National Council for Cement and Building Materials

NCB DESIGNED HORIZONTAL CYCLONE FOR 5-STAGE SUSPENSION PREHEATER SYSTEM

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NCB TECHNOLOGY DIGEST

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INTRODUCTION

WITH the advent of precalcinator technology it has been observed that because of secondary firing in precalcinator, the exit gas temperature increases by about 30°–40°C when compared to conventional 4-stage SP kiln system. The search for avenues of further energy conservation resulted in the development of 5-stage preheater system. But the incorporation of an additional conventional cyclone in the suspension preheater tower resulted in increased pressure loss and consequently increased power consumption of the ID fan. Conceived in this background, NCB took up the task of designing and developing horizontal cyclone as a part of the suspension preheater system suitable to Indian conditions. This Technology Digest places in perspective the developmental work done by NCB in designing the horizontal cyclone for 5-stage SP system and the technical results achieved.

DESIGN PARAMETERS AND THEIR INFLUENCE

Since not only dust collection but also heat transfer and hence calcination take place in the cyclones, utmost care is taken in the selection of the design parameters. Pressure drop and efficiency are the two important characteristics of cyclone that are considered for design.

Pressure Drop

Pressure drop in a cyclone will be considered as that between gas inlet and gas outlet. Factors contributing to pressure drop are:

1) Loss due to expansion of the gas when it enters the cyclone chamber;

2) Loss as kinetic energy of rotation in the cyclone chamber;

3) Loss due to wall friction in the cyclone chamber;

4) Any additional frictional losses in the exit duct, resulting from the swirling flow above and beyond these incurred by straight flow; and

5) Any regain of the rotational kinetic energy as pressure energy.

Pressure drop can be calculated using Shephered and Lapple equation:

$$\Delta P = \frac{(V_g)^2 \rho_g \Delta H}{2g}$$

$$\Delta H = K \frac{ab}{D_e^2}$$

a = Inlet duct height standard ratio

b = Inlet duct width standard ratio

D_e = Vortex finder diameter

V_g = Inlet gas velocity

ρ_g = Density of gas

ΔH = Velocity head

where K=16 for a cyclone with standard tangential inlet.

Collection Efficiency

Collection efficiency of a cyclone increases with:

a) Increasing particle size and density,

b) Increasing speed of rotation in the cyclone vortex,

c) Decreasing cyclone diameter,

d) Increasing cyclone length,

e) Drawing some of the gas from the cyclone through the dust exit duct, and

f) Wetting the cyclone's walls.

Leith and Licht equation is found suitable for predicting efficiency of horizontal cyclone.

Design Criteria of Horizontal Cyclone

A cyclone will operate as well in a horizontal position as in a vertical position provided the dust outlet is designed properly so that plugging of dust exit does not occur. The gas entering the cyclone has both axial and tangential components of velocity flowing through the cyclone. The tangential velocity causes the separation, while the axial component ensures that the gas will flow through cyclone and exit at the other end. The gas executes several complete turns in traversing the length of the separation section. The gas near the outerwall of the tube which contains a concentrated distribution of particles is skimmed off from dust and it is led to dust exit. The gas near the centre which now has relatively few particles, continues on into the cleaned gas duct.

Design criteria for horizontal cyclone are developed based on standard dimension ratios available for conventional cyclones. The effect of cyclone inlet velocity on pressure drop and collection efficiency of horizontal cyclone and conventional reverse flow cyclone is given in Fig 1. For a given pressure drop, the inlet velocity of horizontal cyclone can be increased by two times that of conventional cyclones without affecting the collection efficiency. Therefore, the diameter of horizontal cyclone can be 70% of a vertical cyclone.

Horizontal cyclone is designed for an inlet velocity of 16-18 m/sec keeping in view fan limitations which dictate maximum allowable pressure drop in the cyclone. Cyclone body length should not greatly exceed natural length. That portion of cyclone beyond the natural length will not be of any value for collecting dust because it will not contain vortex. On this criteria the length of horizontal cyclone is taken as 3 × diameter of cyclone. Using the above design criteria and standard dimension ratios of conventional cyclone the standard ratios of horizontal cyclone were developed.

Technical Results

Having evolved the design criteria for horizontal cyclones as above, a pilot scale horizontal cyclone of 2 tpd capacity was fabricated for carrying out experiments to evaluate its performance. The configuration of horizontal cyclone shown in Fig 2 was provided with a tangential entry and axial exit, where the length of the exit pipe could be varied. The average efficiency at a velocity of 17 m/sec was observed to be about 91% and the pressure drop was of the order of 40-50 mmWG.

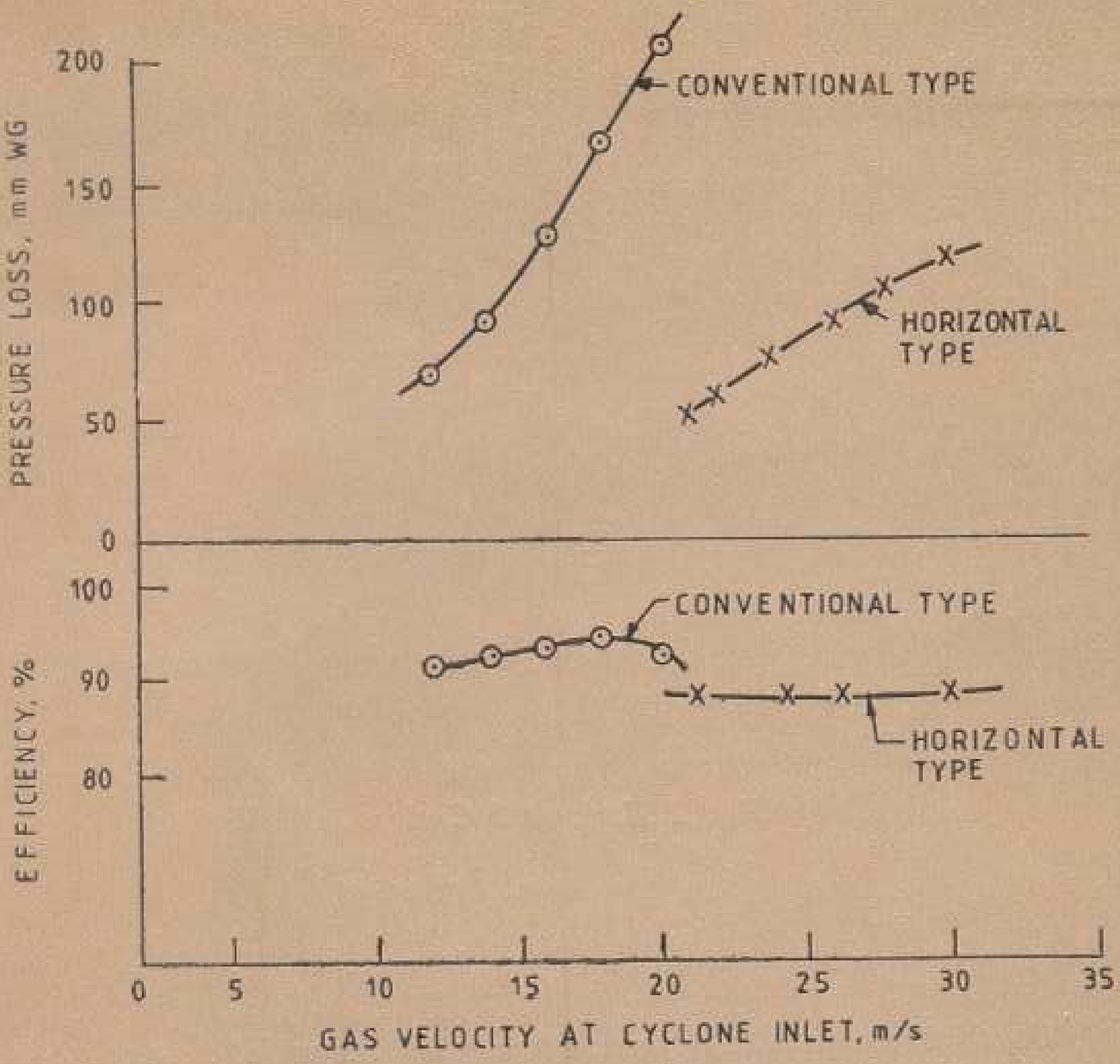

Fig. 1 Influence of Inlet Velocity on efficiency and Pressure Drop

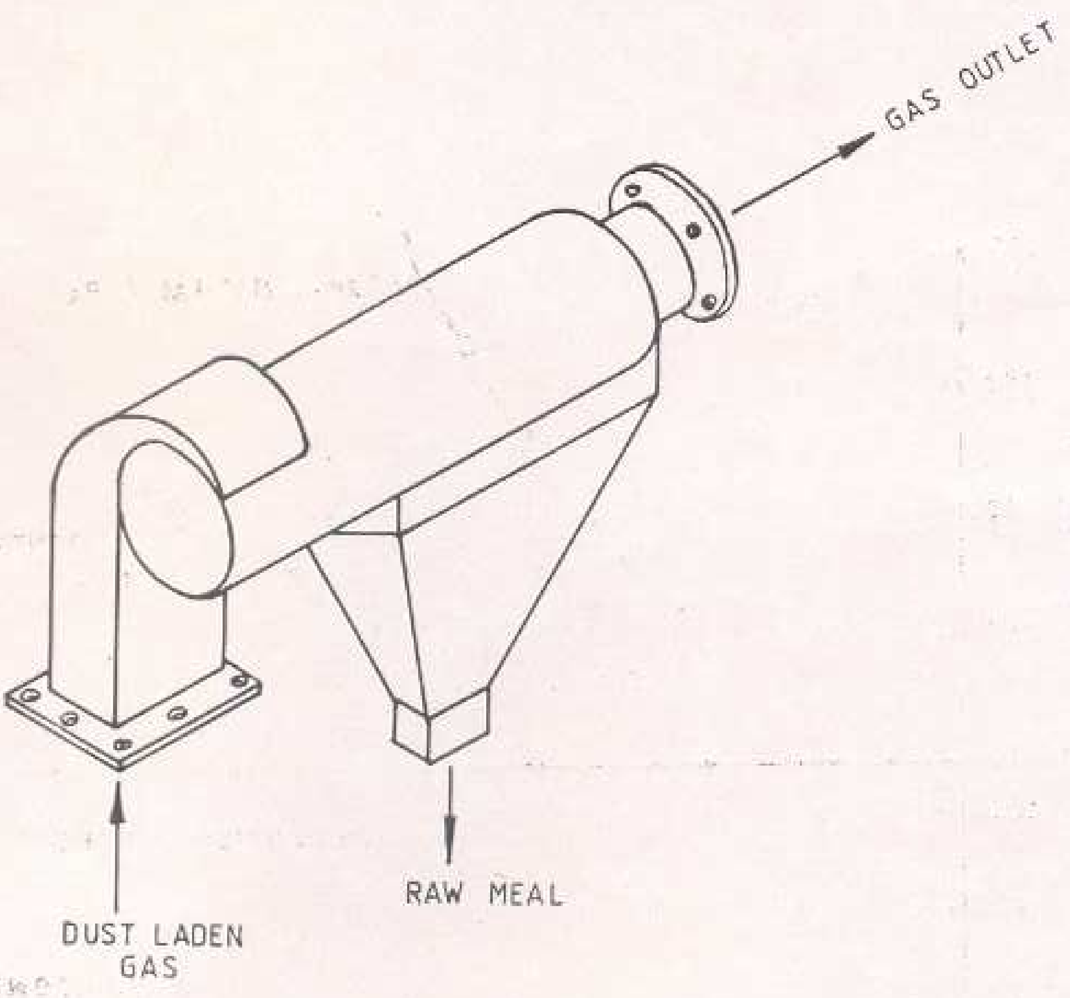

Fig. 2 Horizontal Cyclone

For higher capacities, volume of gas and amount of material to be handled increases; accordingly the sizes of the ductings vary. For the determination of cyclone dimensions, the same criteria and dimension ratios in the design of pilot scale horizontal cyclone have been used with an inlet velocity of 18 m/sec. Already designs for horizontal cyclones at Stage-2 and 3 of 5-stage suspension preheater are available with NCB. Fig 3 depicts construction of 5-stage SP system with NCB designed horizontal cyclone. From the overall system design and techno-economic considerations, incorporation of two horizontal cyclones at Stages 2 and 3 of a 5-stage preheater is found to be optimum in case of either a new plant or existing plant.

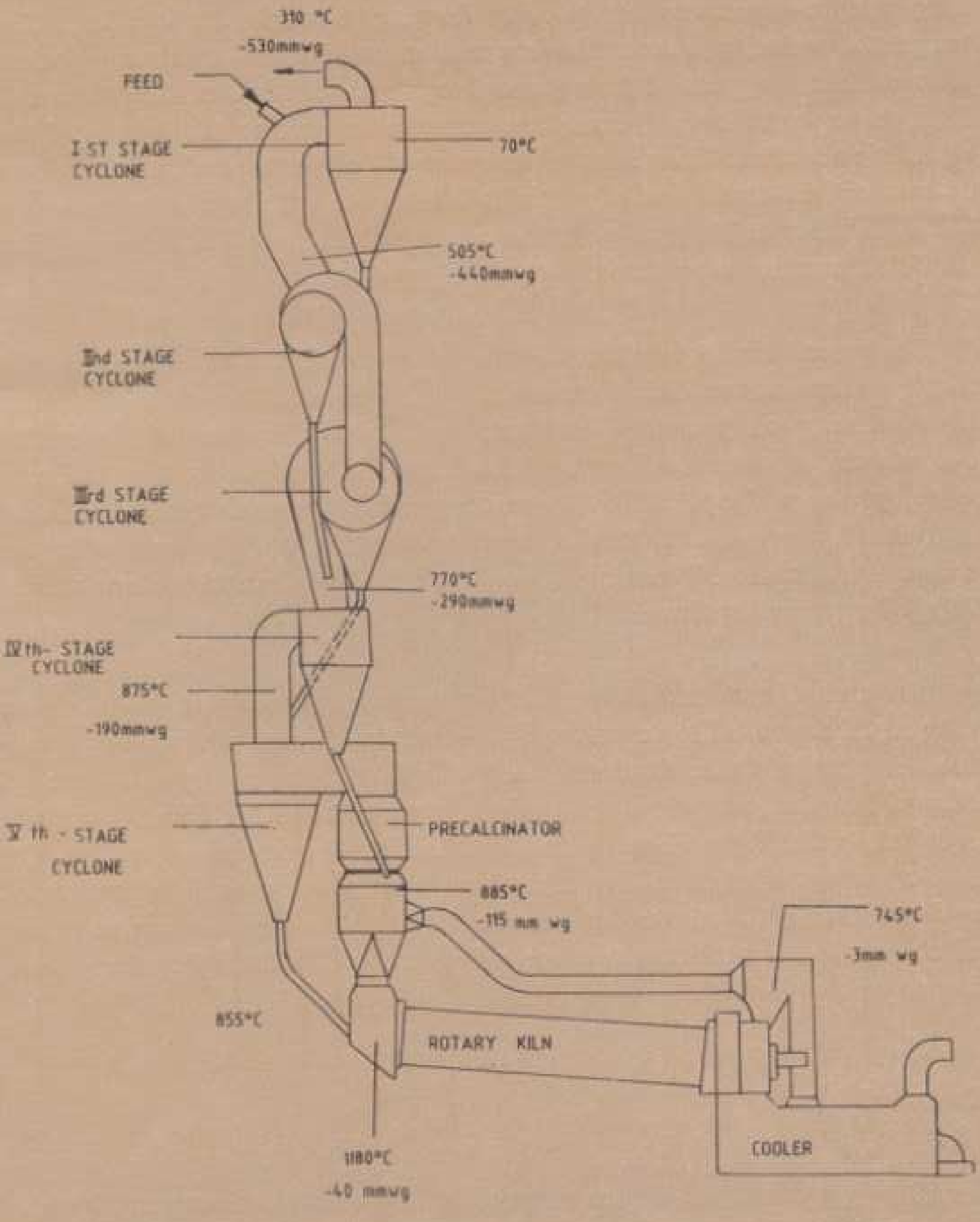

Fig. 3 Five-stage Suspension Preheater with NCB-Designed Horizontal Cyclone

TECHNOLOGY TRANSFER

The NCB designed horizontal cyclone is available as an integral package with NCB designed precalcinator called CRI-PRECAL. The salient features of the above configuration are as given below:

- 30% height saving envisaged in the stage where horizontal cyclone is used.
- Exhaust gas temperature is expected to come down by about 40°C.
- Energy saving of 20-30 kcal/kg Cl may result in corresponding coal saving of 6 kg/tonne of clinker.
- Power saving of 0·5 kWh/tonne of clinker.

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