ABSTRACT: This application discloses a blow-through air fan for evaporative heat exchangers having a diffusion duct containing a moveable damper and a cooperating fixed baffle so that in the full flow position little resistance to air is offered and in the maximum choke position the air pressure across the mouth of the air discharge duct is sufficiently uniform to prevent aspiration of water.
AIR CONTROL DAMPER FOR EVAPORATIVE HEAT EXCHANGERS

This application relates to blow-through type evaporative heat exchangers and, more particularly, to improved equipment for controlling the flow of air to the heat exchange region of such heat exchangers.

Evaporative heat exchangers are devices in which air and water are passed in countercurrent or other contact relation through a heat exchange region. A small portion of the water is evaporated, and the heat of vaporization is extracted from that which is to be cooled. For example, in the case of a cooling tower evaporation of some of the water cools the rest; in an evaporative condenser, evaporation of water extracts heat from the refrigerant. Equipment of this type is extensively used in the heat dissipation phases of air conditioning, industrial cooling and refrigeration. The equipment functions using outside air. Outside air is, of course, subject to temperature variations; and the equipment is subject to variations in the heat load with which it is required to deal. Thus, on a cool day with a full heat load or on a warm day with a light heat load or a combination of both, the equipment has an excess of cooling capacity. To reduce the amount of cooling capacity to meet a low load and/or cool air condition, a usual procedure is to reduce the amount of air flow through the heat exchange region. For very complete control the air flow should be capable of being greatly reduced, for example by as much as 80 to 90 percent.

In blow-through type heat exchangers as shown in U.S. Pat. No. 3,132,190 to Engaltcheff, this air control function has been successfully accomplished by the use of a damper located in the air ducting between the centrifugal fan and the sidewall of the pan section of the equipment. One type of damper which has been used successfully in this environment is shown in U.S. Pat. No. 2,719,666 to Hollingsworth et al.

Recently, there has been developed an improved type of evaporative heat exchanger in which the sump or pan section, that is, the lower portion of the equipment which receives the water as it falls from the heat exchange region, is made in the form of a V. Equipment of this type is shown and described in application Ser. No. 706,003, filed Feb. 16, 1968 now U.S. Pat. No. 3,442,494. While the use of the V-section sump has numerous advantages such as reduced water inventory, reduced weight, greatly facilitated shipping capability, and so forth, a consequence of the use of the V-sump is that the ducting for the air blowers is required to be both substantially shorter and differently arranged than was the case with the blow-through evaporative heat exchanger having sumps of conventional configuration. It has been found, for example, that the conventional damper as disclosed in said Hollingsworth U.S. Pat. No. 2,719,666 has a tendency to cause water leakage into the ducting around its operating shaft and to cause the fan duct to aspirate water if it is located inside the sloping plane of the sump wall of the V-type unit and, even if moved outside that wall still causes aspiration of water and additionally interferes with air flow when the damper is in the maximum flow position. Because of the substantially shorter length of the diffusion ducting between the outlet of the centrifugal blowers and the plane of discharge within the sump, the eddy currents which are produced by the damper create regions of pressure at the mouth of the air duct which are negative relative to the sump pressure resulting in aspiration of water into the fan region to the detriment of its performance and durability.

It is an object of the present invention to overcome the foregoing deficiencies and to provide an air control damper which is characterized by negligible interference with fan efficiency in the full open position and yet is capable in its maximum choke position of reducing the air output to almost a full cutoff without causing aspiration of water into the fan housing.

Furthermore, according to the present invention the damper may be controlled and moved through the full range of positions from a full open position to a maximum choke position under conditions which avoid aspiration of water into the fan housing through the mouth of the air fan duct as well as shaft leakage problems.

Other objectives and advantages of this invention will be apparent upon consideration of the following detailed description of several embodiments thereof in conjunction with the annexed drawings wherein:

FIG. 1 is a view in vertical section of a cooling tower having a V-sump of the type shown in application Ser. No. 706,003, filed Feb. 16, 1968, now U.S. Pat. No. 3,442,494, incorporating an improved air control damper constructed in accordance with the teachings of the present invention;

FIG. 2 is a fragmentary view in vertical section to an enlarged scale of the centrifugal blower, ducting and damper incorporated in the cooling tower of FIG. 1, the damper being shown in the full open position;

FIG. 3 is a view in vertical section and to an enlarged scale illustrating the maximum choke position of a damper of the type shown in FIG. 1;

FIG. 4 is a fragmentary view in vertical section to an enlarged scale of a modified type of damper constructed in accordance with the teachings of the present invention, the damper being shown in the maximum choke position and the full open position being indicated in broken lines; and

FIG. 5 is a fragmentary view in section taken on the line 5-5 of FIG. 4.

Referring now to the drawings in greater detail, FIG. 1 illustrates a cooling tower of the type disclosed and claimed in application Ser. No. 706,003, filed Feb. 16, 1968 now U.S. Pat. No. 3,442,494. This cooling tower comprises a water spray section 10 below which are located heat exchange regions 11 occupied with fill functioning to present a large surface area for water-air contact. Below the fill region there is an air distribution region 12 and below that is the sump 13.

The sump 13 is defined by two triangular vertical walls 14, one of which shows in FIG. 1, a vertical and a sloping wall 16. The walls 14, 15, and 16 define, in effect, a trough having a cross section in the form of a V.

A centrifugal blower 17 is located beneath the sloping wall 16 of the sump 13 and air ducting 18 connects the outlet of the housing of the blower 17 with the interior of the sump region 13. The ducting 18 terminates at a mouth 19 which lies within the sump 13 above the level of water therein.

Briefly stated, the function of the apparatus of FIG. 1 is to extract heat from water. To this end, water which is to have heat extracted from it is introduced into the cooling tower at a header 20 from which there extend a large number of spaced parallel pipes 21 covering the cross-sectional area of the region 10. Each pipe 21 is fitted with a plurality of nozzles 22 and from the various nozzles 22 water is discharged to gravitate through regions 11 and 12 and into the sump 13. As the water falls through the regions 11 and 12, it is contacted by counter flowing air moving upwardly from the fan mouth 19 through the cooling tower. The air-water contact causes evaporation of some of the water and the latent heat of vaporization is extracted from the remainder of the water resulting in cooling of the same. Mist eliminators 23 function to prevent the upflowing air from driving mist out of the top of the cooling tower. The water from which heat has been extracted is collected in the bottom of the sump and is withdrawn through a conduit 24 to a point of use. To replace water losses caused by evaporation and blow down, makeup water is added to the system as needed by conventional means, not shown.

The sump is provided with a baffle at 25 to stabilize the water level against the influences of the withdrawal of water and the impingement of air on the upper surface of it. A baffle 26 is located in the region 12 and functions to assist in distributing air uniformly across the cross section of the cooling tower.

The fill region 11 is made up of modular units which are disclosed and claimed in application Ser. No. 706,004, filed Feb. 16, 1968. For purposes of the present invention, it
suffices to say that a large number of curved metal pieces 27 are arranged in mutually spaced relation to provide an air-

way path therebetween.

The present invention is concerned with the controlling of the flow of air from the centrifugal blower 17 and better to
describe this function, reference is made to FIGS. 2 and 3.
FIG. 2 shows the blower 17 to a much enlarged scale and in
that FIG. most of the remaining structure of the cooling tower
is omitted for convenience of illustration. The blower 17 is of
the centrifugal type having a center air inlet at 28 and blades
29 which discharge the air into the blower housing 30. The
blower housing 30 is of generally rectangular cross section
defined by two vertical walls 31 (one of which shows in FIG.
2) connected by a curved wall 32 which is contoured to
provide a region of increasing cross-sectional area between
the cutoff at 33 and the fan housing discharge region which is
roughly a straight line from the cutoff 33 to the upper end of
the fan housing at 32a. The air discharge duct 18 is supported
from sloping wall 16 of the sump 13 and provides a continuing
ducted air path of rectangular cross section between the end
of the fan housing 30 and duct mouth 19 which is located
within the sump area. Note that the discharge end of the fan
housing 30 telescopes into the ducting 18. Some additional
diffusion occurs between the end of the fan housing and the
mouth 19 of the ducting 18 so that the air issuing from the
ducting 18 has had some of the energy which has been put in
it by the blower 17 converted from dynamic to static form.

Under normal conditions of operation, the air issuing from
the mouth 19 of ducting 18 would flow to the mouth in a
direction generally as indicated by the arrows in FIG. 2. There
are conditions, however, when the heat load is low or when
the ambient air is cool or both when the unit has overcapacity
which makes it desirable to operate the cooling tower with a
reduced flow of air. To this end, there is provided in the
housing ducting 30 on the opposite side of the wall 16 from
the mouth 19, a sheet metal damper 34 made of a
curved piece of metal 34a and a chordwise piece 34b
connected to an operating shaft 35 which passes through the
walls 31 to a point where angular displacement of the shaft 35
can be initiated. Note that shaft 35 lies outside the sump
region and hence does not require to be sealed against water
leaking and that the damper 34 is located in the maximum
choke position and in that position the output of the air from
the mouth of the ducting 18 is reduced by much as 80 to 90
percent. At the same time the air output presents a
substantially even pressure front across the mouth of the
ducting 18 positive with respect to the sump pressure so that
even in the maximum choke condition, the fan is protected
against aspiration of water. This is accomplished by so
locating and arranging the damper 34 that in the maximum
choke position there is space for air flow at both ends of the
damper, these spaces being indicated at regions 36 and 37 in
FIG. 3. Thus, the air to the right of the damper 34, as it is
viewed in FIG. 3, is divided into two streams by the damper,
one issuing through space 36 and the other issuing through
the space 37. A stationary baffle 38 is located downstream of
the axis of the damper 34 and this baffle acts to subdivide the
stream issuing through the space at 37 to promote better
distribution of the air across the cross section of the duct 18.
In effect, the streams passing through regions 36 and 37 are
caused to merge enough before the mouth 19 of duct 18 is
reached so that an even enough pressure front is presented to
prevent water aspiration.

The damper 34 is so shaped and located as to offer virtually
no interference to the air flow when it is in the FIG. 2 position.
This is also true of the baffle 38 which extends between the
walls 33 of the air duct in a plane substantially parallel to the
plane of the air entering from the blades of the blower. Thus, in
the FIG. 2 position neither the baffle 38 nor the damper 34
offers resistance to air flow of any appreciable magnitude.

When baffle 38 is in the FIG. 3 position, however, it tends to
break the air back into the impeller blades 29 greatly to
decrease the output of the blower. Furthermore, the air which
does pass through the space at 37 is not moving in the same
direction as is the case when the damper 34 is in the FIG. 2
position so that now the baffle 38 forms a stream dividing
function. For convenience of construction ducting 18 and
blower housing 30 may be made as shown in FIG. 2. However,
any construction can be used so long as a continuous ducting
surrounds the blower rotor, extends through the sump wall,
and terminates in a discharge mouth within the sump region.

In FIG. 4 there is shown a modified damper constructed in
accordance with the teachings of the present invention but
again offering negligible resistance to the air flow in the open
position but permitting, in the maximum choke position, as
much as 80 to 90 percent reduction in air flow. In this case,
the ducting and baffle are much the same as those described
in FIGS. 1 to 4, inclusive, except that the blower rotor 40 is of
larger capacity and hence of larger diameter and therefore has
to be placed with its periphery closer to the sloping sump wall
41 than is the case with blower rotor 28 and sump wall 16.
This requires that the blower housing 42 as well as the air
discharge ducting 43 inside the sump wall be differently
contoured. As is the case with the FIG. 2 construction, the
particular arrangement of the sheet metal is not the important
thing but rather the resulting ducting which the air issuing
from the blower sees in its travel from the rotor to the
discharge mouth. In this instance, a damper 44 made of two
sheet metal pieces 44a and 44b is fixed to rotate with a shaft
45 which extends through the sidewalls of the fan housing
46. The damper consists of two portions of a sheet metal
framework from the full open broken line position to the maximum choke full line position of FIG. 4 by
operation of the shaft 45. As was the case with damper 34
there is an air passage at 47 between the damper 44 and the
outer curved wall 48 of the fan housing 42, and there is
another space 49 between the other end of the damper and the
periphery of the rotor 40. Again, in the maximum choke
position, two of the air streams are produced and again the stream
issuing through the space 49 is directionally modified by a
stationary baffle. In this case, however, the baffle is in the
form of two rods 50 and 51 which extend between the
sidewalls 52 and 53 of ducting 43, see FIG. 5. Again, the air
streams are distributed so that there is a substantially positive
pressure front across the ducting 43 at its mouth 54.

The invention may be embodied in other specific forms
without departing from the spirit or essential characteristics
hereof. The embodiment and the modification described are
therefore to be considered in all respects as illustrative and not
restrictive, the scope of the invention being indicated by the
appended claims rather than by the foregoing description, and
all changes which come within the meaning and range of
equivalency of the claims are therefore intended to be
embraced therein.

We claim:
1. In an evaporative heat exchanger having a sump for
receiving water gravitating from a heat exchange region, a
wall partially defining said sump, a centrifugal blower located
outside said sump, air ducting surrounding said blower,
passing through said wall and presenting an air discharge
mouth within the sump, the improvement that comprises,
a damper located in said ducting, means mounting said damper
for movement from a full open position in which it lies
substantially parallel to the air flow in the region where it is
located to a maximum choke position in which it passes at
least one stream of air and means downstream of said damper
to modify the direction of said airstream to distribute the air
across the full cross section of the ducting mouth evenly
enough to prevent water aspiration.
2. The improvement of claim 1 in which the means
downstream of said damper is a stationary guide.
3. In an evaporative heat exchanger having a sump for
receiving water gravitating from a heat exchange region, a
sloping wall partially defining said sump, a centrifugal
blower located outside said sump, air ducting surrounding
said blower, passing through said wall and presenting an air
discharge mouth within the sump, the improvement that
comprises, a damper located in said ducting on the same side of said sloping wall as said centrifugal blower, means
mounting said damper for movement from a full open position in which it lies substantially parallel to the air flow in the
region where it is located to a maximum choke position in which it passes at least two streams of air and means
downstream of said damper to modify the direction of at least one of said streams to promote the merging of said streams by
the time the mouth of the ducting is reached.
5. The improvement of claim 4 in which the means downstream of said damper is a stationary guide which in the
full open position of the damper lies parallel to the air flow from the blower.
6. The improvement of claim 5 in which the means downstream of the damper is on the same side of said sloping
wall as said damper.
7. The improvement of claim 4 in which the means downstream of said damper is a pair of rods extending across
the airstream.
8. The improvement of claim 7 in which the pair of rods are located on the sump side of the plane of the sloping wall
partially defining said sump.
9. The improvement of claim 4 in which said damper extends for the full width of said ducting and is curved as
viewed in cross section.