COOLING TECHNIQUES IN TRANSMITTER

Introduction

In modern A.M. transmitters power valves are used in the PA and modulator stages, which are condensed vapour cooled ceramic tetrodes. In the old generation transmitters, triodes are used in the PA, modulator and exciter stages. Both the tetrodes and triodes tubes are capable of being operated at high voltages (11 kV DC) and large anode current of the order of 50 Amps. They also draw large filament current of about 620 Anps at 24 volt CQK-350. Hence the tubes dissipate large amount of power which require effective cooling.

The CQK series of transmitting tubes are tetrode specially designed for transmitters and power amplifiers used in broadcasting.

The tube is installed vertically with the heating connections at the bottom. Handle and transport the tube with utmost care: vibrations and external impacts can cause invisible damage. Avoid sudden movement. Slowly insert the tube in the connection head so that sudden impact is avoided. If the dead weight of the tube is not sufficiently to overcome contact resistance in the connection head, apply gentle pressure. The ceramic parts must be always kept clean. If necessary, they should be cleaned with alcohol or acetone but no circumstances should they be rubbed with emery paper.

The contact surfaces are coated with a heat resistant lubricant film, which does not attack silver. Electrical connections and connection head are provided with contact rings for all electrodes including the anode. The connection head is stationary. It supports and locate the tube, which can be inserted into the connection head only in a certain position. This position is determined by the guide groove on the anode.

Cathodes

All the ceramic tetrodes used in AIR transmitters are directly heated thoriated tungsten cathode. The filament voltage should not vary beyond +5% of the rated filament voltage. The filament voltage must always be measured at the concentric contact rings using sub-standard volt meter. The cathode cum filament has only a very small resistance when cold. Hence the filament voltage is applied and increased smoothly as per the design of the transmitter. In some transmitters, the filament voltage is applied in steps.
In some transmitter, the design of the filament transformer is such, it will restrict the surge current to 3 to 4 times the normal steady current.

**Screen Voltage**

The screen grid current can become dangerously high, even at normal screen grid voltage, when the anode voltage is lower than that of the screen grid. Hence the screen grid supply will be switched ON only when the anode voltage has become about 40% or so of the anode voltage.

**Temperature**

A separate air cooling has been arranged to control the temperature of the ceramic cylinder and all metal ceramic seals in addition to the condensed vapour cooling.

There must not be any high frequency on the supply leads. To ensure this filament RF bypass condensers are provided.

**Cooling System Used in Transmitter**

In high power A.M. transmitter, lot of power is dissipated in the valve as the input power is not fully converted into output R.F. power due to the efficiency of the amplifier which never reaches 100%. Hence the valves have to be cooled. In addition filaments are drawing large current of the order of 210 Amps at 10 volt for CQK valve. Hence they also have to be cooled. The dissipated heat in the valves also circulates in the concerned cubicle and heat develops there. Hence some kind of cooling has to be provided to the transmitting equipment. Different types of cooling are used in AIR transmitter at present.

a) Air cooling  
b) Vapour cooling  
c) Condensed vapour cooling

**a) Air Cooling**

At present forced air cooling is used in AIR transmitters. A blower sucks the air through an Air filter and a guided duct system and the forced air is passed on to the required transmitting tubes. There has to be minimum air flow to cool the valves. Hence there will be an air operated Air Flow Switch (Relay) AFR : the AFR will close only when sufficient amount of air has been built up with the blower. Otherwise, AFR will not close and filament cannot be switched on. Sometimes, if the filter is not cleaned, sufficient air may not go out of the blower. Hence the blower needs periodical cleaning.

**Caution :**

Do not by pass the AFR on any account. In case the AFR has failed but the blower is throwing the required amount of air, the AFR may be shorted to bring the transmitter on air. But AFR should be replaced at the earliest. At times if the 3 phase supply is phase reversed the blower may be running. But air may not go to the valves and AFR will not close. On such rare occasions, through Anemometer or by a paper flop the direction and the amount of air can be
checked and suitable steps can be taken to rectify the phase reversed. At present, transmitting tubes like BEL 3000, BEL 6000, BEL 25000 etc. are forced air cooled types of valves used in AIR transmitters.

b) Vapour Cooling System

This system is used in 100 kW BEL Transmitters. For very high power valves and efficient cooling, air cooling is not sufficient. Hence some of the valves like BEL 15000, BEL 75000 etc. are cooled by vapour cooling. (Hence called Vaptron). Here the principle of heat required to convert water into steam at its boiling point is used (Latent heat of steam). The valves are kept in a in-tight water container filtered and de-ionized water. This water has high resistivity and comes in contact with anode. The water containers called "Boilers" are provided with inlet and outlet pipes.

![Block Diagram of Vapour-Cooling System](image)

The inlet pipes are interconnected at the bottom to keep the water level same in all the boiler and the outlet pipes are joined at the top which provides passage of the steam to the condensing equipment known as Heat Exchanger.

The heat produced at the anode of the vacuum tubes is absorbed by water and gets converted into steam. The steam thus produced goes up through the glass-tube to the steam pipe and to the heat exchanger mounted on top of the transmitter room. The condenser is made of copper tubes. This is a mono-block fine tube moulded from copper in extrusion moulding system and has high terminal conductivity. Steam flows inside the tube and cool air is forced outside through the fins and the action of heat exchange takes place. Now the steam is condensed to water and the cooled water flows down through the water pipe due to gravity back to the boiler.
The main features of this vapour cooling system are as follows:

- This system is based on closed cycle operation and hence does not require large amount of water.
- The cooling efficiency is high. The amount of water flow required for water-cooling system is about 2000 grams per minute to absorb 1 kW of heat whereas in this vapour cooling system the amount of water flow required is only 20 grams per minute to absorb the same heat.
- As water flows in a closed loop contamination due to atmospheric dust and dirt is eliminated and hence the steam and water pipes are free of any deposition. The maintenance of this system becomes easier and requires cleaning of anodes and associated piping assemblies only periodically at long intervals.
- Water level is maintained at the required normal level by the level monitor and water level control mechanism. The system switches off the transmitter and gives as visual warning when the water level goes down behind the empty level.

The capacity of the heat exchanger is 150 kW where the inlet air temperature is 50°C max for 100 kW HMB-105 BEL MW Transmitter. To cool the heat exchanger a 3 phase propeller fan type is used. The outgoing water is about 40L/hour. The temperature of incoming steam is about 100°C and the outgoing water temperature is 100. There are two propeller fan to cool the fins of the heat exchanger. Any one of them can be selected through a change over switch.

The amount of water required in each boiler is about 27 litres. As the water inside the boiler is in direct contact with the anodes of the vacuum tubes where the high tension voltage is present, the specific resistance of water should be high so that the steam pipes and water pipes are free of any dangerous voltages.

To obtain good quality of water for the purpose of using as a cooling medium in the transmitter, a de-ionizing equipment with a filter unit or distilled water plant is used to prepare the distilled water at transmitter. A conductivity tester is used to check the quality of water in terms of resistivity. If the water resistivity is less than 200 kilo ohm, the water should be changed.

There is water level monitor to check the level of water. If the level of water is less than the prescribed level, the transmitter will trip. There is a provision to add water and drain out the old water.

Pressure equalizing line has been provided in the system. Through this line the high pressure formed over the tubes is distributed equally to the level monitoring system. Without this line, the higher pressure on the vapour side of the system would depress the water level in the boiler, relative levels would be determined by the boiling rate that is the valve dissipation and the function of the control box would be utilized.

c) **Condensed Vapour Cooling in HMB-140BEL 100 kW MW XTR:**

In BEL/BBC solid state transmitter of 100 KW/300 kW MW and 50 KW/100KW/500KW SW transmitters, condensed vapour cooling is used for the PA and modulator valves. Here a circulation of fast flowing stream of de-mineralized water is used. A high velocity
water flows through the valve jacket and transforms into vapour due to the dissipation of power in anodes. The tubes are fitted with a specially formed anode which sits in a cylindrical cooler. Due to the fast flow of water, the vapour is condensed to water as soon as they are formed. Hence the cooling efficiency is much higher. The temperature of water coming from the transmitter can theoretically reach about 90°C, but in practice, it is desired to about 70°C in normal programme modulation.

Filaments of the tubes are cooled by forced air by means of a high pressure blower. It also cools the R.F. driver valves, the third harmonic and second harmonic suppression coils.

The demineralized water is pumped by pumps (one in circuit and one as standby) from the water tank to the PA and modulator tubes through the water piping. At the inlet/outlet of each tube, a double ball valve is provided to facilitate shutting off water supply when the valve is required to be changed. Except for changing the valve, this should be kept in open condition always. (Lever in the horizontal position).

![Water Flow Circuit 100 kW HMB 140](Ref.Drg.No:-STI(T)396,(DC148))

The water flow rate is monitored by three flow switches at the outlet side of each tube. For PA tube, the flow switch is set at 37.5 litres/minute and for modulator valve, it is set at 11.5 litres/minute. When the water flow comes below this value, the transmitter will be tripped upto filament & pump will also be switched off. Off condition through the control...
electronic and WFF (Water Flow Failure) fault indication comes ON in the fault indicator panel.

The temperature of the water in the pipes is monitored by 3 thermostats one at the outlet of each tube. These thermostats are set at an operating temperature of 90°C, the transmitter will trip automatically to standby condition and WTR (Water Temperature High) indication comes up in indicator panel. Until the water temperature comes down to normal temperature, it will not be possible to put ON MT or HT.

The hot water from the valves returns to the tank through a water to air heat exchanger where it is cooled (10°C to 15°C) by blower in the heat exchanger. To ensure good quality of the water, a part of water is fed through a pressure reducing valve to de-ionizer for regeneration. A conductivity tester to check the quality of water in terms of conductivity is also available with the transmitter.

A filter is provided before the pump for filtering the water. The actual filter sleeve can be removed with the screw plug whenever required for cleaning. Manometers are provided for indicating the pressures at the inlet and outlet water lines of tubes.

The water level switch senses the level of water and gives indication WLL (Water Level Low) when the water level in the water tank becomes low. The level switch is a pressure switch with a stainless steel pressure element. The switching point can be set with the help of the knob provided in the switch.

More or less the same system is used in the transmitter where the transmitting tubes are of CQK-25, 50, 350, 650 etc.

BE FAMILIAR WITH THE COOLING SYSTEM EMPLOYED IN YOUR TRANSMITTER AND FOLLOW THE INSTRUCTIONS CAREFULLY.

REFERENCE

(1) Transmitter Manual 10 kW BEL HMB 104
(2) Transmitter Manual 100 kW BEL HMB 105
(3) Transmitter Manual 100 kW BEL HMB 140
(4) Radio Transmitter V.O. Stokes.

Ref: File Drg./DC-148, 149.