

## NATURAL AND MECHANICAL DRAFT SYSTEMS

Draft is often classified into two kinds according to whether it is created thermally or artificially, viz: (1) Natural or thermal draft, and (2) Artificial or mechanical draft.

Natural draft is the difference in pressure produced by the difference in weight between the relatively hot gases inside a natural draft chimney and an equivalent column of the cooler outside air, or atmosphere. Natural draft, in other words, is an unbalanced pressure produced thermally by a natural draft chimney as the pressure transformer and a temperature difference. The intensity of natural draft depends, for the most part, upon the height of the chimney above the grate bar level and also the temperature difference between the chimney gases and the atmosphere. Natural draft tends to produce a vacuum and is, therefore, a type of draft by aspiration.

Artificial draft, or mechanical draft, as it is more commonly called, is a difference in pressure produced either directly or indirectly by a forced draft fan, an induced draft fan or a Venturi chimney as the pressure transformer. The intensity of mechanical draft is dependent for the most part upon the size of the fan and the speed at which it is operated. The element of temperature does not enter into the creation of mechanical draft and therefore its intensity, unlike natural draft, is independent of the temperature of the gases and the atmosphere. Mechanical draft includes the induced and Venturi types of draft systems in which the pressure difference is the result of a suction and also the forced draft system in which the pressure difference is the result of a blowing. Mechanical draft systems tend to produce a vacuum or a plenum, according as the system used in its production creates a pressure difference below, or above, atmospheric pressure, respectively. A mechanical draft system may be used either in conjunction with, or as an adjunct to, a natural draft system.

A typical natural draft system consists essentially of a relatively tall chimney built of steel, brick or reinforced concrete, operating with the relatively hot gases which have passed through the boilers and accessories and from which all of the heat has not been extracted. Hot gases are an essential element in the operation of a natural-draft system. The results obtained by natural-draft systems are identical with those obtained by induced and Venturi-draft systems, the only difference in the systems being in the type of pressure transformer used in creating the pressure difference. Natural draft systems are self-operating and, unlike induced and Venturi systems, require no power to operate the system in order to produce the pressure difference and maintain a gas flow.

A natural-draft chimney performs the two-fold service of assisting in the creation of draft by aspiration and also of discharging the gases at an elevation sufficient to prevent them from becoming a nuisance. Hence the two duties of a natural draft chimney are: (1) Draft creation and (2) Gas disposal. The chimney is the pressure transformer and the draft is the result of the thermal difference.

Natural draft is quite advantageous in installations where the total loss of draft due to resistances is relatively low and also in plants which have practically a constant load and the boilers are seldom operated above their

normal rating. Natural draft systems have been, and are still being, employed in the operation of large plants during the periods when the boilers are operated only up to their normal rating. When the rate of operation is increased above their normal rating, some form of mechanical draft is employed as an auxiliary to overcome the increased resistances or draft losses. Natural-draft systems are used almost exclusively in the smaller size plants where the amount of gases generated is relatively small and it would be expensive to install and operate a mechanical draft system.

The principal advantages of natural draft systems may be summarized as follows: (1) Simplicity, (2) Reliability, (3) Freedom from mechanical parts, (4) Low cost of maintenance, (5) Relatively long life, (6) Relatively low depreciation, and (7) No power required to operate. The principal disadvantages are: (1) Lack of flexibility, (2) Irregularity, (3) Affected by surroundings, and (4) Affected by temperature changes.

## PERFORMANCE OF NATURAL DRAFT CHIMNEYS

In order to analyze the performance of a natural draft chimney, it is advantageous to compare its general operating characteristics with those of a centrifugal pump and also a centrifugally-induced draft fan, there being a close similarity between the three. Figs. 1, 2 and 3 show the general operating characteristics of a typical centrifugally-induced draft fan, a typical centrifugal pump, and a typical natural draft chimney, respectively. The draft-capacity curve of the chimney corresponds to the head-capacity curve of the pump and also the dynamic-head capacity of the fan; the efficiency curve of the chimney to the efficiency curves of the pump and fan; and the gas horse-power curve of the chimney to the brake horse-power curves of the pump and fan.

## Theoretical Draft; Available Draft

When the gases in the chimney are stationary, the draft created is termed the *theoretical draft*. When the gases are flowing, the theoretical intensity is diminished by the draft loss due to friction, the difference between the two being termed the *available draft*. The general equation for the available draft intensity of a natural draft chimney with a circular section is as follows:

$$D_a = 2.96HB_o \left( \frac{W_o}{T_o} - \frac{W_c}{T_c} \right) - \frac{0.00126W^2T_c fL}{D^5 B_o W_c} \quad (1)$$

where

$D_a$  = available draft, inches of water.

$H$  = height of chimney above grate bars, feet.

$B_o$  = barometric pressure corresponding to altitude, inches of mercury.

$W_o$  = unit weight of a cubic foot of air at 0 deg Fahrenheit and sea level atmospheric pressure, pounds per cubic foot.

$W_c$  = unit weight of a cubic foot of chimney gases at 0 deg Fahrenheit and sea level atmospheric pressure, pounds per cubic foot.