The Pinion Teeth Temperatures Measured During the Different Power Levels Operation

M. Mazac and M. Maly

Abstract This paper deals with the temperatures of the automobile gearbox final drive pinion teeth during the performance in constant power levels. The temperatures are measured in the teeth of the pinion of the gearbox MQ100 final drive. The temperatures were measured during the mostly real operation conditions of the gearbox. The special temperature measurement equipment was used. The performance of the gearbox on the special designed testing stand was realized. The measurements were performed during many different power levels. The power levels were defined by torque and RPM. The temperatures measured during same power levels were compared. The main goal of this paper is comparing of the average temperature of the final drive pinion gearing measured during different power levels.

Keywords Gearbox · Temperature · Measurement · Teeth · Pinion · Final drive

1 Introduction

During the mechanical power transformation by gears a part of energy is dissipated. The quantity of dissipated energy can be a transformation quality parameter. Part of the energy is dissipated into heat. The dissipated energy changed the temperature of a gearbox parts. The question is a behavior of a gearbox parts during the higher temperature operation. The second question is the influence of mechanical power parameters on the temperature of gears. The final drive pinion gearing as a point of temperature measurements was chosen.

For the temperature measurements to design and manufacture the special equipment was necessary. The measurements were performed on commercial produced mechanical automobile gearbox MQ100 Škoda Auto a.s.. The temperature

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was measured during several mechanical power levels. The several different torque and RPM were set during measurement, but ever power level was constant.

The main aim of this short paper should be description of experimental determination of final drive pinion gearing temperatures.

2 Equipment for Gearbox Loading

The special equipment for operating and loading was designed and manufactured. The stand is designed for the operating of gearbox in mostly real condition. The common combustion engine for the powering of the stand is used. All of the stand parts are connected by the shafts for the lowest temperature impacts. The gearbox is mounted on an engine block for the similar rigidity as in a car operation. The final loading of gearbox is realized by the electric dynamometer. The gearbox cooling by the electric fan is realized. The stand for testing is deeply described in papers [1, 2]. The stand and his main parts is depict on Fig. 1.

3 Equipment for Temperature Measurements

For the temperature measurements the special equipment was designed and manufactured. The temperature measurement on a rotating shaft is possible with this equipment. The NTC thermistors for the temperature measurement are used. The wires for the connection of NTC sensors are located in the middle hole of the shaft.

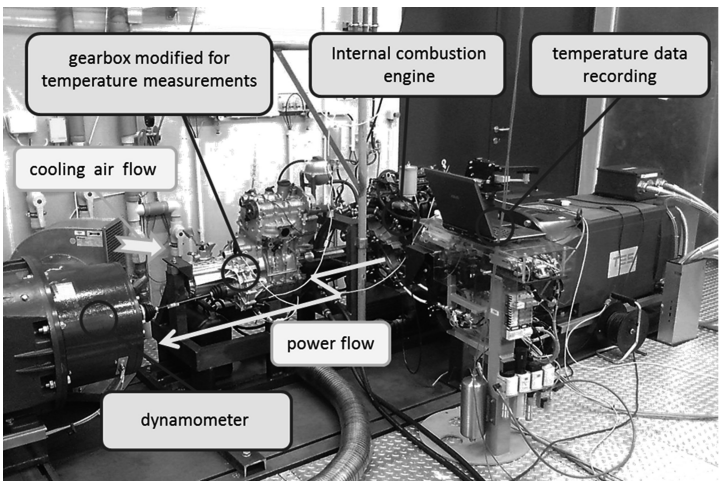

Fig. 1 The laboratory stand for automobile gearbox loading

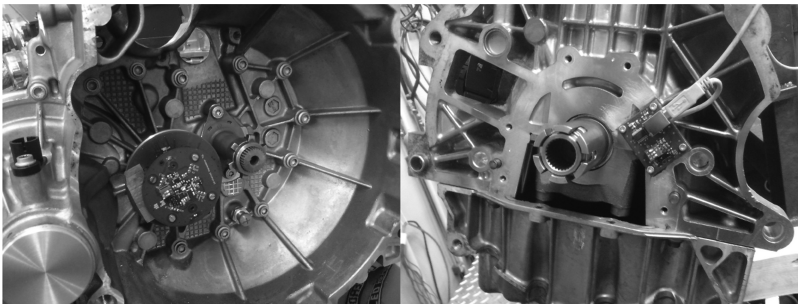

Fig. 2 The equipment for the temperature measurements—rotating parts (*left side*), static parts (*right side*)

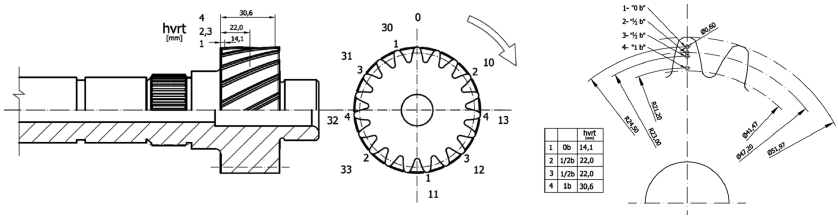

Fig. 3 The NTC sensors position in the teeth of the final drive pinion

The data about temperature are transported by the infrared optic method. The infrared diode is on the rotating part mounted in the axis of rotation. The static parts of equipment for temperature measurements are mounted in front of the infrared diode. The data from the static part are transported by USB to PC and loaded to the data file. For the final processing of the data the special program is used. All this equipment in the [3–5] is fully described. The equipment (rotor and stator) is on Fig. 2.

The temperature sensors were mounted to the teeth of the final drive pinion. The temperature was measured by the eight mounted NTC sensors. The position of every sensor is defined and it is depict on the little Fig. 3. The mounting of temperature sensors is described in [6].

4 Measurements

The measurements were realized in **9 power levels**. Every power level is defined by torque and RPM. The difference between torque and RPM was due to the shifted gear—the temperatures were measured during the operation in all five possible shifted gears. The table of the power levels is on Fig. 4.

P [kW]	1st Gear		2nd Gear		3th Gear		4th Gear		5th Gear	
	Torque [Nm]	RPM [min^{-1}]	Torque [Nm]	RPM [min^{-1}]	Torque [Nm]	RPM [min^{-1}]	Torque [Nm]	RPM [min^{-1}]	Torque [Nm]	RPM [min^{-1}]
7,46	337,0	211,4	180,8	394,1	117,5	606,4	88,7	803,0	73,7	967,3
9,07	337,0	257,3	180,8	479,5	117,5	737,8	88,7	977,0	73,7	1176,9
10,69	337,0	303,1	180,8	564,9	117,5	869,1	88,7	1151,0	73,7	1386,5
14,92	673,9	211,4	361,6	394,1	235,0	606,4	177,4	803,0	147,3	967,3
18,15	673,9	257,3	361,6	479,5	235,0	737,8	177,4	977,0	147,3	1176,9
21,38	673,9	303,1	361,6	564,9	235,0	869,1	177,4	1151,0	147,3	1386,5
22,37	1010,9	211,4	542,4	394,1	352,5	606,4	266,2	803,0	221,0	967,3
27,22	1010,9	257,3	542,4	479,5	352,5	737,8	266,2	977,0	221,0	1176,9
32,07	1010,9	303,1	542,4	564,9	352,5	869,1	266,2	1151,0	221,0	1386,5

Fig. 4 The table of the power levels with their parameters (Torque, RPM)

The **15 min** measurement cycles was realized in all power levels. The values of temperatures from the last **1 min** of the cycle for the final evaluation were used. Only **average value** from the temperatures measured by the seven sensors was used.

The gearbox was cooled by the constant air flow from the electric fan. The temperature of air in the room with the stand was regulated and it was **20 °C (68 °F)**.

5 Temperatures of the Pinion Gearing

The final measured data were evaluated by the special software and the final charts were created. All of the final charts are set for one constant power level. The final charts contain the RPM, torque and average temperature values. For all five possible set gears the measurements are realized. The parameters (RPM, torque, temperature) of all gears on the final charts are depicted. The charts for the lowest and the highest power levels are on Fig. 5.

The ranges of the average gearing temperatures are on Fig. 6. The border temperatures of the depicted gearing temperatures ranges are beginning and final temperatures of 15 min measurement cycles.

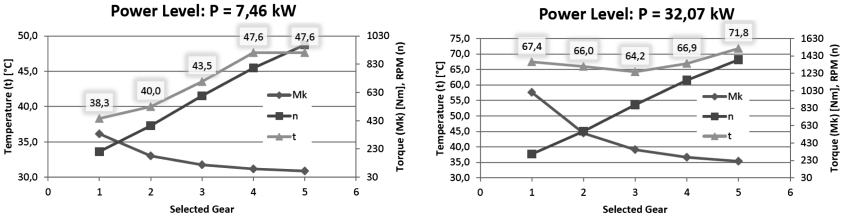

Fig. 5 The samples of the final charts of the average gearing temperatures measured during different power levels, minimal and maximal power level charts are depict

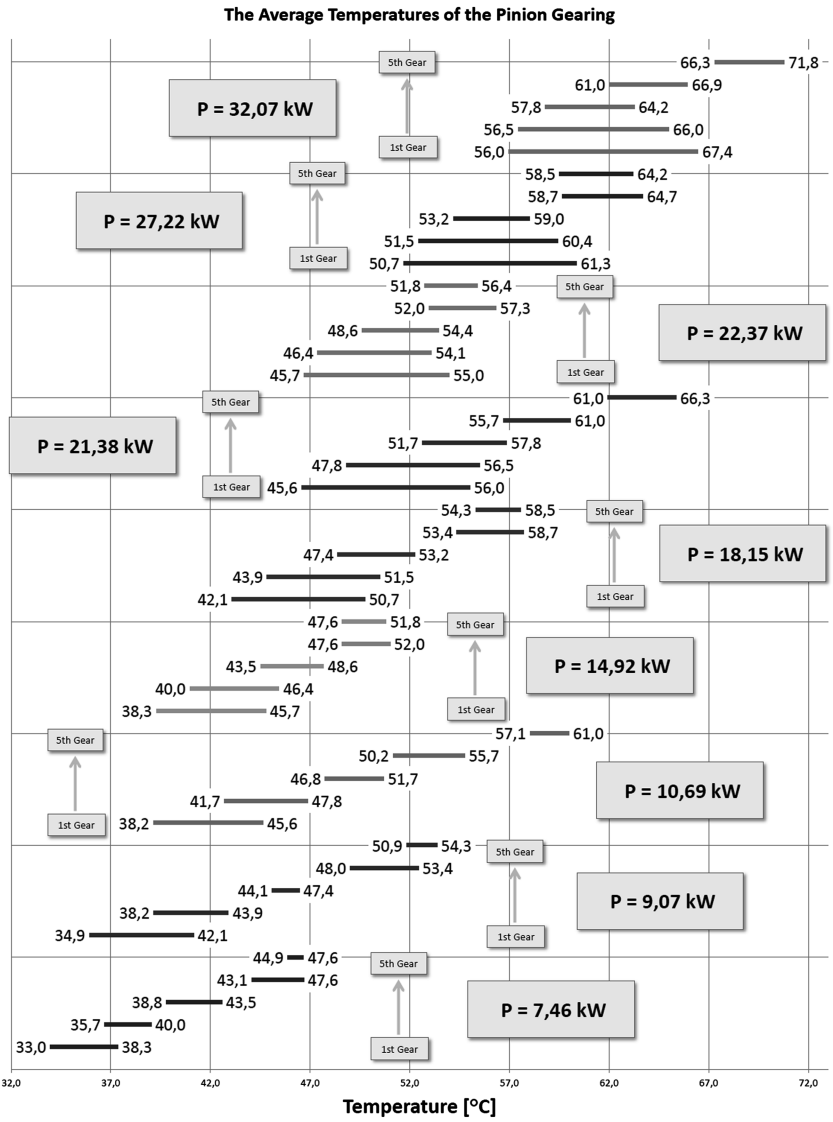

Fig. 6 The chart of the final drive pinion gearing average temperature ranges measured during the power levels

6 Conclusions

This short paper describes the temperature measurements realized in the final drive pinion gearing. The measurements were possible to realize due to special equipment for gearbox operating and for temperature measurements. The temperatures were

measured in several places of the pinion teeth. The measurements were realized during a few power levels operation. The beginning temperatures and the final temperatures measured during the 15 min cycle are summarized in the chart. The temperatures measured during the described test regimes are not danger for the condition of oil. The described measurement methodology is useful for other future testing.

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