QUALITY CONTROL OF SODIUM LAMPS DISCHARGE TUBES

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Abstract

Quality control of discharge tubes of high pressure sodium lamps on pressure of the filling gas, voltage drop and the ionic current of sodium leakage from a tube, for the purpose of assembly exception of potentially unsuitable lamps is considered. Pressure monitoring of inert gas in the discharge tube (DT) is based on excitation in its transverse section of auxiliary discharges. Registration of tension for DT and the ionic current of sodium is carried out in a vacuum chamber in case of power rating of discharge. The measured value of tension on a tube and current of ions are compared to admissible values on which grading of tubes on suitable and unsuitable is carried out. Diagrams of installations and technique for the express quality control of discharge tubes in relation to industrial conditions are provided.

Keywords: Sodium lamp, quality control, radiation, luminous return, plasma pole, sodium leak.

Introduction

The discharge tube is Basic Element of the high pressure sodium lamps (HPSL). The cost of a discharge tube depending on the HPSL type constitutes 60-70% of its all-in cost. The existing DT methods of visual quality control, and control by tension of ignition are obviously insufficient for assessment. By these results it is impossible to judge DT filling gas pressure, condition of DT ceramic cover and consequently, to reveal low-quality DT and by that to exclude assembly of potentially not suitable lamps and providing them to the consumer. The problem resolution of DT quality control is not settled only by production of sodium lamps. Its other aspect is directly connected with indirect management of their production technology. Under quality control of the made discharge tubes on pressure of the filling gas, power failure and ionic current of a sodium leakage from a tube is considered. Schemes of installations and technique for the express control of DT quality control are provided.
Choice of controlled parameters for discharge tubes quality

Increase in ignition tension of the category, working tension on a lamp, decrease in a light stream, and also sodium leakage from a DT ceramic cover are the main reasons for HPSL failure [1]. One of the reasons of ignition tension change of the category and time of a lamp lighting is caused by a pressure deviation of inert gas (xenon), from the provided value TU. Optimum value of xenon in DT HPSL makes 2,6 kPa ± 0,3 kPa.

In figure 1 the histogram of xenon pressure distribution is provided for DT lamps Dnat-400 after a stem detachment from the dosing system, for the part of tubes consisting of 100 pieces.

![Histogram of xenon pressure distribution in discharge tubes DNAT-400.](image)

Follows from it that in the chosen batch of tubes xenon pressure, generally is in admissible values of 2,3 ÷ 2,9 kPa. However in this lot of products there are tubes, xenon pressure in which leaves admissible limits. Pressure in them constitutes 2 ÷ 2,3 kPa and 2,9 ÷ 3,1 kPa. Xenon pressure arises in case of stem banner and stem pieces dispersion from vacuum system, and also because of a tube cover leakage [1]. An essential role in xenon pressure dispersion in production of sodium lamps is also played by a technological condition of batchers, in particular their adjustment.

Deterioration in electric and light characteristics of HPSL and their premature failure is caused by reduction of sodium amount in tube volume. The ionic leakage of sodium through a ceramic cover of a tube is a basic reason for decrease of sodium from DT amount.

Sensitive parameters of sodium decrease from amount of HPSL are tension on a lamp and current of the sodium ions which is selected from DT surface.

Temporary dependence of Ul tension on a lamp from coefficient of diffusion of D both parameters of structure a and b of a ceramic DT cover has an appearance [2]:

\[
U_n = \left[ 5 \times 10^{-9} \left( 1 + 0.115 \frac{M_{Hg}}{M_{Na} - 4BB^2D_{rpt}} \right) I_3(T - 273)^4 \left( \frac{K_b}{W} \right)^{0.2} \right]^{1.25},
\]
where $M_{Hg}, M_{Na}$ – respectively a weight of mercury and sodium in DT; $B$ – constant; $a, b$ – respectively the average sizes of height and width of a layer between grains; $D_{gr}$ – diffusion coefficient on borders of grains; $l_e$ – distance between electrodes; $T$ – temperature of cold DT zone; $C, W$ – respectively a power factor and capacity of a lamp.

From (1) follows that tension on lamp depends on a condition of ceramic DT cover. The structure of tube cover in the course of production is created as a result of course of multistage physical processes: molding, drying, agglomeration, heat treatment, etc. Availability of defects in the made tubes – the sodium leakage reason from DT leading to increase of tension on lamp.

Other parameter connected with quality of the made DT is ionic current of a sodium leakage. Dependence of ionic current of sodium emission from surface of discharge tube, coefficient of sodium diffusion to exploitation duration of HPSL is given in work [3]. We established that current of an ionic sodium leakage from DT increases with increase in coefficient of diffusion and monotonously decreases because of reduction of sodium concentration in the category over time.

Thus, sensitive parameters to a sodium leakage from amount of DT HPSL are power failure on a lamp and ionic current of DT sodium emission. These parameters depend on quality of the made tubes connected with observance of engineering procedures of HPSL production.

**Express control of discharge tubes**

Quality control of the made discharge tubes should be exercised on pressure of the xenon filling a tube with the subsequent voltage measurement and ionic current of DT sodium emission at the rated power of the category. For DT classification on the classes "suitable" and "unusable" the measured values of the specified parameters are compared to their maximum permissible values.

[4] express method of xenon pressure determination offered by us in DT are based on actuation in the cross section of a tube of an auxiliary categories (fig. 2).

![Fig. 2. The diagram of the device for pressure determination in a discharge tube.](image-url)
The device (fig. 2) contains four outer electrodes – 1, 2 and 3, 4 which contact to DT 5 surface. For excitation of discharge between electrodes stress removed from windings of 6 and 7, transformer 8 is put to them. Constants on currents value of auxiliary discharges are supported by resistors 9 and 10. Control of currents is exercised by micro-ampermeters 11 and 12.

Pressure in discharge tubes is as follows:

1. Stress removed from the generator 15 is put to the transformer 8 and the discharge between outer electrodes 1, 2, and 3, 4 is actuated;
2. By means of resistors 9 and 10 the currents of discharges proceeding between electrodes 1, 2 and 3, 4 are set;
3. The resistor 16 tension between couples of electrodes 1, 2 and 3, 4 smoothly increases to ignition of discharge in an interval in between. Ignition of a circuit current is registered by the micro-ampermeter 17;
4. Pressure of inert gas in a discharge tube is determined by the measured breakdown voltage from the grading diagram.

In the invention [6] we offered quality control of discharge tubes by means of the outer electrode located on a lamp flask, directly in the made HPSL. Unlike [6] in operation [7] the method of determination of sodium diffusion factor from a surface of a discharge tube on the ionic DT current located in a vacuum chamber with a pressure of residual gases of value $10^{-6} \div 10^{-7}$ Pa is considered.

In fig. 3 the installation diagram for tension determination in DT and the ionic current of sodium leakage is given. Installation is developed by us taking into account operations [7, 8].

**Fig. 3. The schematic diagram of installation for quality control of sodium lamps discharge tubes: 1 – vacuum chamber; 2 – discharge tube; 3 – measuring electrode.**
The installation diagram includes a measuring circuit and a supply DT circuit. A supply of a discharge tube is carried out by stress removed from a secondary winding of the isolation transformer Tr1. The discharge is actuated in a tube by means of the PU starting mechanism. The measuring circuit consists of the regulated rectifier and a measuring electrode.

For DT strain measurement the vacuum chamber is pumped out to limit vacuum. Further gas-discharge plasma is actuated in DT. After stabilizing of discharge tension on a discharge tube and the ionic current of sodium leakage is measured in DT. For measuring a leakage current of sodium on a measuring electrode by means of potentiometer R4 continuously adjustable tension moves. Then the measured ionic current of sodium leakage and tension on tube are compared to their maximum permissible values by analogy with the technique given in operation [8].

The offered technique of monitoring the made DT allows to restrict further assembly of potentially unsuitable lamps and providing them to a customer.

**Conclusions**

1. It is established that classification of DT sodium lamps of a high pressure on the classes "suitable" and "unsuitable" should be made on pressure of the xenon filling the tube, tension and current of DT sodium emission.
2. Installations and techniques are developed for quality control of discharge tubes.
3. Grading tubes is performed by comparison of the measured parameters with their maximum permissible values.
4. The offered technique of the made DT control allows to limit assembly of potentially unusable lamps and their provision to the consumer.

**Summary**

It is established that quality control of HPSL discharge tubes should be made on pressure of inert gas, on DT tension and on sodium current leakage from a tube. It is established that the xenon pressure dispersion arises in case of a stam banner and stam pieces derivation from vacuum system, and also because of a tube cover leakage. Deterioration in electric and light characteristics of sodium lamps and their premature failure is caused by reduction of sodium amount in tube volume.

The ionic leakage of sodium through a ceramic tube cover is a basic reason of sodium leakage from DT. It is shown that sensitive parameters of a sodium decrease from amount of DT are tension on tube and current of sodium ions issue from a tube. Installations and techniques are developed for quality control of discharge tubes of sodium lamps. Selective control of the made DT in production will allow to limit further assembly of potentially unusable lamps, to
exclude their sending to the consumer, and also the possibility of indirect management of the sodium lamps production technology opens.

References


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