

# Effect of Lubrication on the Quantity of Heat Emission of two Spur Gears in Meshing

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**Abstract**—This paper investigates the effects of lubrication on the quantity of heat emission of two spur gear. System with and without lubrication effected on the quantity of heat induced on the gear box (oil - bearings – gears). Both of lubrication and speed of motor are affected on the performance of gears. Research investigated the lubrication on the system with and without loading as well as the wear of gears and bearing's conditions. Gear box investigated includes the motor, pump, two spur gears, two shafts; speed change used pulleys and belts. Load used equal one weight ones of gear. Lubrication mechanism used jet system (upper and lower jet). Gear box we used system of jet lubrication is perpendicular direction of the contact line between two teeth. Results appeared in this work that the lubrication is the vital parameter which is affected on the performance and durability of gears and bearings. In macroscopic observation, we noted that damage of bearings happened during the absence of lubrication as well as abrasive of wear of teeth. Higher speed of motor without lubrication increased the noise, but in the presence of lubrication was decreased.

**Keywords**—Lubrication, jet, laser gun, spur gear, temperature

## I. INTRODUCTION

**D**UE the importance of effects of environment pollution, this paper investigated the quantity of heat emission of two spur gears in mesh. High speed affected on the quantity of heat and wear of gears under conditions with and without lubrication [2]. Types and lubricant selection effect on the quantity of heat emission [3]. In fact we were using different parameters which are effect on the temperature of gears especially on contact line. Wear is the gear failure which is affected on the performance on the gears. Micro pitting, pitting, and abrasive wear. Bearings failure results from speed up the system. Load has a more significant effect on the tooth temperature in comparison with the rotational speed [1]. Failure due to high tooth temperatures can be prevented with the knowledge of temperature distribution in gear teeth under operation [3]. Heavy wear caused by operating the gears without any lubrication or under conditions of heavy overload or severe misalignment of contacting tooth surfaces [4]. Jet placement had a significant effect on the gear bulk temperatures [5]. Power losses were calculated from temperature measurements of lubricating oil, gears, gear box, and oil flow rate [6]. Highest temperature point occurred at high speed in the middle of contact line of spur gear [2, 7]. Lubrication affected on the performance of high speed spur gears [8]. Non lubrication and lubrication were generated heat emission [9].

## II. EXPERIMENTATION

This paper investigates the effect of lubrication of gears on heat emission wear gears during meshing. The test is prepared in two phase, first phase with loading which equal to 13.5 N weight of one gear as in Fig. 1 (right) to show the difference of quantity of heat emission in comparison to unloading system. Laser Gun temperature (Infrared Thermometers Cason -32°C – 380 °c) was used to measure the temperature as shown in Fig.1 (left) as different from previous work as in Fig.2 (left) [1]. Two gears geometry pitch diameter is 12.4 cm and the face width is 13 mm and gear material is steel 0.3 % normalized carbon, and Laser Gun Temperature to measure temperature at contact line of two gears during mesh.

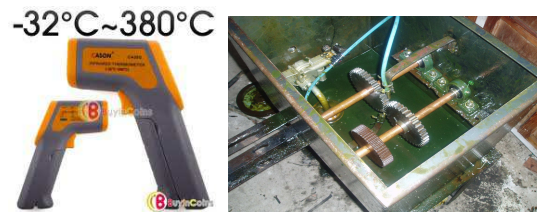


Fig. 1 Illustrates Laser Gun Temperature (left) test rig with load (right)

Lubrication is construct with two jets (up – down) which is orthogonal at contact line as shown Fig. 2 (right).



Fig. 2 Shows, previous test (left) and up jet lubrication (right).

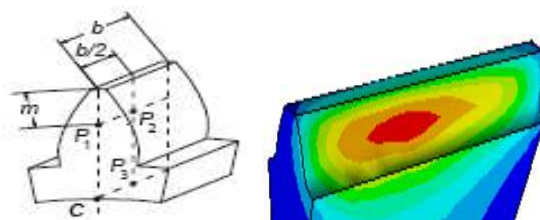


Fig. 3 Shows P2 at middle of contact line which measure temperature along (left), temperature is distributing over the face width (right), which colors indicate the red is highest temperature

A Figure 3 shows the position of points was taken to compute the quantity of heat emission during one an hour, measurements was taken each five minutes. System of

lubrication was held in the case of using jet lubrication, up and down jet are perpendicular of contact line of two teeth, one point of reading at the middle of contact line and four point two in the left of middle and another point at the right side of middle point.

### III. RESULTS AND DISCUSSION

In the process of machining the gear box, we measured the ambient circumstance of gear box, by measuring room and oil temperature before working. We let the test rig to work two hours [2] and start to take measurements over the contact line.

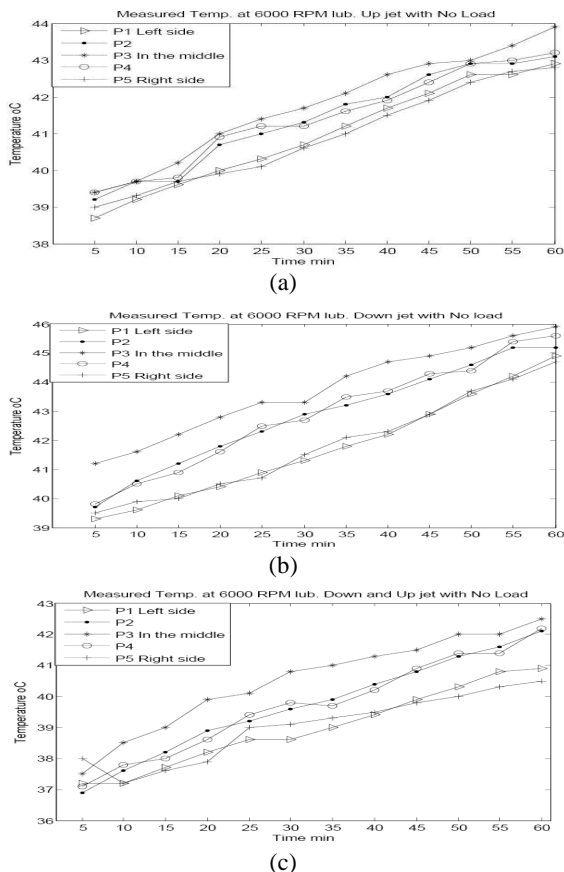


Fig. 4 Illustrates relation time (min) and Temperature (°C) of two spur gears in contact with lubrication at 6000 RPM, up jet only (a), down jet only (b) and up and down jet (c).

In Figure 4 using test rig without loading up jet lubrication only (A), down jet lubrication only (B) and up – down jet lubrication (C) in the time with at 6000 revolutions. We noted little abrasive wear of gears under using of lubrication. In the system of non-lubrication, the temperature decreased in the system with loading at 6000 RPM (A) with respect to the system with loading at 9000 RPM (B) about three and half °C as shown in Fig. 5.

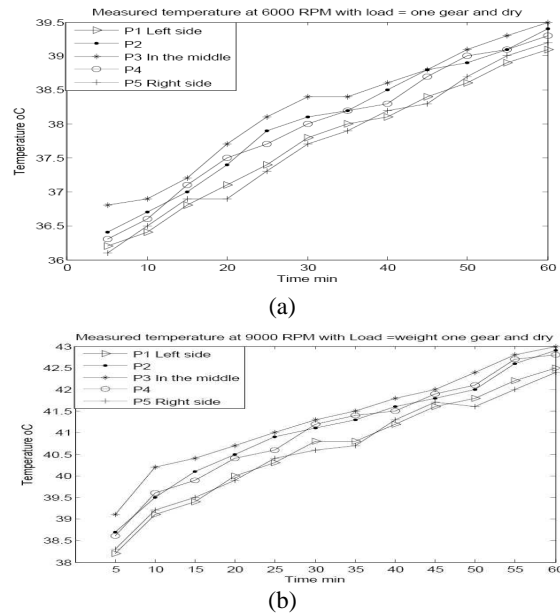


Fig. 5 Illustrates relation time (min) and Temperature (°C) of two spur gears in contact without lubrication and with loading, at 6000 RPM (a) and at 9000 RPM (b)

Figure 6 shows that quantity of heat emission is less than for using up – down jet regards to use only one of both jet at up or down under the condition of 3000 RPM and no loading except in the first two points for the case of using only up jet.

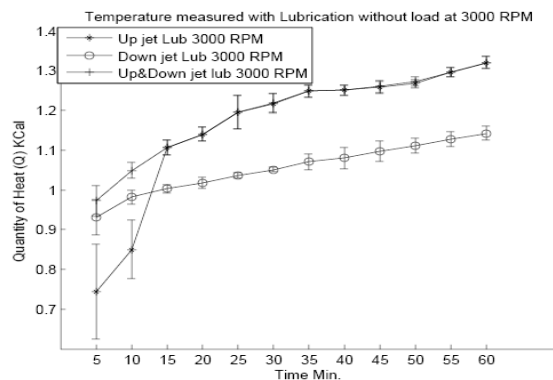


Fig. 6 Shows, the relation between the quantity of heat emission and Time at 3000 RPM

Lubrication using the system of up – down jet lubrication without loading. The quantity of heat emission is less than for using up – down jet regards to use only one of both jet at up or down under the condition of 6000 RPM and no loading as shown in figure 7.

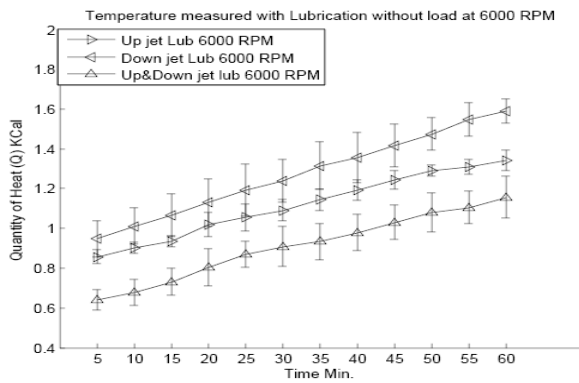


Fig. 7 Shows, the relation between the quantity of heat emission and time at 6000 RPM

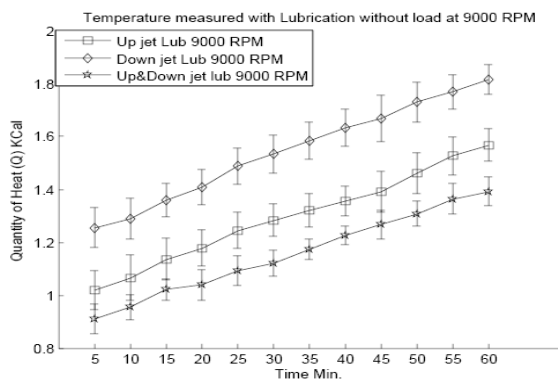


Fig. 8 Shows, the relation between the quantity of heat emission and time at 9000 RPM

Figure 8 shows quantity of heat emission during one an hour, measurements was taken each five minutes. System of lubrication was held in the case of using jet lubrication, up and down jet are perpendicular of contact line of two teeth, one point of reading at the middle of contact line and four point two in the left of middle and another point at the right side of middle point. This Figure shows that quantity of heat emission is less than for using up – down jet regards to use only one of both jet at up or down under the condition of 9000 RPM and no loading.

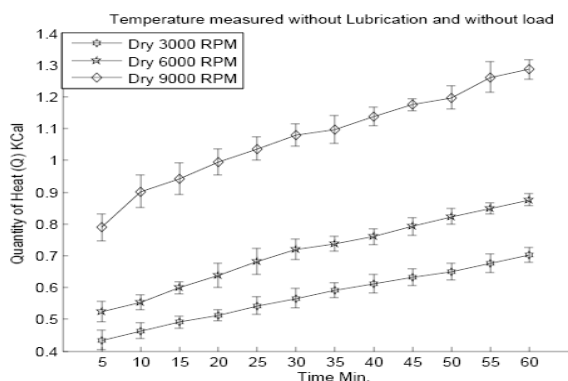


Fig. 9 Shows, the relation between the quantity of heat emission and time without lubrication and loading at 3000, 6000 and 9000 RPM

In higher speed without lubrication the quantity of heat is increased as shown in Fig. 9.

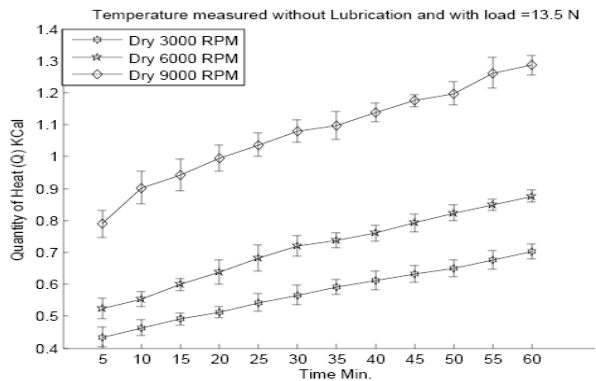


Fig. 10 Shows, the relation between the quantity of heat emission and time without lubrication and with loading = 13.5 N at 3000, 6000 and 9000 RPM

In Figure 10, the quantity of heat increased 38 % for 9000RPM with respect to the 6000 RPM as well as increased 25 % for 6000 RPM with respect to 3000 RPM.

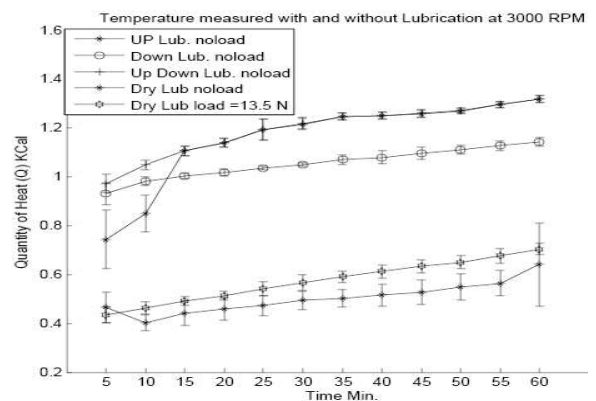


Fig. 11 Shows, the relation between the quantity of heat emission and time at 3000 RPM

Quantity of heat increased in case of presence of lubrication with respect to the absence of lubrication at 3000 RPM as shown in Fig. 11 as well as in Fig. 12 and Fig. 13.

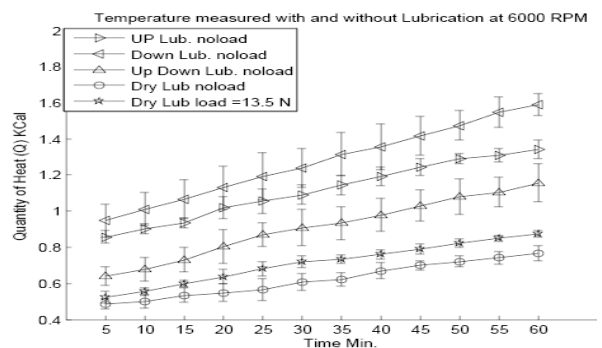


Fig. 12 Shows, the relation between the quantity of heat emission and time at 6000 RPM

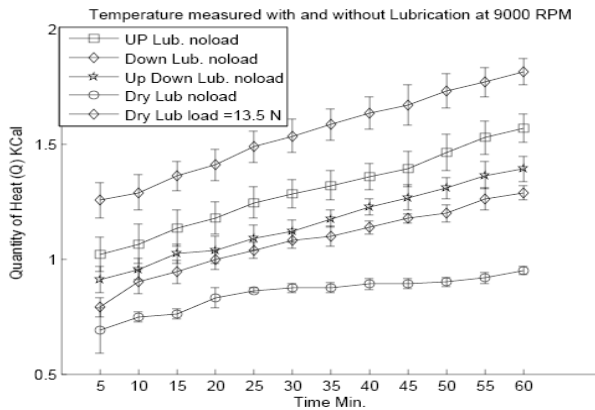


Fig. 13 Shows, the relation between the quantity of heat emission and time at 9000 RPM

#### IV. CONCLUSION

In this research, the lubrication is the vital parameter to prevent the wear and failure of bearings. In the absence of lubrication, we have noise and micro pitting wear of gear in the lower speed but abrasive wear, damages of bearing are crucially at a higher speeds of the test rig. In the presence of lubrication, we have been increasing in quantity of heat in the higher speed regardless of lower speed. In artifact, the quantity of heat dissipated increased with higher speeds. A regard to the loading and unloading system without lubrication, the quantity of heat increased for loading increased of loading in comparison to unloading system. In using lubrication the quantity of heat increased with respect to the system without lubrication. In fact, this phenomenon is related to friction induced in the presence of lubrication. Results showed that the quantity of heat decreased in the case of up – down jet than the case only up jet or down jet only.

#### REFERENCES

- [1] A. Mihailidis, V. Mihailidis, K. Panagiotidis, and N. Drivakos: Prediction of the fiction coefficient of spur gear pairs, VDI-Berichte Nr. 1665, 2002.
- [2] S. A. M. Elshourbagy: Investigated the effect of higher speeds on bearings and spur gears, Zurich, ICAMAME, 2012
- [3] T.T. Petry-Johnson, A. Kahraman, N.E. Anderson and D.R. Chase: Experimental Investigation of Spur Gear Efficiency, International Design Engineering Technical Conferences & Computers and Information in Engineering Conference IDETC/CIE, Las Vegas, Nevada, USA, 2007.
- [4] Long, H., Lord, A. A., Gethin, D. T. and Roylance, B. J.: Operating temperatures of oil-lubricated medium-speed gears: numerical models and experimental results.', Proceedings of the I MECH E part G: journal of aerospace engineering., 217 (2). pp. 87-106, 2003.
- [5] P. R. Thyla and R. Rudramoorthy: Investigations On Gear Tooth Surface And Bulk Temperatures Using ANSYS, PSG College of Technology, Coimbatore, INDIA, Conf. 2004.
- [6] J. L. Radovich: Theory and Practice of Tribology, Volume II: Theory and Design, CRC Handbook of Lubrication, Richard E. Booser, Pages 539-564, CRC Press 1988.
- [7] Robert F. Handschuh; Effect of Lubricant Jet Location on Spiral Bevel Gear Operating Temperatures, technical report, 1993.
- [8] Hachiro Mizutani, Yuuichi Isikawa and Dennis P. Townsend: Effects of Lubrication on the Performance of High Speed Spur Gears, Fifth International Power Transmission and Gearing Conference, sponsored by ASME, Chicago, Illinois, 1989.
- [9] S. A. M. Elshourbagy, "Study the temperature is generated during meshing two spur gears", P2003, ICPSE, 2011.
- [10] A. Flodin, "Wear of spur and helical gears", Doctoral Thesis, Department of Machine Design Royal Institute of Technology S-100 44 Stockholm, Sweden, 2000.