

# NOZZLE-MIXING BURNERS

## CHAPTER 6

### BLUE-FLAME NOZZLE-MIX BURNERS

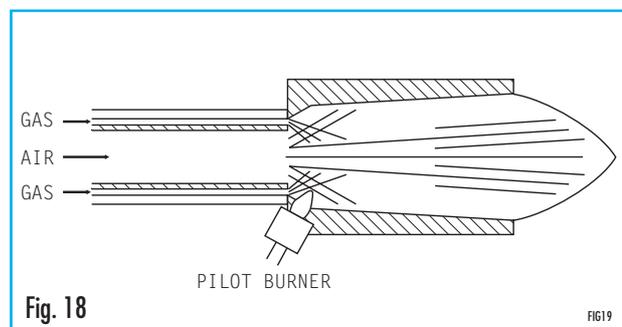
Thus far we have examined burners utilizing mixers which prepare the mixture in the desired air-fuel ratio. Nozzle-mix burners on the contrary maintain the air separated from the fuel until the combustion starts. The air-gas mixing takes place directly in the combustion chamber. Clearly enough in this way it is impossible to have flashback. Another feature of this type of burners is that they utilize very low-pressure inlet air and gas which result in a more economical and safe equipment. The type of flame resulting from these burners depends upon the way and direction air and gas are supplied to the burner head and upon the turbulence in the refractory block.

Furthermore they develop a wide range of flames, from soft and long ones typical of atmospheric burners, to short and hard ones typical of pre-mix burners.

Thus nozzle-mix burners have no real mixer, but rather a metallic body similar to a mixer designed to adequately direct the two fluids to the refractory block, which is, though, very similar to the ones described in the previous chapter.

The combustion air is introduced in a coflowing arrangement with the gas. More precisely the gas flows through an annulus surrounding

the combustion air tube which is similar to the circular gas tube but has a smaller diameter. Then the gas flows through an annulus: fig. 18 shows this type of burners. The annulus where the gas flows is usually ten times smaller than the one where air flows. However the two areas may change depending on the type of gas used and the type of flame required. This type of burners, just like pre-mixing burners, allow for extremely high thermal loads per unit volume of combustion chamber.

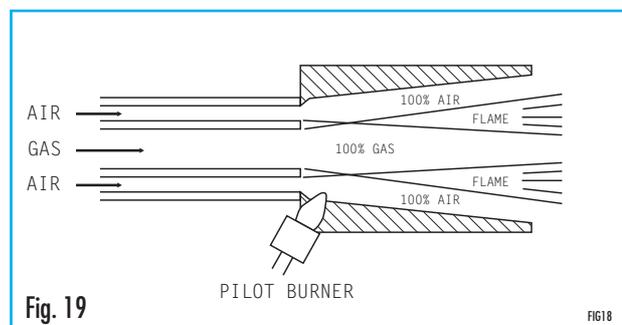


### LUMINOUS-FLAME NOZZLE-MIX BURNERS

In nozzle-mix burners luminous flames may be obtained by inverting the inlet system of the two fluids, that is by making air flow through the outer annulus and gas through the inner annulus. Clearly enough both the areas and speed must be modified. If the outlet speed of air and gas is the same that is equal to less than 6m/s, the two fluids stay in the laminar speed field. Air and gas mixing is thus slow and combustion will start only when they get in contact (Fig. 18). The heat radiating from the combustion chamber walls and the flame itself produces a phenomenon called "thermal cracking" of the fuel; the carbon released during the cracking burns slowly with luminous flame. That is the phenomenon by which flame radiates. Its length, greater than standard length, on the other hand, depends on the slow air-gas mixing. In order to obtain the maximum luminosity it is advisable not to exceed a thermal load amounting to 350,000 kCal per metre of combustion chamber, otherwise the turbulence of the

combustion products will reduce the flame luminosity.

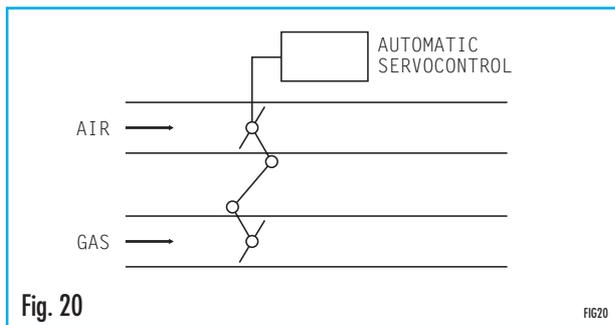
The flame length may be reduce also in the burners shown in Fig. 19 by increasing the gas and air outlet speed. Luminous flame burners may be converted into blue flame burners and their capacity increased by up to 100% the initial value.



## REGULATION OF NOZZLE-MIX BURNERS

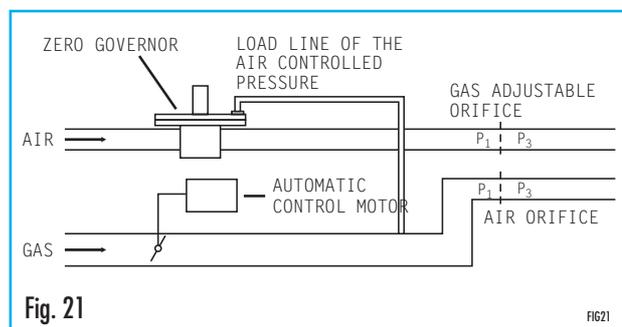
The simultaneous regulation of gas and air in nozzle-mix burners cannot take place as described for atmospheric burners, nor as described for pre-mix burners. As a matter of fact, not only do air and gas reach the burner at high pressure, but also reach it through different ways. Anyway the regulation of such burners follows the principle of the modification of the two orifices: one on the air pipe and the other on the gas pipe which in some way must be connected one to the other.

As a matter of fact one way to regulate the capacity of these burners is to place two regulating valves; one on the air pipe, the other on the gas pipe and then to connect them to a single servocontrol, so that the ratio of the 2 fluids does not change (Fig. 20). Usually the regulation of such device is done by means of the mechanical connection, first on the gas valve then on the air valve. Anyway it is rather difficult to obtain perfect regulation of both fluids and keep their ratio constant.



Another way to regulate nozzle-mix burners relies on the simultaneous control of the pressure drop through 2 fixed-area orifices: the first one placed on the gas pipe, and the second one placed on the air pipe. The former is usually a built-in orifice, whereas the gas orifice stands by itself and it is possible to regulate its area. The possibility of regulating the flow of the two fluids is useful to start the equipment or when the working conditions must be changed, but it can only be regulated once and for all. As a matter of fact once the desired fuel-air ratio is calculated, the gas orifice is regulated so as to reach and maintain such ratio, then it is blocked and sealed, as if it was a fixed-area orifice.

In order to obtain regulation of the flows without changing the air-gas ratio which was first fixed, it is necessary that the pressure of the two fluids upstream of the two fixed orifices is exactly the same. This is possible if gas and air pressures are the same from the very beginning. For this reason loaded atmospheric regulators are used. They allow to maintain the gas and air pressure the same through the whole range of regulation. They are to be placed on the gas pipe upstream of the calibrated orifice; through a datum line the upper part of the diaphragm is loaded by means of the pressure taken upstream of the air fixed orifice. Fig. 21 shows the schematic of the control system described above.



It is clear that with such system and given the operational features of atmospheric regulators described above, every modification in the air pressure will entail an equal modification in the gas pressure. Thus it will be sufficient to place a butterfly valve on the air pipe, upstream of the plug of the datum line capable of regulating the air pressure as a function of the quantity to regulate (temperature, pressure...). The pressure drop through the two fixed orifices will always remain the same hence the volumetric ratio of the comburent to the fuel will always be perfectly constant (see Ch. 2, Fig. 2).

In order to obtain good results, it is necessary that the gas pressure in the pipe is at least the same as the air pressure. If this is not the case, that is if the air pressure exceeds the gas pressure, the so called "relief orifice" is placed on the datum line connecting the air pipe to the atmospheric regulator. The relief orifice is designed to relieve part of the air pressure in order to make it equal to the gas pressure.