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SIMULATION OF TEMPERATURE REGIME OF WATER-COOLED LOW-PRESSURE GAS MAGNETRON SYSTEM WITH INTERNAL MAGNET

Modern electronics and sensor technics is mainly based on thin-film microstructures, for the production of which the technology of ion sputtering with the help of low-pressure gas magnetron systems is widely used [1]. The peculiarity of this system is that about 80% of the electrical power is spent on heating the target (sputtered material) with magnetron discharge ions and hence strong heating of the entire system, including internal magnets, occurs [2]. This affects the characteristics of the target and magnets and, accordingly, the reproducibility of the sputtering technology, and it is necessary to use intensive water cooling. The choice of the cooling mode is usually carried out experimentally, but it is advisable to supplement it with mathematical modeling, which is what this work is devoted to.

The magnetron for the widely used VUP-5M (Sumy-ELMI) installation is taken as the object of modeling. The simulation was performed using the standard turbulent hydrodynamic k–ε model (k is the turbulence kinetic energy, ε is its rate of dissipation) within the "CFD-Module. User's" of Comsol Multiphysic [3]; this model has proven itself well for solving similar hydrodynamic problems [4]. Fig. 1 shows the calculation scheme of the magnetron and the material of its parts. The target (T) is heated by ions, the heating power is 100 W, and cooled by water through the target holder (H) cover. A water flow (W) is fed into the holder through the outer tube, which is then discharged through the inner tube. The range of specified water flow rates at the inlet is 5…100 mm/sec. The water temperature at the inlet is 10°C.

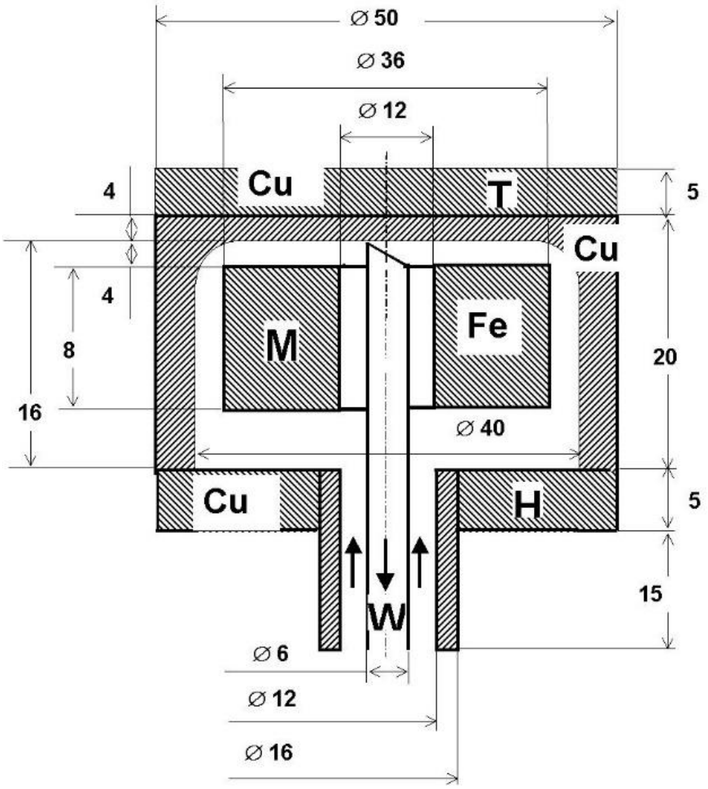
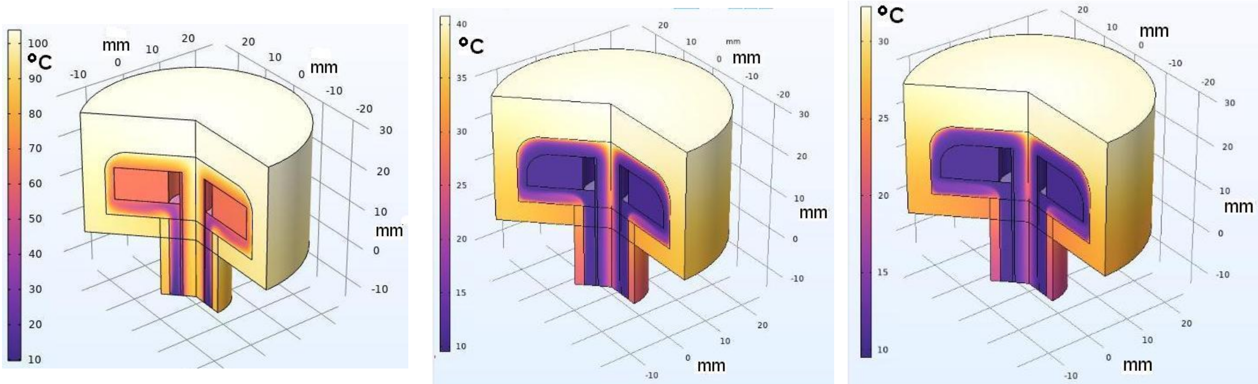


Fig. 1 – Scheme of magnetron: T – target, M – magnet, H – target holder, W – water flow

Figures 2 and 3 show three-dimensional and radial temperature distributions in water and metal parts of the magnetron system, which is especially important for understanding the thermal regime of the target and magnet, the latter being very sensitive to heating.



a) b) c)

Fig. 2 – 3D temperature distributions inside of the magnetron system at target heating power of 100 W. The water flow rates at the inlet: a) is 5 mm/sec, b) is 50 mm/sec, c) is 100 mm/sec

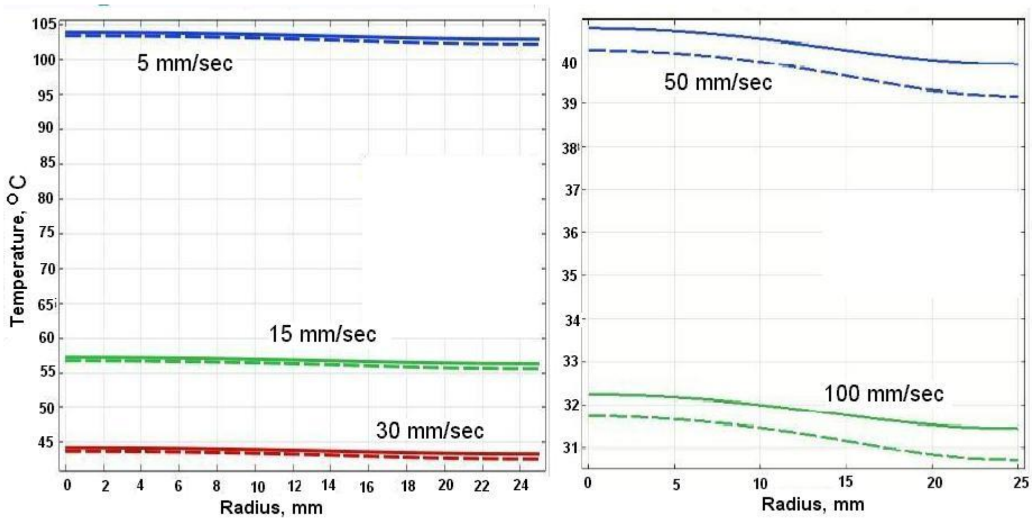


Fig. 3 – Temperature radial distributions over (solid lines) and under (dashed lines) the target at various water flow rates at the inlet. The target heating power is 100 W

The simulation results show that for this magnetron system, a water cooling mode of 10°C and flow rates of 30-50 mm/sec (or 150-250 cm^3/min) at the inlet can be recommended, which will eliminate significant heating of the magnet and the target itself. This conclusion was confirmed by practical work on the VUP-5M facility.

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