

## Exhaust gas temperature during startup is hard to determine in catalytic converters

**QUESTION:** To find out if the exhaust gas temperature varies between the different channels in our catalytic converters we take control readings with thin sheathed thermocouples. So as not to disturb the flow upstream of the catalytic converter we insert the thermocouples from the rear. The thermocouples sit freely inside the channels and the distance from the thermocouple tip to the leading edge of the channel is about one channel diameter. During the startup process the exhaust gas heats the catalytic converter up to the operational temperature, which is just over 300 °C. After the startup the exhaust gas temperature is constant or changes very slowly. How good is the measurement result?

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**ANSWER:** When you insert a thermocouple so it sits freely in one of the channels inside the catalytic converter you will measure a temperature that is being affected by both the exhaust gas temperature and that of the channel wall. If the thermocouple tip is lying totally freely in the channel, see A in Figure 1, you will mainly be measuring the gas temperature but the wall temperature also has some effect. Heat is transferred from the gas to the thermocouple and channel wall via forced convection. The thin thermocouple is heated up faster than the channel wall and thereby reaches a slightly higher temperature than the wall. This means that heat is transferred from the thermocouple to the channel wall via radiation. In this case the wall temperature will affect the measurement result.

If the thermocouple tip is in contact with the channel wall, see B in Figure 1, the wall temperature will have a large influence on the measurement value. The heat exchange between the thermocouple and the channel wall occurs via heat conduction. As in the previous case, the heat is transferred from the gas to both the thermocouple and the channel wall via forced convection. The better the contact is between the thermocouple and the wall, the greater the influence of the wall temperature on the measurement result. In this case the influence of radiation on the measurement result is small.

The gas velocity in a catalytic converter is often high and the force from the gas flow will influence the thermocouples' location in the channels. In reality, therefore, we do not know if the thermo-

Questions should be of general interest and be about temperature measurement techniques and/or heat transfer.

**QUESTIONS?**  
**ANSWERS!**

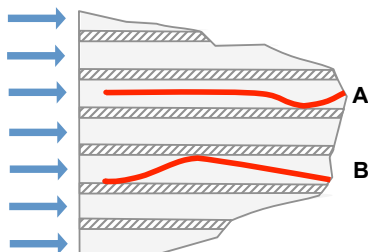


Figure 1. Catalytic converter channels with thin sheathed thermocouples (red) inserted from the rear against the flow direction.

couple tip is in contact with the channel wall or how good any contact is. We must also assume that the contact between the thermocouple and the wall varies during the startup phase. In some cases the thermocouple will vibrate. During startup it is therefore somewhat unclear which temperature is being measured.

During the operational stage the measurement situation is often more favourable. The gas temperature is almost constant when the catalytic converter has achieved its operational temperature of about 300 °C. The wall and thermocouple should now have about the same temperature as the gas that is flowing into the channel in question and we are now measuring a relevant temperature. During the operational stage and while the gas flow is constant it is therefore not so relevant whether or not the thermocouple has contact with the channel or not. In the case of vehicle engines, where the gas flow and gas temperature vary greatly, similar problems unfortunately occur as those during the startup phase.

The thermocouple disrupts the flow inside the channel, which reduces the flow velocity and increases the response time. By fixing the probe tip in the centre of the channel, we reduce the uncertainty during the startup, but the equipment increases the flow resistance and reduces the velocity. Whether or not you should accept the uncertainty during the startup phase must be decided from case to case.

If you have questions or comments, contact  
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