Simplified Modeling of Electrical Cabinets

Rade Karamarković[1*], Vladan Karamarković[1], Miljan Marašević[1], Anđela Lazarević[2]
[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo (Serbia)
[2]Faculty of Mechanical Engineering, University of Niš, Niš (Serbia)

Calculating temperature inside an electrical cabinet by the use of e.g. VDI or ASHREA standards for sizing HVAC systems is not adequate because they are intended for: (i) sizing economically optimal HVAC systems, (ii) specific climate, (iii) average environment wind conditions, and (iv) typical building constructions. Electrical cabinets should secure functioning of electrical equipment in extreme weather conditions with as economical design as possible. This paper aims to present a relatively simple procedure to model temperature inside electrical cabinets and to analyze different cabinet constructions depending on the weather conditions. The model principle is based on seven dependent energy balances: on each side of a cabinet and of the airflow through it. Two different wall constructions as well as forced and natural ventilation of a cabinet were analyzed. The goal is to avoid using air conditioning systems in electrical cabinets and to use only if necessary fans or electrical heaters. Insulation of walls is suitable for colder continental climates whereas the use of walls consisting of two metal sheets, with air circulating freely between them, is suitable for hotter continental climates for the equipment with heat dissipation inside cabinets of up to 120 W/m^3.

Keywords: electrical cabinets, heat transfer, natural convection, forced convection, wall construction

1. INTRODUCTION

An electrical enclosure is a cabinet for electrical or electronic equipment to mount switches, knobs, and displays and to prevent electrical shock to equipment users and protect the contents from the environment [1]. For the proper functioning and duration of electrical and electronic equipment inside an outdoor electrical cabinet, it is very important to keep the inside temperature in a required temperature range. This range is limited by minimal and maximal (peak) operating temperatures specified by the producer. For the majority of electrical equipment, these temperatures lies in the range from -10 to 50 °C. Exposing the equipment to higher and lower temperatures than these affects their functioning and lifetime. Depending on the environment conditions and heat dissipation inside an electrical cabinet, the manufacturers require precise answers what kind of wall construction to use, whether to use fans and/or electrical heaters or even air conditioners to maintain the inside temperature in a required temperature range. For these reasons, it is very important to predict the temperature inside an electrical cabinet in a simple and reliable manner. Calculating temperature inside an electrical cabinet by the use of e.g. VDI or ASHREA standards for sizing HVAC systems is not adequate because they are intended for: (i) sizing economically optimal HVAC systems, (ii) specific climate and (iii) average environment wind conditions, and (iv) typical building constructions.

This paper aims to present a relatively simple procedure to model temperature inside electrical cabinets and to analyze different cabinet constructions in summer and winter weather conditions. The intention was to develop as simple as possible model that can be implemented to different constructions of electrical cabinets.

Fig. 1 shows the modeled electrical cabinet, which is intended to store electrical appliances in open space. The cabinet is 1.2 x 1.4 x 0.7 m and has a steady heat gain from electrical appliances of 140 W. The cabinet stands on metal support, with the height 100 mm above the ground. For air intake, this metal support has in total 60 openings, 30 on the front and 30 on the back side, each opening with the dimensions 60 x 3 mm (see Fig. 1 and 2). After passing through these openings, the air enters into the cabinet from the bottom (see Fig. 1 and 2). At the top, there is double metal sheet that forms an "attic" with the variable height from 50 to 70 mm (see Fig. 2).

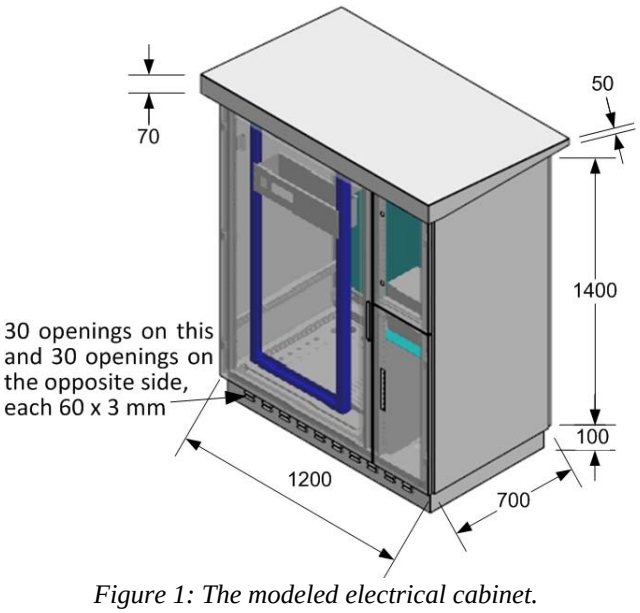

Figure 1: The modeled electrical cabinet.

Two different wall constructions are analyzed. The first one is composed of an outer metal sheet 1.55 mm thick, 20 mm K-FLEX ST insulation, and an inner metal sheet 0.55 mm thick. The proposed insulation has thermal conductivity 0.034 W/mK at -20°C, 0.036 W/mK at 0°C, and 0.040 at 40°C [2], see Fig. 2. The other common insulating materials that could be implemented have the thermal conductivity in the same range, see e.g. [3,4]. The

*Corresponding author: Dositejeva 19, 36000 Kraljevo, Serbia, karamarkovic.r@mfkv.kg.ac.rs