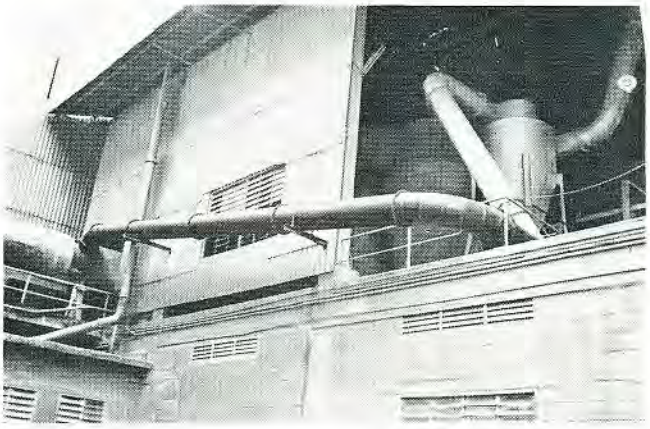

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Figure 3: High pressure fan.

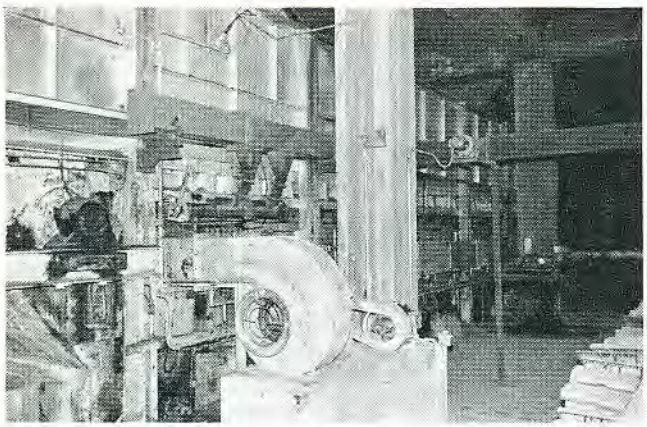

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Figure 4: Air duct, additional pulsating device.

Figure 5: Driving motor of pulsating damper.

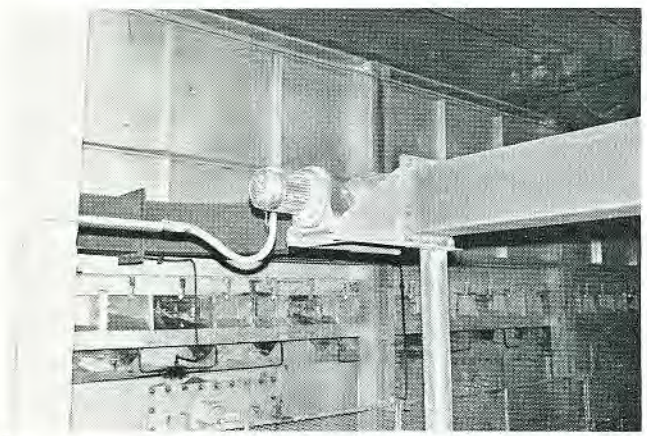

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Figure 6: Air nozzle inlets.

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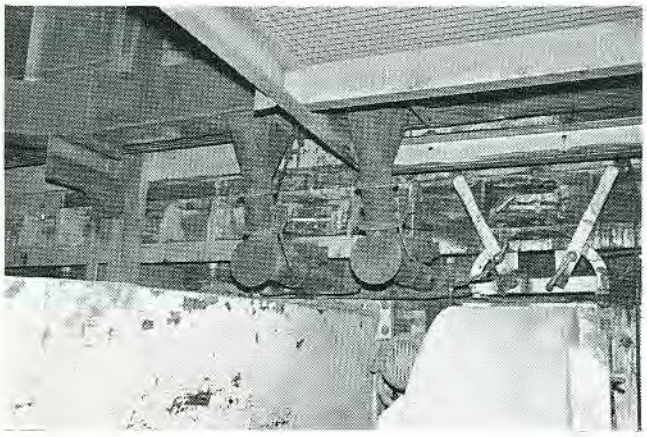
Figure 7: Hot air return duct.



Additional air requirement = 18·2 — 14
= 4·2 m³/sec at 30°C.

The following auxiliary cooling fan was installed:

designed capacity	5 m³/sec
temperature referred to	30°C
static pressure	230 mm WG
impeller speed	940 rev/min
motor	30 kW.

This fan is shown in Figures 1 and 2.

Pulsating device

The original pulsating function was effected by means of two radial fans of the following specification:

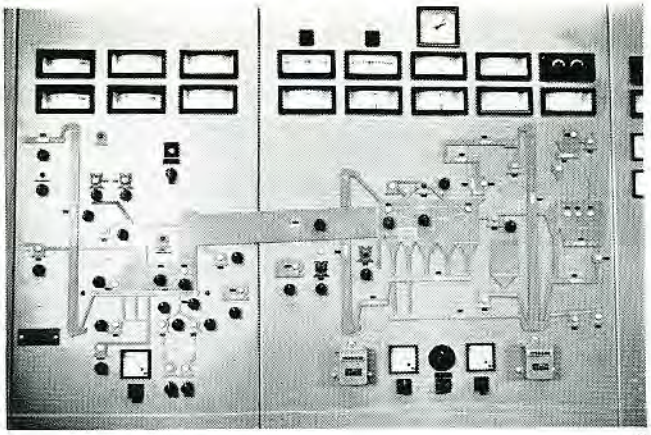
capacity	6 480 m³/h
temperature referred to	30°C
static pressure	270 mm WG
impeller speed	2 150 rev/min
motor	11 kW.

and also one rotary pulsating damper:

width of damper	135 mm
length of damper	2 × 775 mm
rotating speed	30·5 to 112 rev/min
pulsating frequency	61 to 224 strokes/min
motor	0·5 to 2·0 metric h.p.

The air blast opening was as follows:

width	120 mm
length	1 590 mm
air velocity	19 m/sec.



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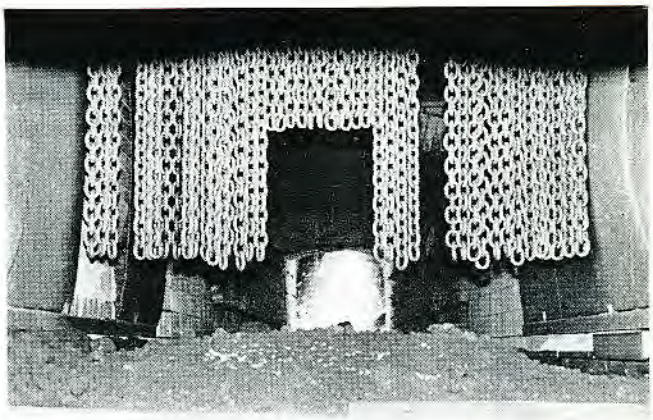

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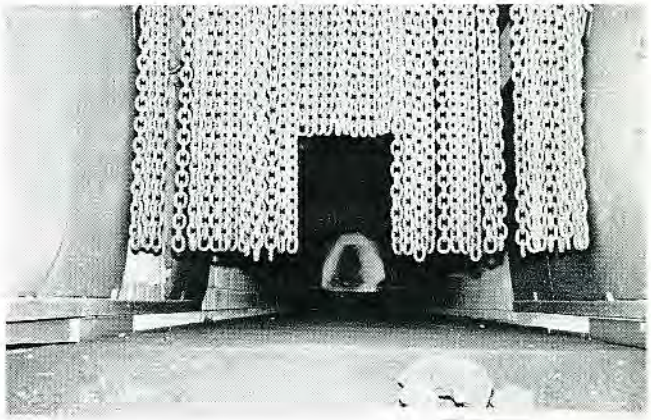
Figure 8: Control panel with additional controls.

Figure 9: Clinker bed when only original damper was used.

Figure 10: Clinker bed when additional pulsating device was in operation.

Figure 11: Air balance diagram (units: m³/kg of clinker).



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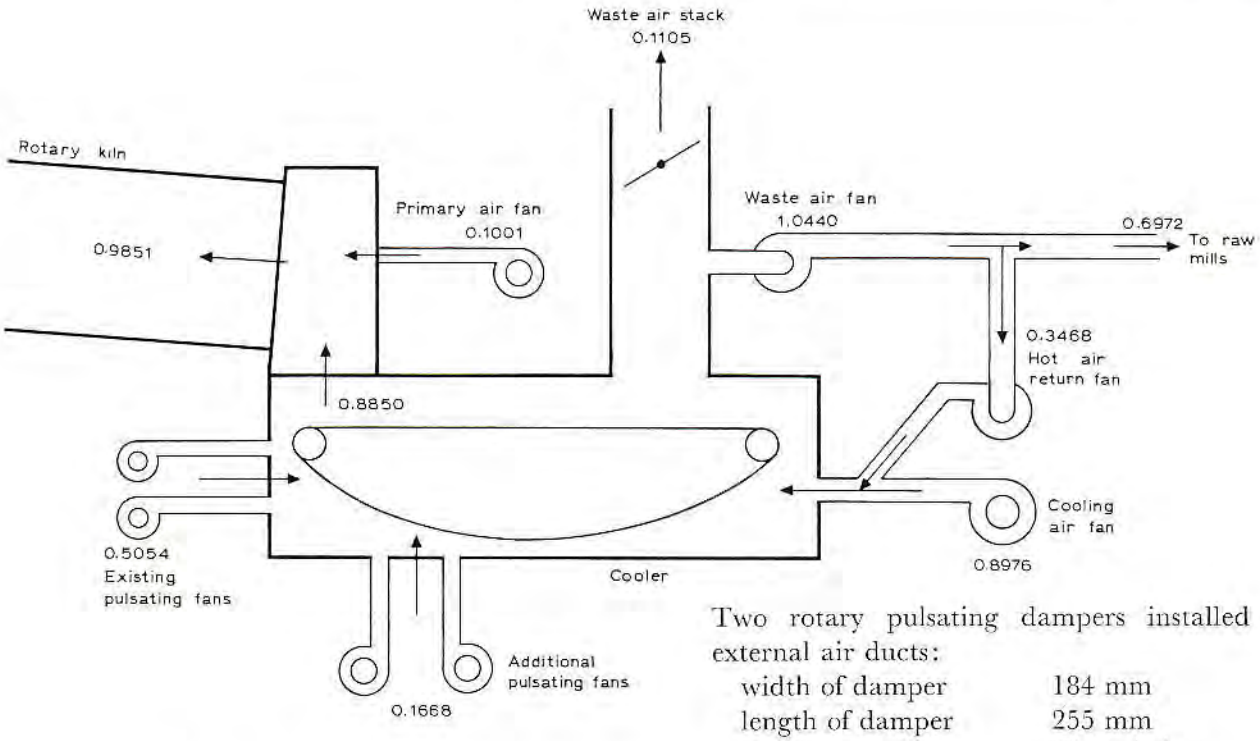

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The additional pulsating device (Figures 3 to 6) comprises the following:

Two radial fans with the following specification:

capacity	3 600 m³/h
temperature referred to	30°C
static pressure	700 mm WG
impeller speed	2 700 rev/min
motor	18·5 kW.

Two rotary pulsating dampers installed in the external air ducts:

width of damper	184 mm
length of damper	255 mm
rotating speed	56 rev/min
pulsating frequency	112 strokes/min
motor	0·75 kW.

Four air nozzles:

width	30 mm
length	400 mm (centre nozzles)
	350 mm (side nozzles)
air velocity	32 m/sec.

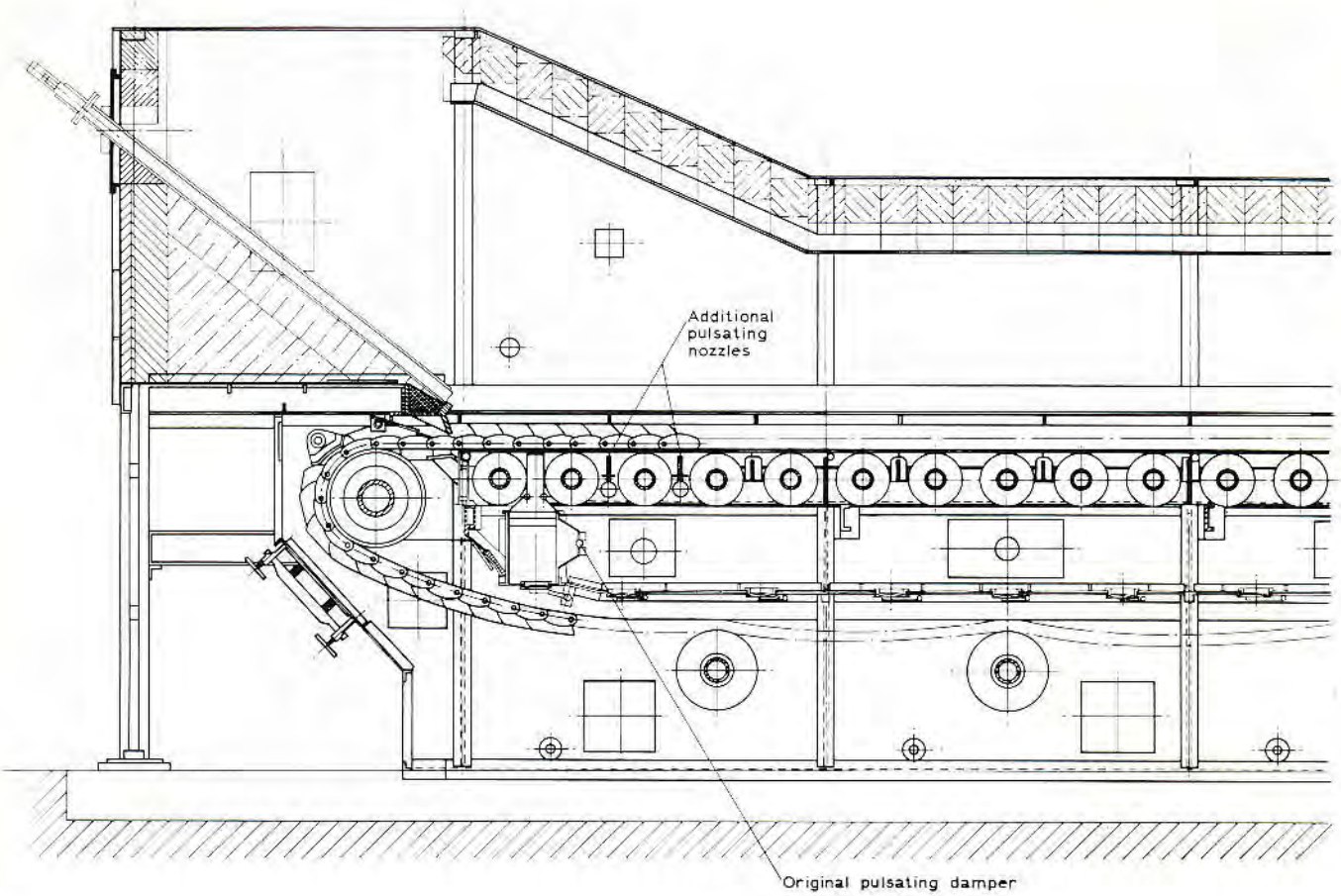


Figure 12: (above and opposite) Elevation, section and plan of cooler showing original and new equipment.

Hot air return duct
The hot air return duct is illustrated in Figure 7.

General
The control panel with additional controls is shown in Figure 8.

Results

The performance of the plant before and after modification is summarized in Table 1, and the improvement in the clinker bed is immediately apparent from Figures 9 and 10. The heat balance and cooler efficiency is shown in Table 2 and the air balance of the cooler in Figure 11. (Outline elevations and a plan are reproduced in Figure 12).

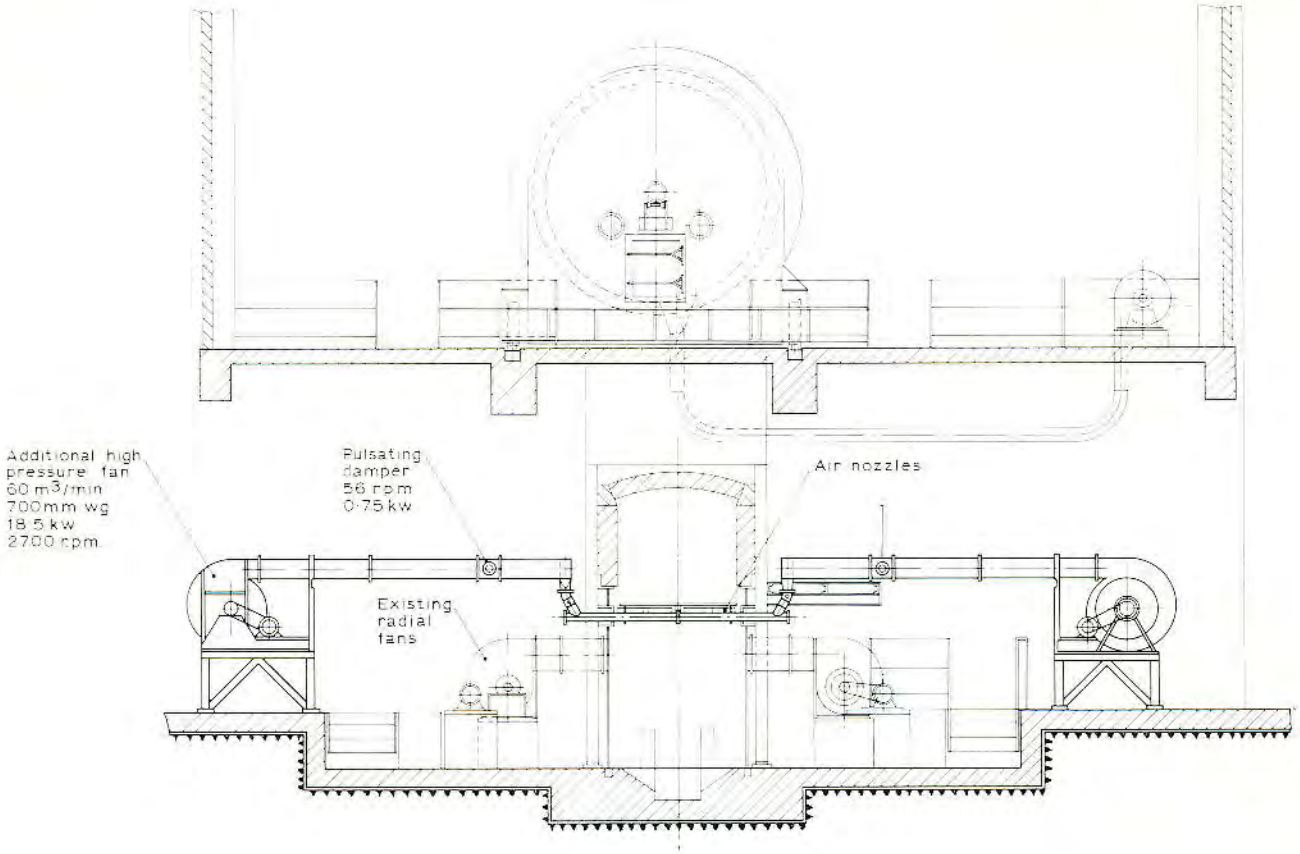
5. Conclusion

Reduction of clinker waste heat
Mean specific heat of clinker at 260°C
= 0·201 kcal/kg°C
Mean specific heat of clinker at 127°C
= 0·189 kcal/kg°C
Previous clinker waste heat per kg of clinker:
Qa = 0·201 × (260 − 30)
= 45·8 kcal/kg.
Present clinker waste heat per kg of clinker:
Qb = 0·189 × (127 − 30)
= 19 kcal/kg.
Reduction of heat consumption per kg of clinker:
Qa − Qb 45·8 − 19
= 26·8 kcal/kg. .. .. (1)

Reduction of heat losses with waste air
Mean specific heat of hot air at 250°C
= 0·313 kcal/kg°C
Mean specific heat of hot air at 265°C
= 0·314 kcal/kg°C
Previous heat losses per kg of clinker:
Waste air volume = 1·1545 Nm^3/kg*
Qc = 1·1545 × 0.313 × (250 − 30)
= 80 kcal/kg-clinker.
Present heat losses per kg of clinker:
Waste air volume = 0·8077 Nm^3/kg
Qd = 0·8077 × 0·314 × (265 − 30)
= 60 kcal/kg.
Reduction of heat losses:
Qc − Qd = 80 − 60
= 20 kcal/kg. .. .. (2)

Increase in heat recovery in secondary air
From Table 2, previous heat recovery per kg of clinker:
Qe = 220·6 kcal/kg.
Present heat recovery:
Qf = 268·8 kcal/kg.

*The 'N' indicates Normal conditions (i.e. at 0°C and 1 atmosphere pressure).


Additional high pressure fan
60 m³/min
700mm wg
18.5 kw
2700 rpm
Pulsating damper
56 rpm
0·75 kw
Air nozzles
Existing radial fans

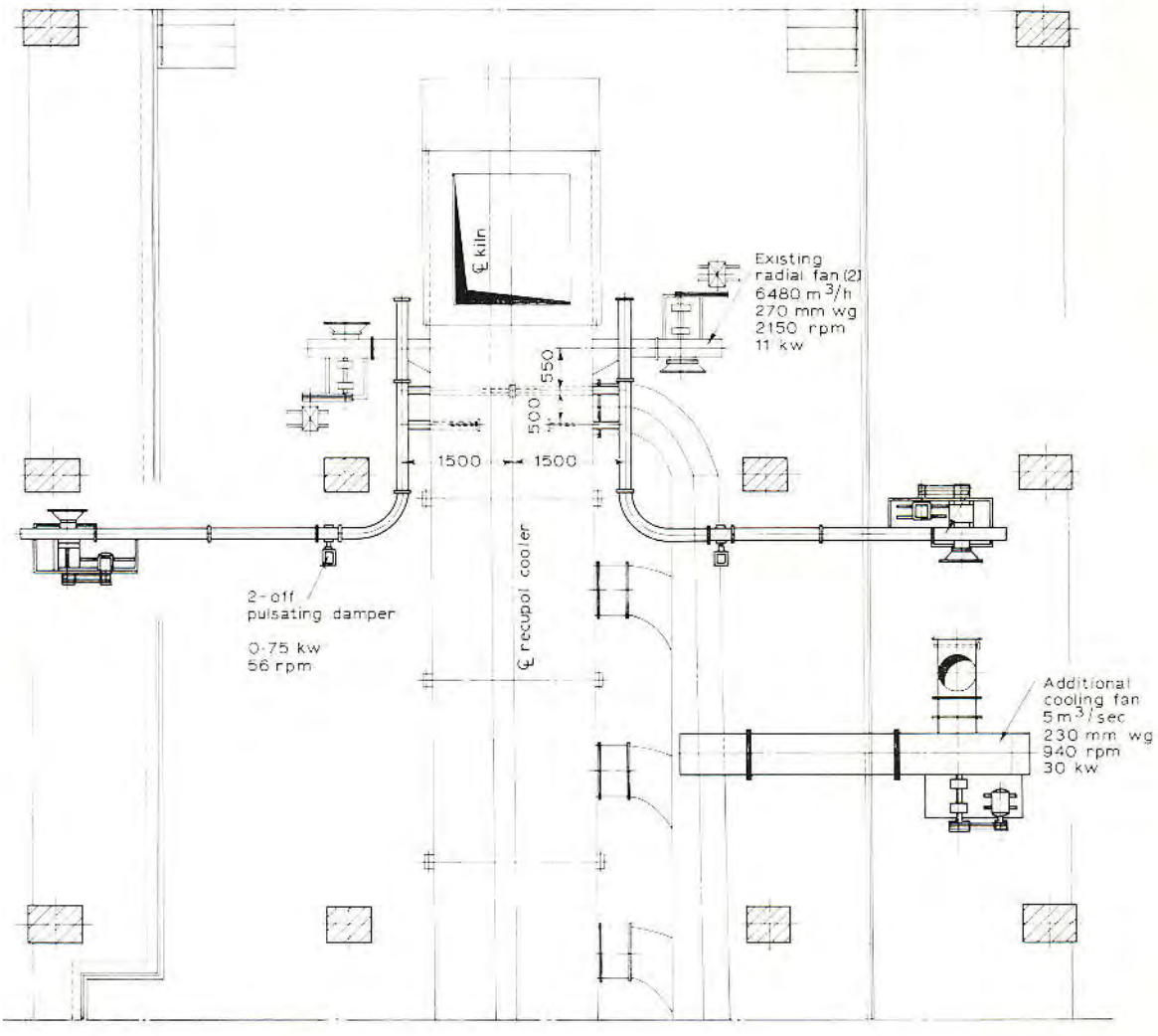

℄ kiln
Existing radial fan (2)
6480 m³/h
270 mm wg
2150 rpm
11 kw
550
500
1500
1500
2-off pulsating damper
0·75 kw
56 rpm
℄ recupol cooler
Additional cooling fan
5 m³/sec
230 mm wg
940 rpm
30 kw

Table 1. Comparison of Performance.

Item	Unit	Original		Modified
		at 600 tons/day	at 700 tons/day	at 725 tons/day
Clinker temperature at cooler inlet	°C	1 350	1 380	1 380
Clinker temperature at cooler outlet	°C	200	260	127
Secondary air	°C	910	910	960
Waste air	°C	200	250	265
Total heat consumption of kiln plant (per kg of clinker)	kcal	930	930	835
Clinker waste heat (per kg of clinker)	kcal	30	46	19
Cooler speed (shaft)	rev/min	0·9	1·1	0·8
Cooler speed (grate)	m/sec	0·036	0·044	0·032
Clinker bed thickness	mm	75	70	95
Power consumption of kiln plant (per ton of clinker)	kWh	17·5	16·0	16·5

NOTE.—The metric tonne is approximately equal to the Imperial ton. (1 long ton = 1·016 metric tonne)

Increase in heat recovery:

$$Qf - Qc = 268{\cdot}8 \text{ \& } 220{\cdot}6 = 48{\cdot}2 \text{ kcal/kg.} \quad \ldots \quad \ldots \quad (3)$$

Total heat gain

The increased secondary air temperature and the overall cooler efficiency help to improve combustion and heat transfer in the kiln, thus reducing the overall heat consumption of the kiln plant to an average of 835 kcal per kg of clinker, which is considered fairly good under forced-production conditions.

From equations 1, 2 and 3:

Total heat gain = 26·8 + 20 + 48·2
= 95·0 kcal per kg of clinker.

Table 2. Heat balance per kg of clinker (Referred to 30°C).

Item		Original		Modified
		at 600 tons/day	at 700 tons/day	at 725 tons/day
		kcal	kcal	kcal
Heat input				
Sensible heat of clinker	Q1	339	350	350
Sensible heat of cooling air	Q2	1·7	3·8	3·9
Total heat input	QA	340·7	353·8	353·9
Heat output				
Heat losses with waste air	Q3	87·7	79·6	59·6
Clinker waste heat	Q4	33·5	45·8	19·0
Heat carried into the kiln by secondary air	Q5	213·4	220·6	268·8
Radiation, convection and other losses	Q6	6·3	7·8	6·5
Total heat output	QB	340·7	353·8	353·9
Cooler efficiency	Q5/QA	62·6%	62·4%	76·0%

Other benefits

The slower speed of the cooler grate (which was reduced from 0·044 to 0·032 m/sec) has been found to result in less wear and tear to the moving parts by about 27%.

The cooler clinker has eliminated problems which had been constantly encountered in storing and grinding the clinker and in controlling the setting time of the cement.

Acknowledgement

The author expresses particularly thanks to Mr C. K. Wang, Manager, Engineering Division, Taiwan Cement Corporation, for his guidance and for information provided on problems and possible means of modification to clinker coolers. Without Mr Wang's inspiration, this modification would not have been achieved.