EAN 2018
56th conference on experimental stress analysis

The Design of Final Drive Pinion Temperature Measurements Realized During the Real Passenger Car Operation

MAZAČ Martin[1,a], HERAJN Pavel[2] and MALÝ Miroslav[3,c]

[1,2,3]Technical University of Liberec, Liberec, Czech Republic

[a]martin.mazac@tul.cz, [c]miroslav.maly@tul.cz

Keywords: temperature, measurement, gearbox, final drive, pinion, gearing, contactless method.

Abstract. This short article describes the design of unique experimental passenger car gearbox final drive pinion teeth temperature measurement. The MQ200 (Skoda Auto a.s.) for the measurement was chosen. The special temperature measurement system in article is described. The measurement system combined the contact temperature system using the NTC sensors with contactless optical IR data transfer method. The temperature sensors parameters are contained. The hardware (used electronic parts) of the measurement system are shortly described too. The temperature sensors and other measurement system parts placing possibilities are designed.

Introduction

The temperature is one of the most important parameters for the machine operation condition analyses. The temperature can cause machine parts damage or destruction [f.e. 1]. The temperature is danger for all kinds of used technical materials. The physical material parameters are changed by temperature. For the correct and economical operation of any machine the optimal temperature is necessary. The passenger car gearbox is a typical sample of the temperature depended mechanical system. The temperature changing the mechanical wills and physical parameters of oil. The right oil temperature for the optimal viscosity and lubrication parameters is necessary. The part of the input power to heat is changed during the gearbox operation. The heat cause the temperature changes. The gearbox efficiency is depend on temperature directly. The majority of dissipated mechanical energy during the gears operation to heat is transformed. The temperature of the gears is very useful parameter shows the tooth flank friction processes consequences [f.e. 2]. The gearbox parts temperature measurements is very useful for the construction optimization. The modern simulation methods are not able to summarize all of the ongoing processes yet. The right boundary conditions for the simulation in necessary to know. The heat is not produced by the gearbox during the real passenger car operation only. The heat from the combustion engine by the clutch case to gearbox is conducted. The many processes and surroundings influence the gearbox operational condition. The temperature measurement is possible way how to find the gearbox temperature condition.

The Temperature Measurement System (TMS)

The temperature measurement system [f.e. 3] was developed by Technical University of Liberec employees. The system was tested and the functionality was verified. The system is used for the temperature measurement and data transportation primary. The temperatures are measured on a rotating shaft by the thermistors.

The miniature NTC sensor for the temperature measurement can be used. The TMS for the 2K7MCD1 sensors by Telemeter Electronic GmbH (Fig. 1) is designed. The small thermistor size is suitable for the application- the teeth are only about 5 millimetres high (teeth module about 2,5mm, circular teeth thickness about 2,5mm).

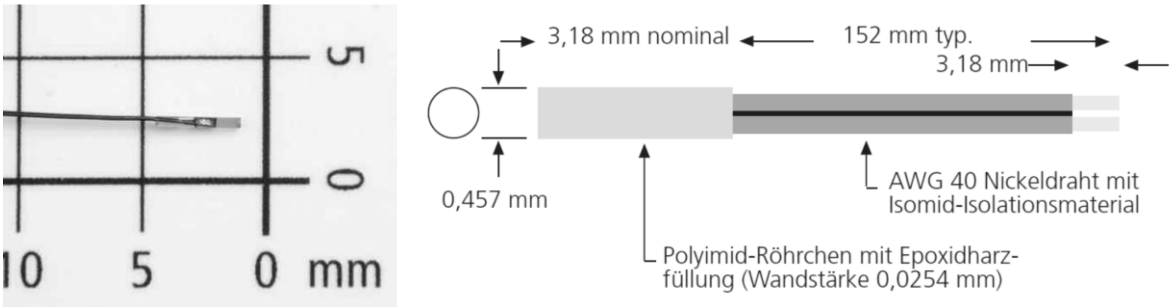
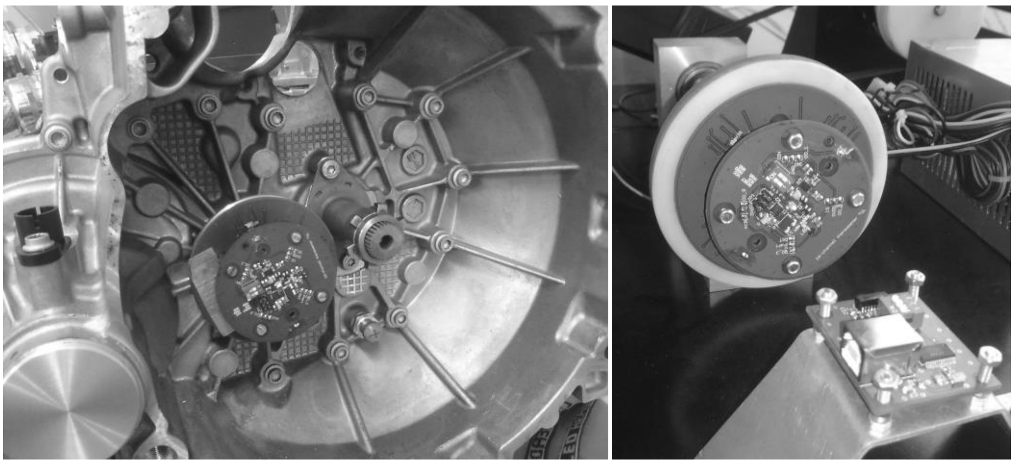


Fig. 1 Thermistor NTC 2K7MCD1

The 2K7MCD1 is one of the smallest temperature sensors. The reaction time of this sensor is 200 ms only during use in a liquid medium. The characteristic resistance of 2K7MCD1 is 2 kΩ in 25 °C/77 °F. The possible error of the measurement in 25 °C/77 °F is ± 0,2 °C. The temperature sensor is good protected by a polyamide tube cover and inner filling of the epoxy resin. Connection of the sensor is realized by the sheathed cable. The connection cable and sensor are supplied by the producer as a set.

The rotating part of the system evaluate the temperatures and coding them for transmission to static parts of the system. The data transmission by the infrared radiation technology is realized. The infrared diode in the rotation axis of a shaft is placed.



a. b.

Fig. 2 a.- TMS application, b.- TMS

The rotation parts of the system are on the metal disc out of a gearbox mounted- the last application in the MQ100 gearbox on the Fig. 2a. The static part of the system with the IR sensor in front of the rotating IR diode is placed. The static part of the system decode the IR signal and processes data. The computer for other data processing by USB to connect is possible. The TMS rotation and static parts are on Fig. 2b. The data processing by the

LabVIEW software is realized. The TMS in the [3] is deeply described. The main electronic function principle as a block scheme is on the Fig. 3.

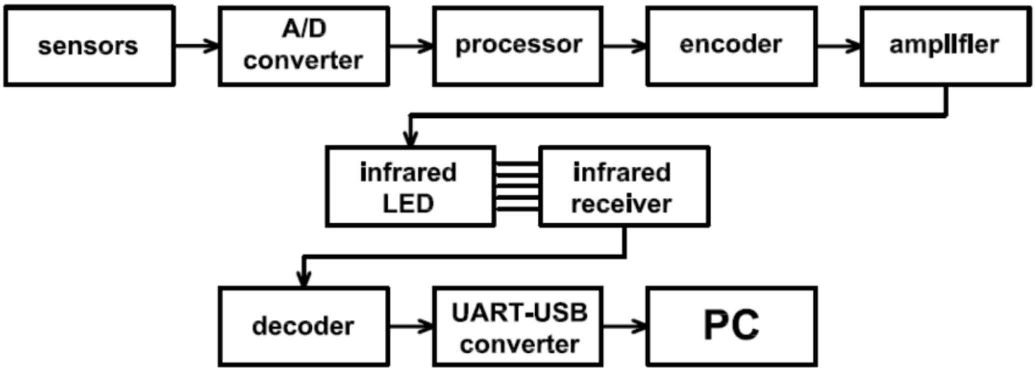


Fig. 3 TMS block scheme

The rotating part of the equipment contents two printed circuit boards with mounted electrical parts. The sensor signal evaluation and a battery are there. For the measurements of the voltage drop on the NTC sensors an A/D converter is used. There are four A/D converters type ADS1248. The ADS1248 is the 7-channel, 24-bits A/D converter with an internal amplifier and two adjustable electric current sources. The three-wire configuration for connection of the temperature sensors is used. Sixteen channels are possible to use.

The rotating part contains the processor (microcontroller) ATTiny2313 8-bit microcontroller with 2K bytes in the system programmable flash. The microcontroller is necessary for operation of the A/D converter and next sending of information to an encoder. The communication between the microcontroller and A/D converters is realized as a SPI with auxiliary signals (START, CS...).

The data from the microcontroller are sending to the encoder by the UART. The encoder transforms data to the right format for the successful sending to the static parts of the equipment. For transforming of the data the TIR1000 encoder is used. The signal transformed by the encoder is amplified by the transistor. The sending of the amplified signal out by the TSMF1020 high speed infrared light emitting diode (with double hetero technology (DH), moulded in a clear SMD package with dome lens) is realized.

The stator part is primarily designed for receiving and treatment of the IR signal from the rotor part. The TFDU4101 infrared receiver module is used here. The MCP2120 microchip for decoding of the signal from the IR receiver on the stator is used. The IR signal is decoded back to the UART.

The output data from the decoder are the UART format and the USART/USB converter for the transformation is used. The FT232RL converter for conversion of the signal is used. The output data from the converter are in the USB format and reading of them by the computer connection is easy and comfortable.

The temperature measurement system to calibrated is possible. The special calibration furnace with the cooper isothermal chamber is used. The optimal thermistor constants are computed by the special algorithm, described in [3].

The Gearbox and Measurement Places

The gearbox MQ200 for the experiment was chosen. The MQ200 is produced by Skoda Auto a.s.. The MQ200 is two shaft manual shifted gearbox. The maximal input load is

200Nm. The MQ200 with a five or six gears (without a reverse) is manufactured. The gearbox with many types of combustion engines is set. The final drive pinion gearing as a critical temperature loading place was chosen.

The termistors to mount near of a tooth flank is possible. The thermistor position with the teeth strength consideration can be chose. The termistors can be put into the holes in the teeth. The electrical discharge machining for the holes manufacturing can be used. The sample of the thermistors position (as MQ100 final drive pinion was used) on the Fig. 4.

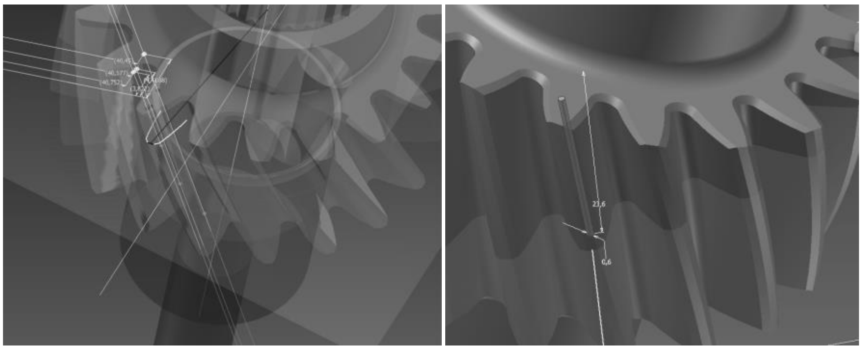


Fig.4 Temperature sensors position sample- CAD model

The Design Description

The shafts of gearbox are axially drilled for the weight reduction. The wires of sensors inside of the shaft can go through. The rotating output of the temperature measurement system out of the gearbox (near of fifth gear) can be placed. The rotating parts can be placed on a metallic disk which is mounted on a steel shaft extending part. The steel shaft extending part can be pressed to the gearbox output shaft. The shaft extending part with the case sealing element can go through.

The modified gearbox in a real car can be mounted and the final drive pinion temperature measurements during the normal operations can be realized. The design of experiment on Fig. 5.

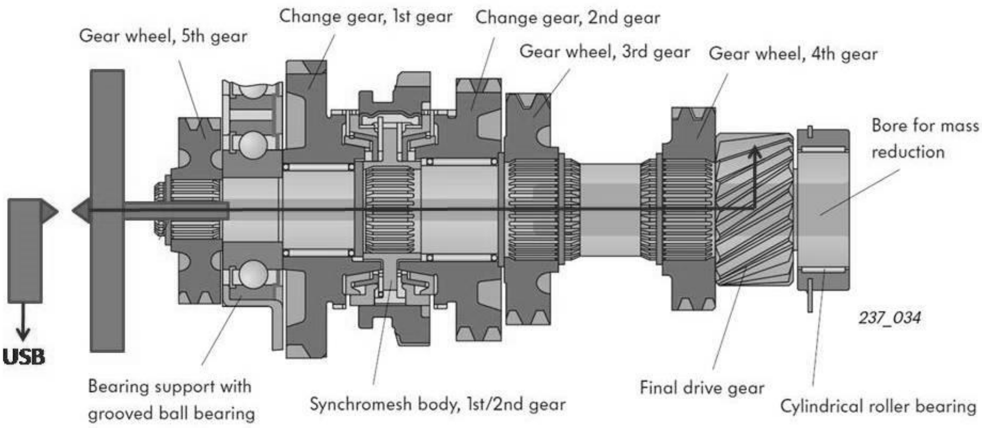


Fig. 5: The TMS application for MQ200 gearbox [4]- modified

The thermistors mounting is possible with the supporting plastic tubes. The supporting tubes to lead by the holes at first is necessary. The thermistors final mounting by the moving of supporting tubes is realized. The thermistors by the epoxy resin in the final places can be fixed- for the heath conduction the using of epoxy resin with the metallic filling is the best. The mounting of thermistors on the Fig. 6 is depict- application in MQ100 final drive pinion.

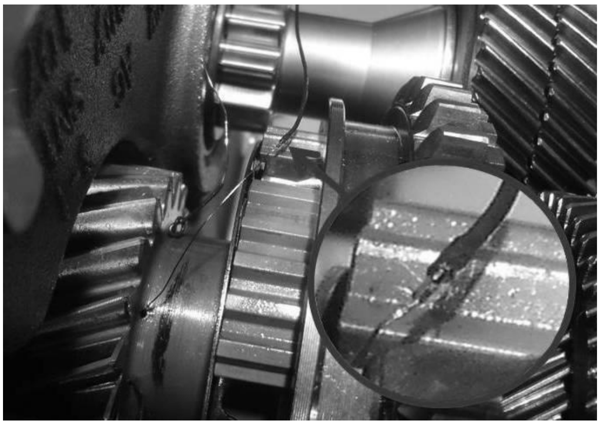


Fig. 6 The thermistor mounting

Conclusions

The short article deals with an unique design of the experimental temperature measurements of the final drive pinion gearing of the MQ 200 passenger car gearbox. The application and important technical parameters of TMS are described. The aim is design of the experimental real gearing operational temperature measurements. The unique experiment can be realized during the common passenger car operation, the parameters as a air flow or heath convection are not ignored. This short study describes the equipment for the teeth temperature measurement developed by TUL, the equipment is suitable and ready for chosen application. The designed experiment is the next important source of the operational parameters for other experiments and optimizing.

Acknowledgment

The results of this Project LO1201 were obtained with co-funding from the Ministry of Education, Youth and Sports as part of targeted support from the “Národní Program Udržitelnosti I” program.

References

[1] B.R. Höhn, K. Michaelis, H.P. Otto, Influence of immersion depth of dip lubricated gears on power loss, bulk temperature and scuffing load carrying capacity, International Journal of Mechanics and Materials in Design [online], 4.2 .2008: 145–156, DOI 10.1007/s10999-007-9045-z.

[2] S.B Rao., D.R. Mcpherson, Gear tooth temperature measurements, Gear Solutions, Pelham - Alabama: Gear Solutions Magazine, August 2009.

[3] M. Mazac, P. Herajn, M. Svoboda, The Gear Tooth Flank Temperature Measurements System. Transactions on Electrical Engineering Vol.4 [online], No.1, p.27-30, ISSN 1805-3386, Praha CTU, 2015.

[4] Volkswagen AG, The Self-study Programme 237- Manual Gearbox 02T- Design and Function, Wolfsburg, Germany, 2001.