Buletinul Ştiinţific al Universităţii "Politehnica" din Timişoara

Seria ELECTRONICĂ şi TELECOMUNICAŢII
TRANSACTIONS on ELECTRONICS and COMMUNICATIONS

Tom 51(65), Fascicola 1, 2006

A New 450 kW Electric Motor – It Can Withstand Temperature Of 400°C Over A Period Of Two Hours

Robert Pucher[1], Karl Pucher[2]

Abstract – Due to national guideline RVS 9.261, a heat resistance of 400°C over a period of 120 minutes has to be verified for exhaust ventilators in Austria. For this reason a 450 kW electric motor was tested in a chamber in a 400°C environment. The test gave evidence that the motor could be operated under load for approximately 165 minutes without serious problems.
Keywords: Fire, Road Tunnel, Heat Resistance, RVS 9.261.

I. INTRODUCTION

Austria has many long motorway tunnels, for instance the Plabutschtunnel (10 km long), Gleinalmtunnel (8 km), Pfändertunnel (7 km), Tauertunnel (6,4 km), Katschbergtunnel (5,4 km) and others. All these tunnels where planed for two tubes. But the traffic amount 30 years ago was low, so only one tube was built at that time. These tunnels are equipped with a transverse ventilation system. The cross section of such transversely ventilated tunnels consists of three ducts: the tunnel itself (traffic room), the fresh air duct and the exhaust duct. Fresh air and exhaust air duct are separated from the tunnel by the false ceiling and a separating wall is between the fresh air and exhaust duct.

In normal case of operation fresh air is sucked on by the fresh air fan and pressed into the fresh air duct. The fresh air streams via small fresh air openings (0.1 m^2) into the tunnel. The fresh air dilutes the car exhaust gases in the traffic room. This exhaust air was sucked out of the tunnel into the exhaust duct every 12 m via small exhaust hoods (0.5 m^2). This ventilation system was not changed in case of fire. The idea was to suck up the smoke in case of fire to the false ceiling and extracted it over a long part of the exhaust duct. The advantage of this solution was thought to have a smoke free bottom zone on the one hand and a not extreme hot smoke in the exhaust duct because of mingling with fresh air on the other hand. So the temperature on front of the exhaust fans will not be higher than 250°C.

The authors found out it is better to suck off the smoke directly near the fire place into the exhaust duct through large adjustable exhaust dampers (open area ~12 m^2) to avoid smoke propagation in the tunnel. The adjustable smoke dampers are installed every 100m. In normal case of operation all dampers are a little bit open, so that the same amount of exhaust air can be sucked off through each damper. But in case of fire only this damper will be opened fully which is closed by the fire place and all others will be closed. So a concentrated smoke extraction is possible. With smoke extraction there is no mixing with cold fresh air. Therefore the smoke temperature can be very hot when the smoke extraction is near the exhaust fan. So the new requirement in the Austrian guideline (RVS 9.261) is: the electric motor from the exhaust fans must withstand a temperature of 400°C over a period of two hours.

For the exhaust fans of the new Plabutschtunnel (this tube was opened for the traffic in January 2005) we needed electric motors with a power output of 450 kW. At that time no company was able to guarantee that their electric motor can withstand 400°C over a period of two hours. Therefore a acceptance trial had to be made [1-5].

II. EXPERIMENTAL SET UP AND PERFORMANCE

The new 400°C electric motor was manufactured by Flender / Loher AG, Munich, Germany and tested in the research laboratory of the Institute of Building Climate Control and Housing Technology, TU-Munich.

The experimental set up was formed by a test chamber, holding the test motor and a coupled generator to simulate varying loads. The latter was necessary for two reasons:

- The electric motor should be run loaded under 400°C.
- The electric current produced by the generator could be used as a source, thus, the

[1] University of Applied Sciences – Technikum Wien, Höchstädtplatz 5, A-1200 Wien, e-mail: robert.pucher@technikum-wien.at
[2] University of Technology-Graz, pucherk.drtech@gmx.at

external energy demand for the test could be reduced.

In order to simulate the radial forces, which emerge by axial impellers mounted on a shaft-stump, a radial load was installed behind the electric motor.

A constant temperature of 400°C was generated by using gas burners in the test chamber. The test chamber, together with the shaft opening in the wall, was insulated, such that no temperature deviations from the 400°C occurred close to the outer walls. Observations of the electric motor during the 400°C test were possible by means of several special windows of glass.

In order to obtain a constant temperature within the test chamber, it was heated for several hours before the test. During the test the electric motor was operated with the frequency converter at 990 rpm, the same as in the tunnel operation. Due to the decreasing load down to 44 % of the power rating (approximately 220 kW) in the case of fire – because of the lower density of air – the load was also reduced during the test.

III. RESULTS

Figure 1 shows the temperature of the ambient air in the middle of the motor during the test. Except at the beginning of the test, where the temperature was still adjusted, it was kept constant throughout the test at 400°C

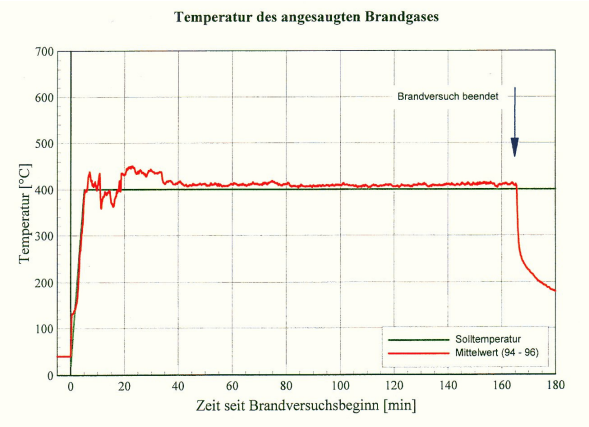

Fig. 1: Measured temperature of air sucked into the test chamber.

Figure 2 depicts the observed temperatures in the motor versus time. In the bid regarding the electric motors and exhaust ventilators, 120 minutes of operation at 400°C was demanded. This requirement could be accomplished. Temporarily temperatures at certain locations exceeded more than 400°C (a detailed explanation has not been found yet).

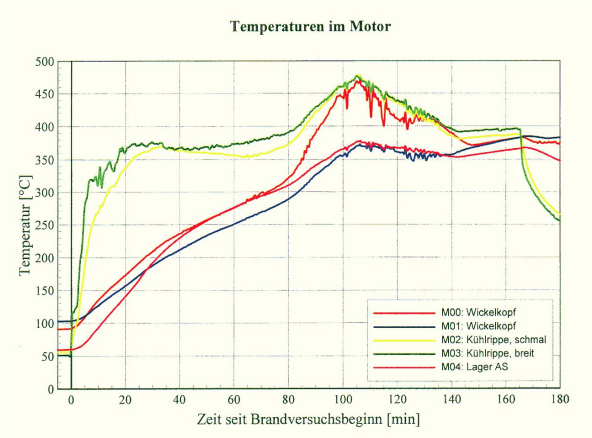

Fig.2. Observed temperature in different parts of the motor during the test

After the motor passed the test (400°C over a period of 120 minutes), it was decided to continue the operation of the motor in the 400°C environment. The temperatures in the motor fell below 400°C after 140 minutes. The motor could be operated for a further 45 minutes without serious problems and finally was switched off but driven with a low frequency for cooling purposes. After about 17 minutes later the motor stopped moving and it could not be used anymore.

REFERENCES

[1] Kommission fuer Sicherheitsmassnahmen in Strassentunneln. Schlussbericht über die Brandversuche im Tunnel Ofenegg, Eigenverlag, 31.05.1965

[2] Pucher K., Pinter R.: Aerodynamische Untersuchungen über die Belueftung von Strassen-tunneln, Österr. Ingenieur-Zeit-schrift, Heft 2, S. 33-37, 1972.

[3] Massachusetts Highway Department and Federal Highway Administration, Memorial Tunnel Fire Ventilation Test Report, November 1995.

[4] Reichstaler G.: Tunnel safety: Water mist fire suppression system in an Austrian road tunnel, 2th symposium Tunnel Safety and Ventilation, P.209-212, 19-21. April 2004

[5] Santner J.: Lessons learned from Fre Tests, 2th symposium Tunnel Safety and Ventilation, P.157-162, 19-21. April 2004.