

## Residual Fuel Combustion: Rotary Cup Burner

The oil is first heated in steam or electric fuel oil heaters. This reduces its viscosity and makes it easier to pump, filter and atomize.

If overheated, 'cracking' can occur which will result in carbon deposits and the formation of gas in the fuel lines. This gasification can cause instability with the combustion process.

The heated oil now passes through the burners where it is atomised (broken down into tiny droplets – presenting a very large surface area). The droplets formed are of two main types, very fine droplets (lighter fractions) and the heavier droplets (heavier fractions).

With the rotary cup burner, the burner imparts rotational energy to the fuel so that it leaves the burner tip as a hollow, rotating cone formed of fine droplets of oil.

The combustion stage itself can now commence, and in a boiler furnace a type of combustion often referred to as a 'suspended flame' is used. For this, a stream of oil particles and air enters the combustion zone at the same rate at which the products of combustion leave it. The actual flame front therefore remains stationary, while the particles pass through it, undergoing the combustion process as they do so. The combustion zone itself can be sub-divided into two main stages; these are referred to as the primary and secondary flames.

### PRIMARY FLAME

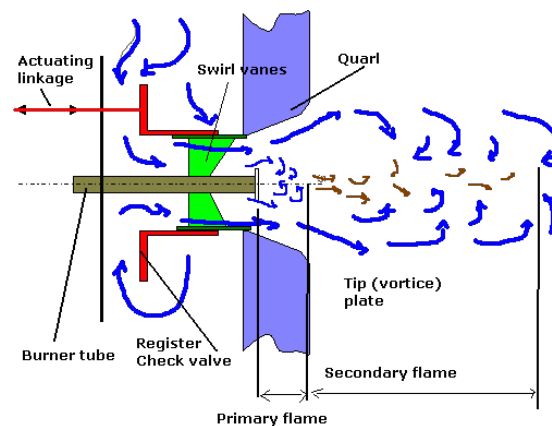
For the oil to burn, it must be raised to its ignition temperature, where continuous vaporization of the oil required for its combustion takes place. Note this temperature should not be confused with the flash point temperature of the oil, where only the vapour formed above the oil in storage tanks, etc. will burn. The ignition or burning temperature should normally be at least some 20°C above this value.

This ignition temperature cannot be obtained in the fuel oil heaters, and therefore the heat radiated from the flame itself is utilized so that, as the cone of atomized oil leaves the burner, the lighter hydrocarbons are rapidly raised to the required temperature by the heat from the furnace flame; they then vaporize and burn to form the primary flame.

The heat from this primary flame is now used to heat the heavier constituents of the fuel to

their ignition temperature as they, together with the incoming secondary combustion air, pass through the flame.

The stability of the combustion process in the furnace largely depends upon maintaining a stable primary flame and, to ensure it is not overcooled, a refractory quarl is usually placed around it so as to radiate heat back to the flame. The primary flame should just fill the quarl. If there is too much clearance excessive amounts of relatively cool secondary air enter the furnace; too little and the heavier oil droplets impinge on the quarl and form carbon deposits.



Another important factor for the formation of the primary flame is that it must be supplied with primary air in the correct link proportion and at the right velocity. In the case of air registers using high velocity air streams this is done by fitting a tip plate that spills the primary air over into a series of vortices. This ensures good mixing of the air and fuel and, by reducing the forward speeds involved, helps to maintain the primary flame within the refractory quarl.

## SECONDARY FLAME

The larger oil droplets, heated in their passage through the primary flame zone, then vaporize and begin to burn. This, although a rapid process, is not instantaneous, and so it is essential that oxygen is supplied steadily and arranged to mix thoroughly with the burning particles of oil. An essential feature for the stability of this suspended secondary flame is that the forward velocity of the air and oil particles must not exceed the speed of flame propagation. If it does the flame front moves further out into the furnace and the primary flame will now burn outside the quarl with resulting instability due to overcooling.

Careful design of the swirl vanes in the air register can be used to create the required flow

patterns in the secondary air stream. The secondary flame gives heat to the surrounding furnace for the generation of steam.

Sufficient time must be given for complete combustion to take place before unburnt oil particles can impinge onto tubes or refractory material. This usually entails the supply of a certain amount of air in excess of the theoretical amount required for complete combustion if these practical considerations could be neglected, and unlimited time taken for the mixing of the air and fuel. The actual amount of excess air supplied depends upon a number of factors, such as the design of the furnace, the efficiency of the combustion process for the condition of load, etc., but will in general reduce the boiler efficiency to some extent due to the heat carried away by this excess air leaving the furnace. It can also lead to increased deposits in the uptakes due to the increased amount of sulphur trioxide that will form from sulphur dioxide in the presence of excess oxygen.