ATMOSPHERIC MIXERS
CHAPTER 3

LOW-PRESSURE ATMOSPHERIC MIXERS

Atmospheric mixers (or injectors) (see chapter 2, fig. 4) utilize the energy generated by some fuel gas flowing at pressure P_1 out of orifice A_1 to entrain air from the atmosphere through the aperture of the primary air regulator. Thus the mixture arrives at the burner head at very low pressure.
The flow energy in P_1 is amost completely used to create the draft in P_2 which allows for the entraining of air from the atmosphere. Only a very small quantity of the original pressure is available to create the positive pressure P_3 at area A_3.
Although the pressure values are in this case very different, the theoretical working principle is the same as the venturi.
With a gas boost of 150 mm H_2O in P_1, pressure P_3 will be lower than 2.5 mm H_2O and the draft P_2 much lower than the previous one. Although such low pressures are difficult to be measured, the measuring of the air flow through the annular area A_2 confirms that some draft exists in this point. Low-pressure atmospheric mixers entrain a quantity of primary air amounting to 20/40% the air necessary for complete combustion. This means that for natural gas some 4 volumes of air per volume of natural gas supplied will be available for mixing.
The area referrred to as A_T is the smallest of the areas of a venturi mixer and is also called "throat". It represents one of the elements which limit the working opportunities of an atmospheric mixer of that type.
For a mixture having a very precise air-gas ratio, only one ideal relation exists among areas A_1, A_T and A_3. These ideal conditions may be obtained when the jet divergent cone reaches the venturi throat (A_T) tangentially and continues its expansion with the divergence of the venturi until the maximum area A_3 is reached. If the system was made to operate beyond the ideal levels mentioned above by enlarging area A_1, problems during the mixing would arise due to some turbulence originated inside the venturi. This is due to the fact that by enlarging area A_1 pressure P_3 increases and hence the negative value of pressure P_2 decreases. For the same reason, the quantity of air entrained by the greater quantity of gas flowing from A_1 decreases and hence the air-gas ratio will be modified. That is why burner manufacturers fix a maximum capacity for each mixer operating in specific conditions. The only way to obtain an increased capacity while keeping tha air-gas ratio constant, is to increase pressure to A_1. In this way, as we have shown in Chapter 2 (working priciple of the venturi), the negative value of pressure P_2 increases as well as the positive value of pressure P_3. Otherwise, by changing only area A_1 and hence modifying the air-gas ratio, longer, too soft and yellowish flames are obtained, that is not well aired.

THE DRAFT IN ATMOSPHERIC MIXERS

Atmospheric mixers are sometimes connected to combustion head of the type with "several orifices" that is to burners of the type with pipe, ring or plate etc. In these cases, usually the air-gas mixture flows out of the holes of the combustion head at atmospheric pressure.
Combustion systems made up of an atmospheric mixer and a nozzle-combustion head, will often work in draft conditions that is at pressures which are slightly below the atmospheric pressure.
The draft (as compared to the atmospheric one) existing downstream of the orifice of the burner head A3, is transmitted into the mixer and causes a relative increase in the negative value of pressure P2. This entails automatically an increase in the quantity of combustion air entrained from the atmosphere through the annular orifice A2. If for instance some draft of only 5 mm H2O was created downstream of the burner head (or nozzle), the gas load of the mixer could be increased by 250% as compared to the capacity the same combustion system would have if downstream of the nozzle there was a 0 pressure that is atmospheric pressure. As for the opportunity to increase the capacity of a mixer, very small draft values in combustion chamber (even tenths of a millimetre of H2O) are more important than great draft values created by the gas flow through the venturi throat.
When choosing the most adequate dimension of an atmospheric burner to obtain a specific heat rating, the draft value (or depression) available in the combustion chamber, is one of the most important factors.

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MEDIUM-PRESSURE ATMOSPHERIC MIXERS

Atmospheric injectors working at low gas pressures may also be fed via pressures of up to 7,000÷10,000 mm H_2O. When working with such pressures though it is advisable to use mixers having a smaller area A_1 allowing to obtain a greater negative value of pressure P_2 and consequently greater primary air premixing. With gas boost ranging from 3,500 to 7,000 mm H_2O the result is a 40% to 60% premixing.
With highere boosts and leaner mixtures greater values of P_3 can be obtained.
If a pressure P_1 of 7,000 mm H_2O is available, the mixture pressure at the burner nozzle (P_3) may be as high as 25÷50 mm H_2O.
In these working conditions, having draft values P_2 much greater, the draft value in the combustion chamber will no longer be as important as in low-pressure gas burners. However some draft is necessary especially in order to obtain better capacity performances. Using the capacity of a burner working in neutral conditions (no draft) it is possible to obtain an increase in the capacity by 65% creating a draft of 5 mm H_2O. This is true of a mixer operating with gas at 7,000mm H_2O.

HIGH-PRESSURE ATMOSPHERIC MIXERS

When the gas boost exceeds 7,000 mm H_2O it is better to use a mixer designed to better exploit the different behaviour of the mixture threads (figure 5).
If gas pressures amounting to 1.7 bar (some 17,000 mm H_2O) are available, it is possible to premix at 100% that is to entrain all the air necessary for combustion via the fuel gas energy by premixing it with gas in the venturi before it arrives in the nozzle.
High-pressure mixers differ from low- and medium-pressure mixers in the design, yet the working principle is exactly the same.
Given a specific area A_3, we will try to obtain some specific draft P_2 created by the gas flowing out of orifice A_1 at pressure P_1. The latter allows to obtain the draft of air from the ambient through the annular orifice A_2.
The flare of the outer face of the injecting nozzle is modified so as to produce a jet cone following the less divergent inner shape of the venturi. This change is adopted in order to exploit the maximum energy of gas available. The annular orifice of the primary air A_2 has an almost cylindrical shape, too; its section may be regulated manually by moving the proper regulator.
When natural gas is used at a boost of 1.7 bar and when the system is regulated so as to obtain a mixture with 80% aeration a pressure P_3 ranging between 50 and 75 mm H_2O will be obtained. Obviously

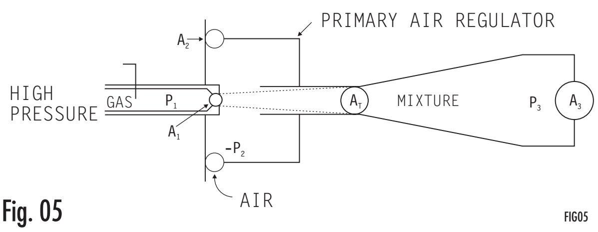

Fig. 05

the remaining 20 % of air will be utilized as secondary air to be supplied to the combustion system with a specific draft in the combustion chamber. The latter though is not very important as far as the effects of the assessment of the capacity limits of the mixers is concerned.
As for the mixers we have mentioned above, the high-pressure venturi may present bad performances if specific limits of the orifice A_1, which are ususally reported by the manufacturer, were exceeded. The values reported in the tables by the manufacturer may correspond to maximum potentail (or maximum capacities) or to maximum section of the nozzle A_1, which can be tolerated for a corresponding section of discharge of the burners A_3. The ratio of the minimum capacity to the maximum capacity of such burners is very wide and is only limited by the number of heads or nozzles of the burners which make up section A_3.

DECREASED CAPACITY - TWO POSITION REGULATION

From what we have said up to now, it is quite obvious the regulation of the thermal or volumetric flow of an atmospheric combustion system is easily done when regulating the boost P_1 of the motor fluid. As the value of depression P_2 is always directly proportional to the value of the pressure drop through A_1, the connection regulating the pressure ratio is comprehended in the venturi working.
As you will remember, this connection entails variations which are directly proportional in one fluid flow to the variation in the capacity of the other fluid. This is true in the whole flowfield fixed by the manufacturer for each dimension of the mixer. Therefore by reducing the fuel gas capacity through orifice A_1, also the combustion air capacity through orifice A_2 of the primary air regulator will be reduced automatically. This will keep the air-gas ratio in the mixer constant for all the ranges of capacity mentioned above.
An automatic controlling system , the so-called "2-position" system or "low and high fire" system may be realized by connecting a solenoid valve on the gas pipe to a thermostat or pressure switch. The valve works on a "by-pass", thus reducing the thermal capacity of the burner to the required effects.
Such regulating system, shown in the schematic in figure 5A, allows for greater simplification of the automatisms of many industrial combustion systems thus reducing their cost.
Once again the modulatory regulating system is based on the same principle. The modulation of the burner capacity is obtained by placing an electrically or pneumatically (via a modulatory thermostat or pressure switch) servocontrolled valve on the gas line. It is however necessary to pay much attention when choosing and installing the control. It is important to remember that this type of regulation can only be used at high pressures and gas capacities. The use of the modulatory regulating system is recommended for pressures of at least 3,000 mm H_2O.
A good example of this type of regulation is shown in figure 5B.

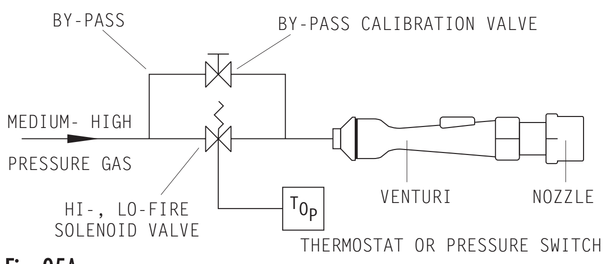

Fig. 05A

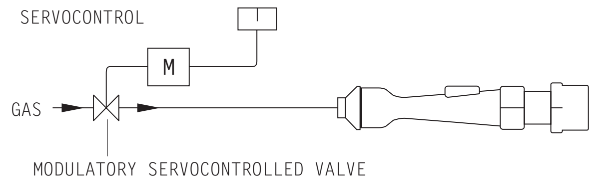

Fig. 05B