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Adam Barylski[1]

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PROBLEMS ASSOCIATED WITH THE HEATING UP OF ACTUATING SYSTEM OF A SINGLE-DISC LAPPING MACHINE FOR FLAT SURFACES

PROBLEMATYKA NAGRZEWANIA SIĘ ELEMENTÓW UKŁADU WYKONAWCZEGO DOCIERARKI JEDNOTARCZOWEJ DO PŁASZCZYZN

Abstract

The paper presents the results of the examination of the heating up of the basic elements of the actuating system of a single-disc lapping machine with standard kinematics, intended for machining flat surfaces. The increase of the temperature of the drive assembly, rollers and separator guide ring, as well as the lapping disc and machined elements were analysed. Heating up of the machining system was examined during the machining of a cast iron tool and flat surface lapping. Lapping is one of the methods of abrasive machining applied during the individual fitting of elements in assembly or when a technological compensator is used. The increase of temperature in the machining system influences, among others, the dimensional accuracy of lapped metal elements.

Keywords: mechanical engineering, assembly technologies, lapping, temperature, analysis

Streszczenie

Przedstawiono wyniki badań nagrzewania się podstawowych elementów układu wykonawczego docierarki jednotarczowej o standardowej kinematyce do obróbki powierzchni płaskich. Analizowano przyrost temperatury zespołu napędowego, rolek i pierścieni prowadzących separatory oraz tarczy docierającej i obrabianych elementów. Badano nagrzewanie się układu obróbkowego podczas wyrównywania żeliwnego narzędzia i docierania powierzchni płaskich. Docieranie jest jedną z metod obróbki ściernej stosowaną podczas indywidualnego dopasowywania elementów w montażu lub przy wykorzystaniu kompensatora technologicznego. Przyrost temperatury w układzie obróbkowym ma między innymi wpływ na dokładność wymiarową docieranych elementów metalowych.

Słowa kluczowe: inżynieria mechaniczna, technologie montażowe, docieranie, temperatura, analiza

1. Introduction

One of machining methods applied during the assembly of components is lapping with a loose abrasive [1]. This technology has been applied during individual fitting of elements of a construction or during assembly of a technological compensator. In the case of a unilateral machining of flat surfaces, it is conducted on a single-disc lapping machines where standard actuating system consists of a ring system [2]. Guiding rings, from one to four, with machined elements placed in separators are set in motion directly through the revolving lapping disc. The rings are also applied to dress the surface of an active lapping disc [2].

Current production and examinations include lapping machines featuring water cooling of the metal lapping disc [3, 4], as well as machines without forced cooling. The second solution eliminates problems with possible corrosion of the lapping machine elements. The main source of heat during lapping of flat surfaces, apart from the very process of grinding by abrasive grains (interaction of the abrasive with machined material and the material of the lapping disc) is the worm gear – acting as a drive system of the machine.

Changing temperature of the elements of a lapping system significantly influences the yielded dimensional accuracy of lapped elements. Knowledge of the temperature increase pattern (and consequently the

[1] Professor Adam Barylski, PhD, DSc, ME – Gdansk University of Technology, Faculty of Mechanical Engineering and Ship Technology, G. Narutowicza 11/12, 80-233 Gdańsk, abarylsk@pg.edu.pl, ORCID: 0000-0003-1672-8445.

expansion of the lapped metal elements) can facilitate the selection of place and time of the control of linear dimensions, as well as determination of the machining dimension in the technological documentation of assembly.

2. Test stand

The examinations of the heating up of lapping machine elements [5] were conducted using a single-disc lapping machine Abralap 380 and thermal vision camera Optris PI200 (fig. 1).

An increase of the temperature of the actuating system and driving assembly of the lapping machine was analysed (fig. 2). During the examination, abrasive paste based on aluminium oxide (500 Grit Aluminium Oxide) produced by States Products Co was applied.

Fig. 1. General view of the test stand: 1 - single-disc lapping machine, 2 - thermal vision camera, 3 - camera stand, 4 - guiding ring rotational speed sensor, 5, 6 - device recording the rotational speed of the lapping disc and guiding rings, 7 - laptop computer

a) b) c)

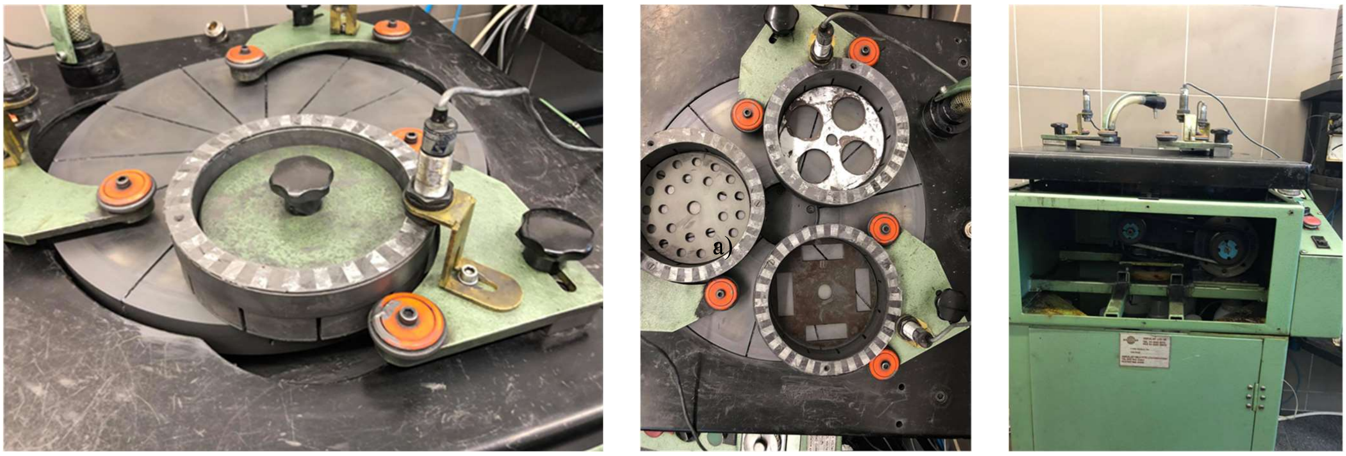


Fig. 2. View of: a) guiding ring containing machined elements and their ballast loads b) separators placed in the three guiding rings, c) uncovered drive system of Abralap 380 lapping machine

3. Results of the examinations

3.1. Heating of the drive assembly of the lapping machine in idle mode

Figures 3-6 show the results of the measurements of average temperature of the elements of the lapping machine drive assembly, both before initiating the examinations and, e.g. after 20 minutes of operation in the idle mode and for two values of the rotational speed of the lapping disc n_t. The distance between the thermal vision camera and the analysed drive assembly was 1 m.

In analysed situation presented in fig. 3b, V-belt heated up to, on average, 48ºC, driving pulley to 48.6ºC, and driven pulley to 49ºC. The average temperature of the electric motor was 39.8ºC and of the worm gear (driving the lapping disc) - 45ºC. After increasing the rotational speed of the lapping disc to $n_t = 80\ min^{-1}$ the temperature if the belt drive increased by 1.95ºC/min (fig. 4). In the examined system, the temperature of the V-belt after 20 minutes of operation was 64ºC, the temperature of the driving pulley was 64.4ºC, the temperature of the driven pulley reached 65ºC, electric motor temperature was 52ºC, and the temperature of the worm drive was 59ºC.

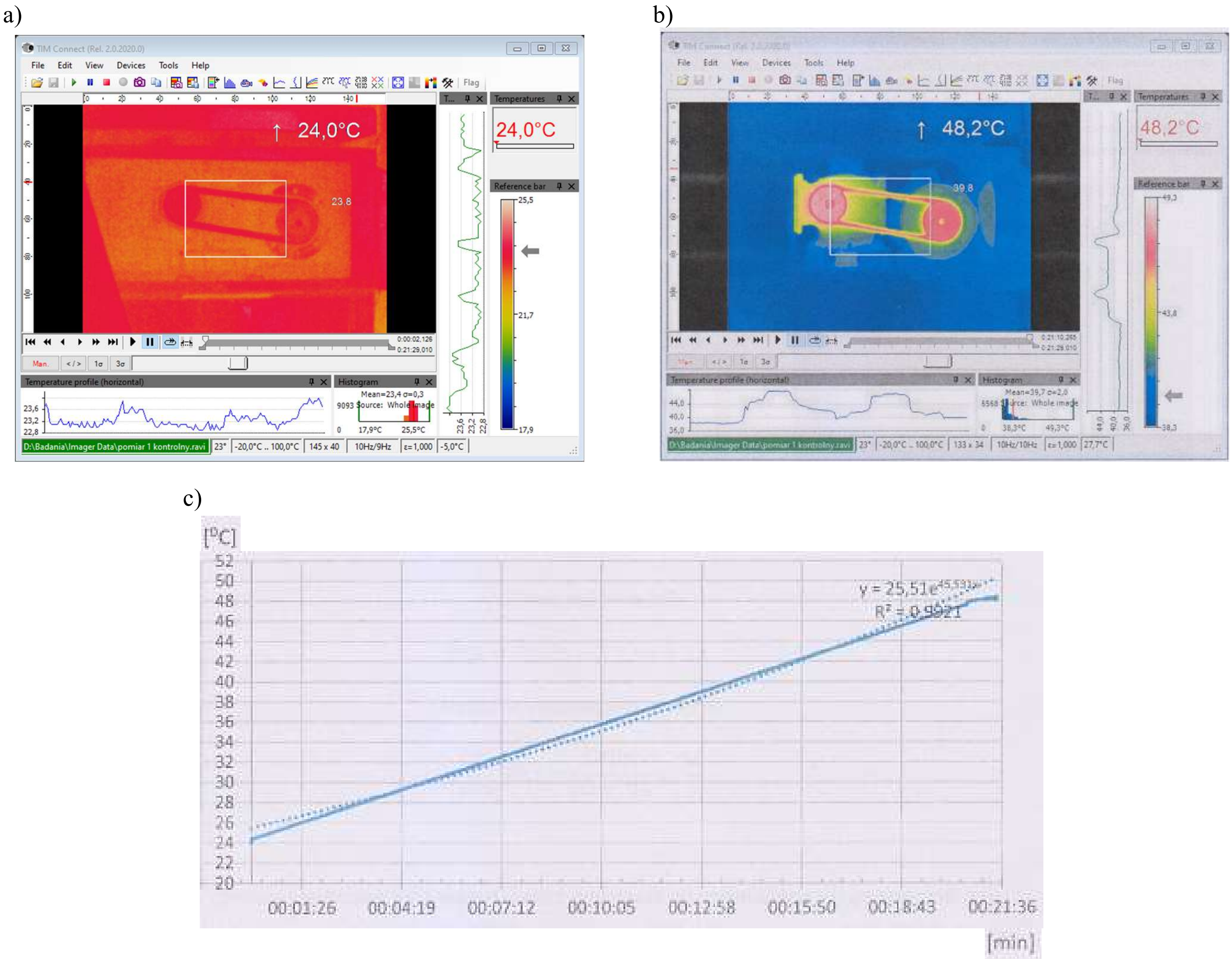


Fig. 3. Results of the measurements of the temperature of the lapping machine drive assembly: a) initial moment, b) after 20 minutes of operation without placing the guiding rings on the lapping disc (n_t = 40 min^{-1}), c) the graphic representation of the increase of the temperature of the belt drive in time (on average, 1.2ºC/min)

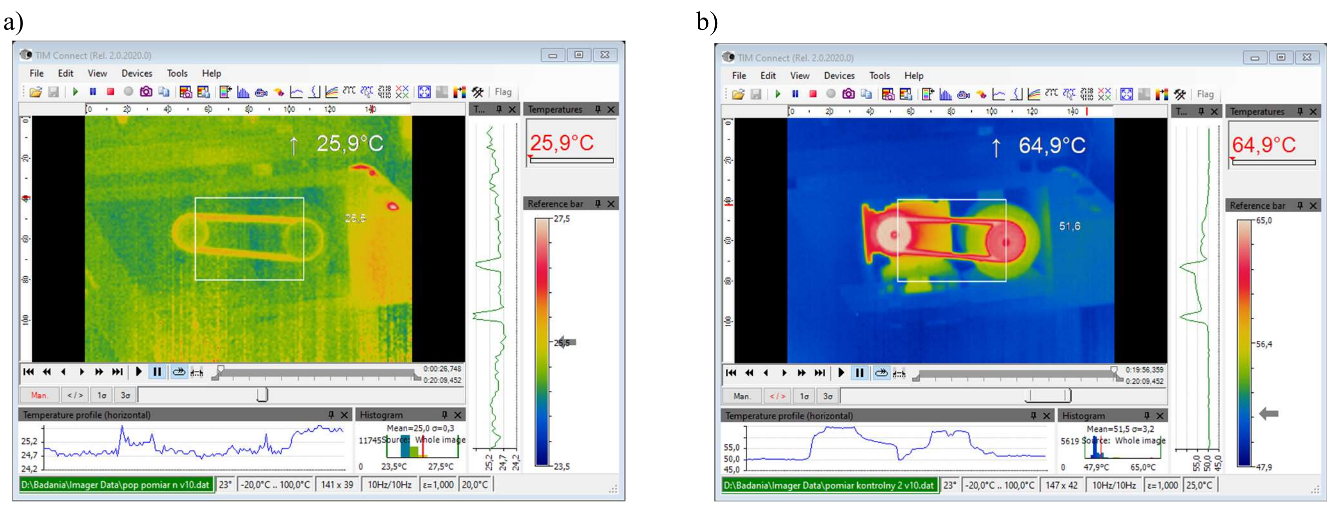
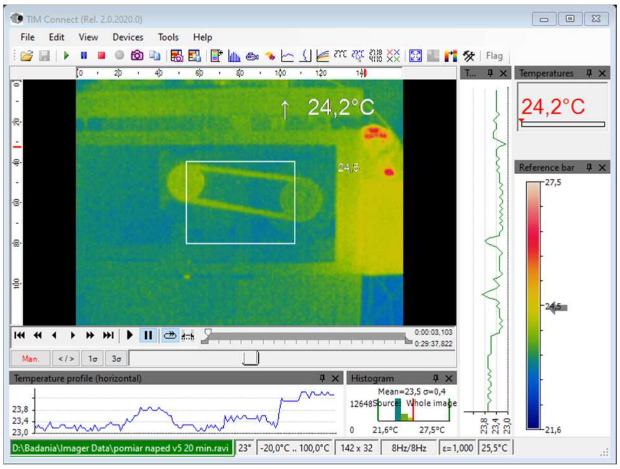


Fig. 4. Results of the measurements of the temperature of the drive system of the lapping machine: a) in the initial moment, b) after 20 minutes, without guiding rings placed on the lapping disc (n_t = 80 min^{-1})

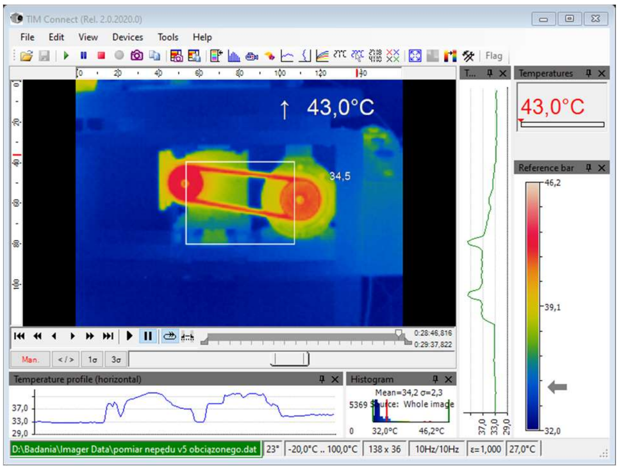
3.2. Heating up of the drive system and lapping disc during dressing

During dressing of the lapping disc (with guiding rings) a dosage of abrasive was refilled manually (using an appropriate brush). Due to a 7-minute break in the operation of the lapping disc (between 12th and 18th minute of dressing) further increase of the temperature of the drive system elements was less intensive (fig. 5). The maximum temperature of the driven pulley was 44ºC, of the V-belt 43ºC, of the driving pulley 42.5ºC, of the electric motor and of worm gear 36ºC. When rotational speed of the lapping disc increased to 80 min^{-1}, the increase of the V-belt temperature was 1.65ºC/min (fig. 6), while the average temperature of the driving pulley increased to 58ºC, the temperature of the electric motor increased to 49ºC and the temperature of the worm gear reached 51ºC (the break in operation of the lapping disc for refilling the abrasive was 5.5 minutes).

a)



b)



c)

Fig. 5. Results of the measurements of the temperature of the lapping machine drive system: a) in the initial moment, b) after 20 min of dressing the lapping disc with guiding rings (n_t = 40 min^{-1}) and manual refilling of the abrasive after 12 min, c) graph showing the increase of the temperature of the belt drive in time (on average by 0,94ºC/min)

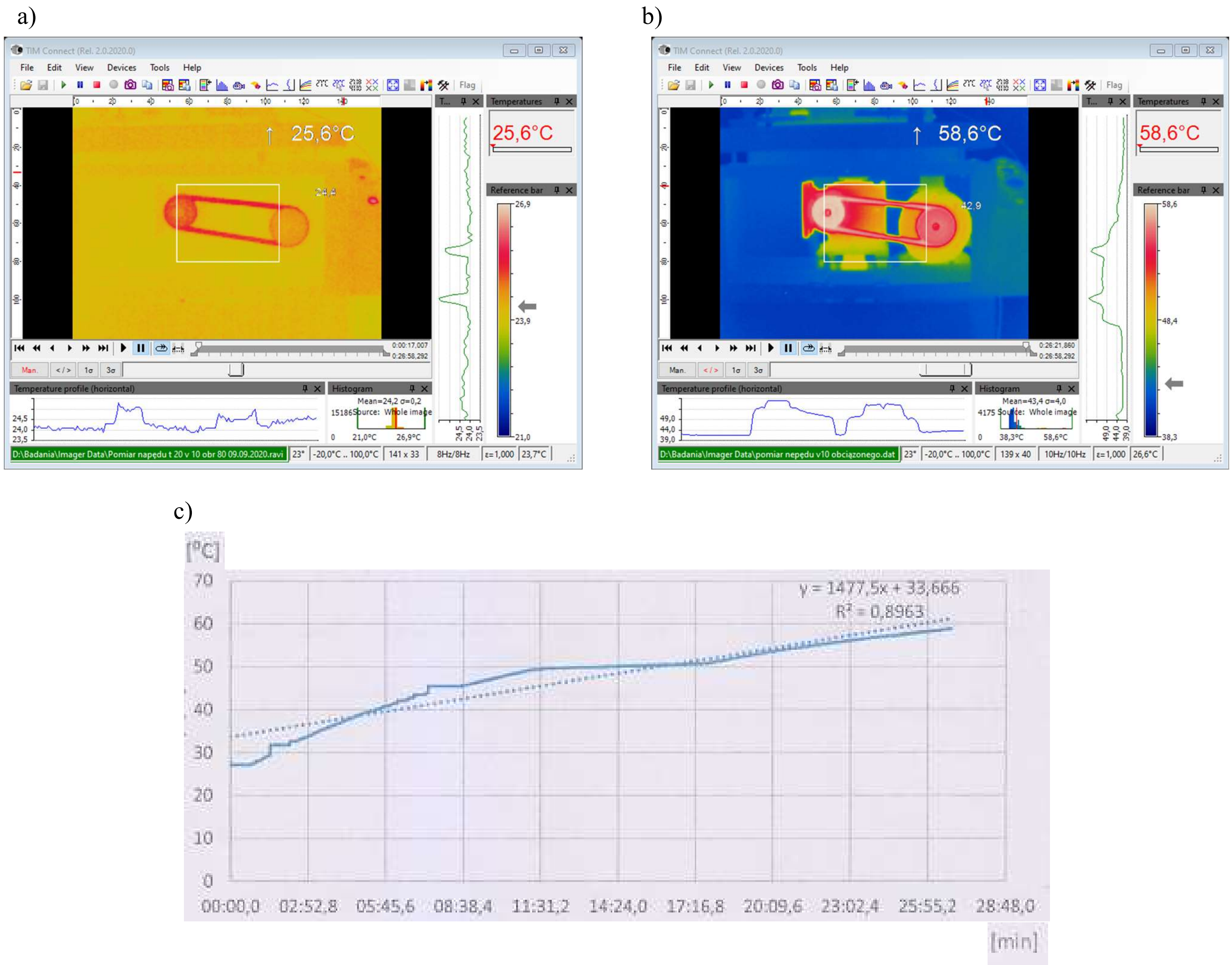


Fig. 6. Results of the measurement of the temperature of the lapping machine drive system: a) in the initial moment, b) after 20 min of dressing the lapping disc with guiding rings (n_t = 80 min^{-1}) and manual refilling of the abrasive after 11.5 min, c) graph presenting the increase of the temperature of the belt drive in time

Results of the measurements of the temperature of the rotating lapping disc during idle mode can be seen in figures 7 and 8. When n_t = 40 min^{-1}, the highest temperature was noted in the centre of the lapping disc (it is thinner in this area) and it reached 27.6ºC. The average temperature in other areas on the surface of an active lapping disc was, on average, 24,5ºC. For n_t = 80 min^{-1} the increase of the tool temperature was, on average, 0.29ºC/min.

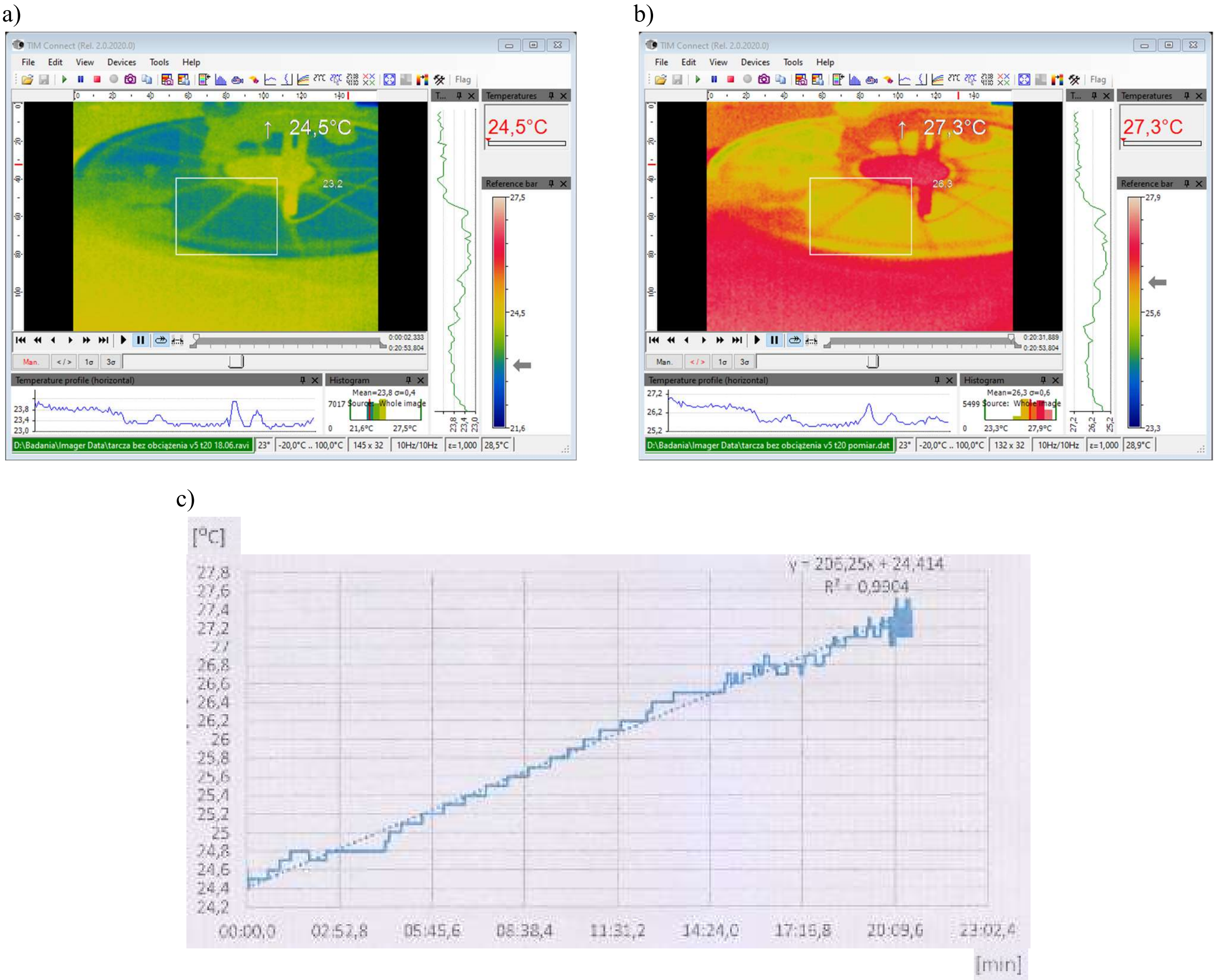


Fig. 7. Results of the measurements of the temperature of lapping disc in idle mode: a) in the initial moment, b) after 20 min (n_t = 40 min^{-1}), c) graph showing the increase of the temperature of the lapping disc in time (on average, 0.14ºC/min)

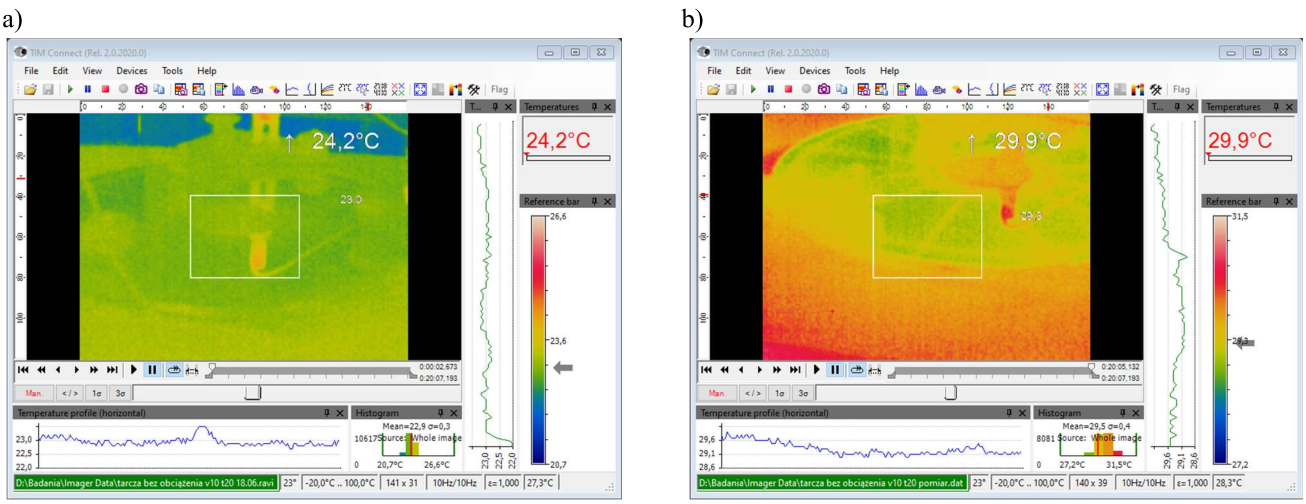


Fig. 8. Results of the measurements of the temperature of the lapping disc in idle mode: a) in the initial moment, b) after 20 minutes (n_t = 80 min^{-1})

3.3. Heating up of the actuating system of a machine during lapping of elements

The examinations of the increase of temperature of a single-disc lapping machine Abralap 380 were conducted during lapping of flat elements of C45 steel. The abrasive based on artificial corundum 95A F320 was dosed manually, with removed guiding rings. In the first stage, the machining was conducted throughout 10 minutes without refilling the abrasive. The rotational speed of the lapping disc was 80 min^{-1} (average lapping speed was 0.37 m/s), while unit pressure was 0.10 MPa. Figure 9 presents the example results of the temperature measurements. During the machining of a batch of elements, the average temperature of the tool increased to 33.4ºC, the temperature of the rollers guiding rings increased to 32.9ºC and the temperature of the guiding rings increased to 31.9ºC.

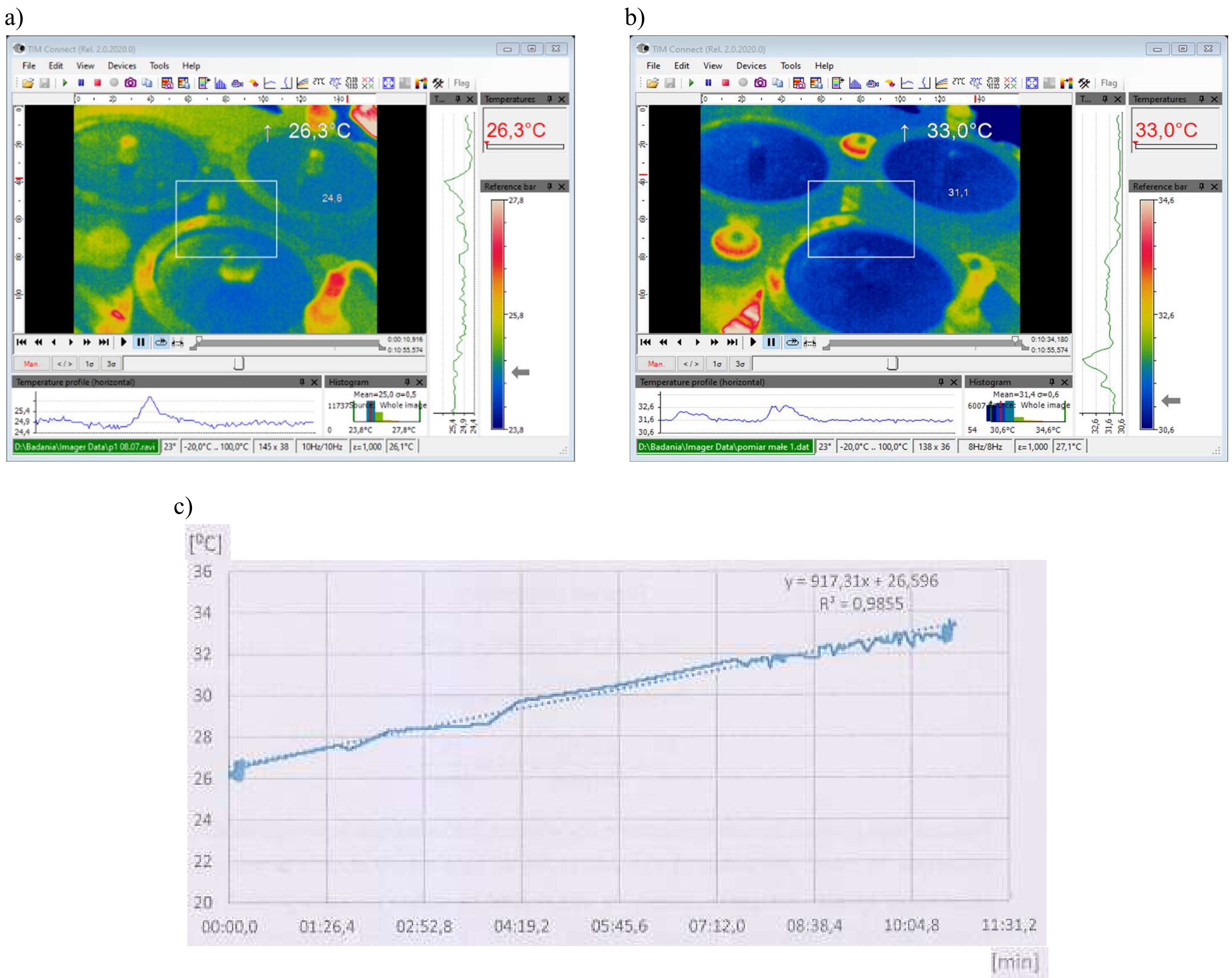


Fig. 9. Results of the measurements of the temperature of the actuating system during lapping of steel elements: a) in the initial moment, b) after 10 min (n_t = 80 min^{-1}), c) graph showing the increase of the temperature in time (on average by 0.67ºC/min)

When lapping duration was increased to 15 minutes, an increase of the average temperature of the lapping disc (fig. 10) occurred along with disturbances of the uniformity of rotational speed of the guiding rings and, consequently, separators with machined elements. With 5 minute long lapping (fig. 11), the intensity of the heating up of the tool was 0.12ºC/min.

A situation when the elements are lapped throughout 30 minutes, with refilling the abrasive after 15 minutes of machining is shown in fig. 12.

a) b)

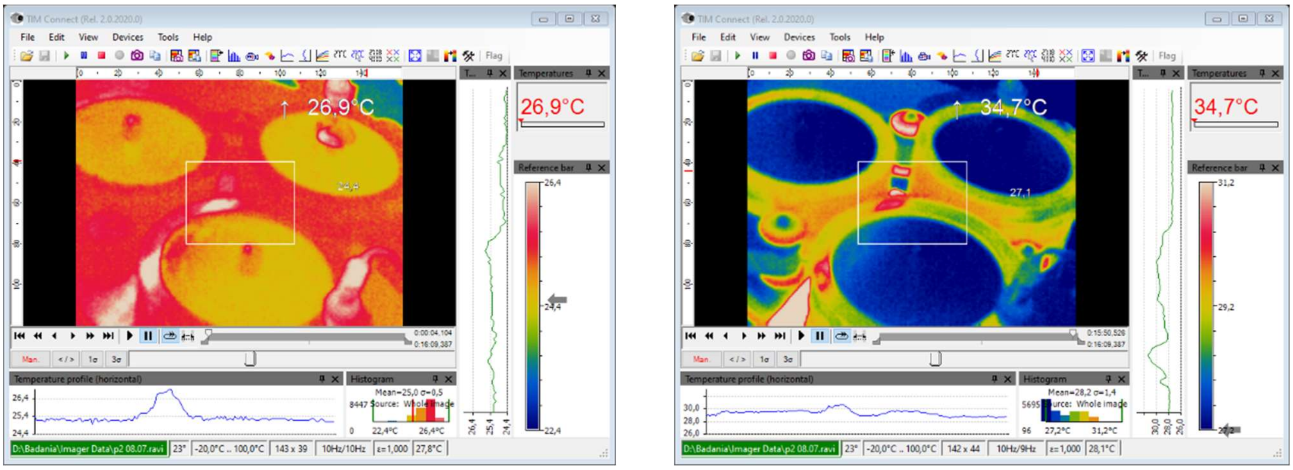


Fig. 10. Results of the measurements of the temperature of the actuating system of the lapping machine during lapping of steel elements: a) in the initial moment, b) after 15 minutes (n_t = 80 min^{-1})

a) b)

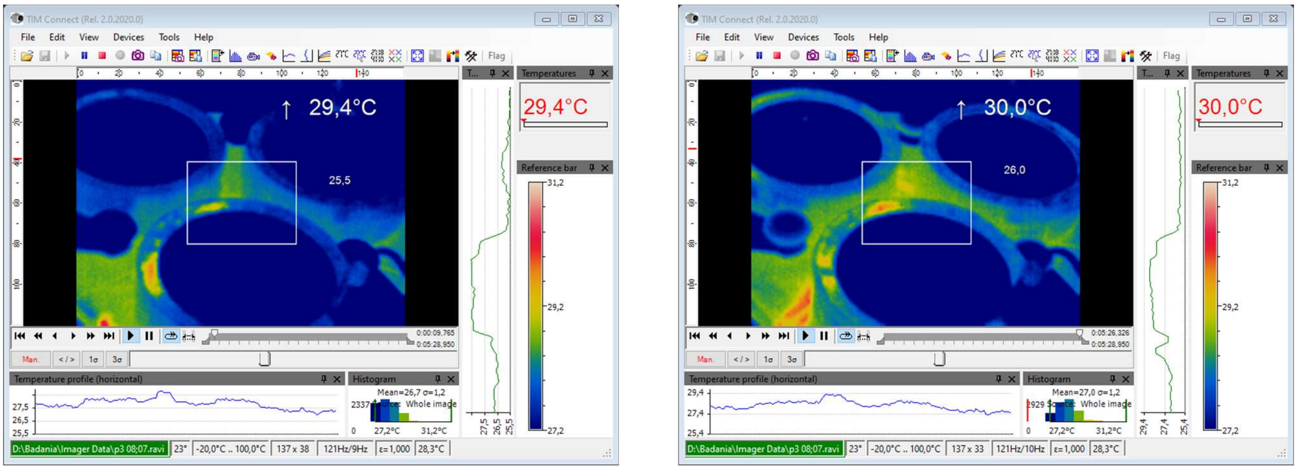


Fig. 11. Results of the measurements of the temperature of the actuating system during lapping of steel elements: a) in the initial moment, b) after 5 minutes (n_t = 80 min^{-1})

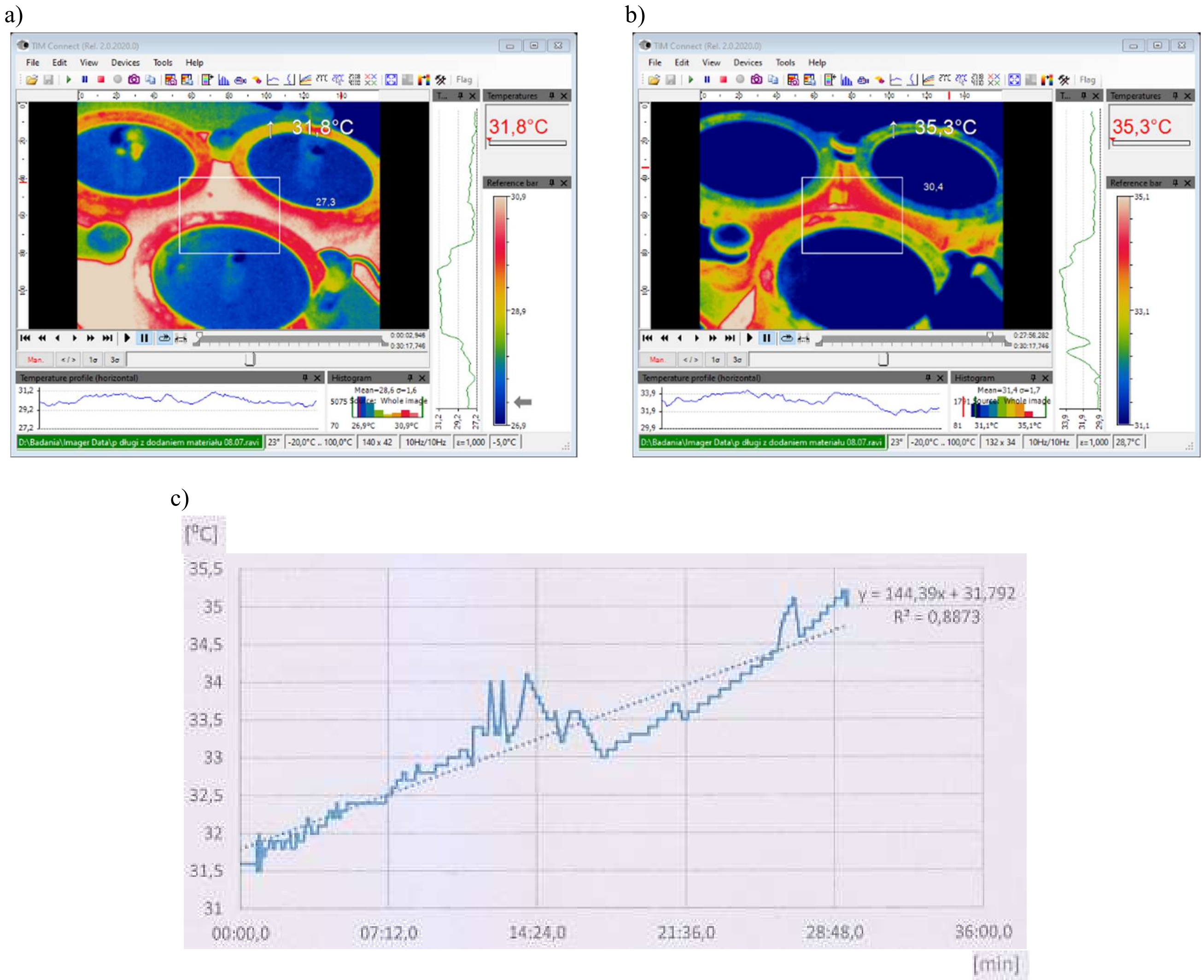


Fig. 12. Results of the measurements of the temperature of the actuating system during lapping of steel elements: a) in the initial moment, b) after 30 minutes (n_t = 80 min^{-1}), c) graph showing the increase of temperature in time

4. Summary

On the basis of the conducted examinations it can be seen that the assembly which exhibits the highest increase of temperature is the worm gear, being a part of the lapping machine drive system. Relatively approximate location of the gear and the lapping disc exerts a significant influence on the temperature of a metal tool. An important issue in construction of machines of such a type consists in the appropriate thermal insulation of the lapping disc.

Another significant factor consisted in the influence of the rotational speed of the lapping disc, and, consequently, of the guiding rings. In order to prevent the heating up of the elements of lapping machine drive system and of machined elements, one should aim at decreasing the values of kinematic parameters (lapping speed) and, obviously, decrease the exerted unit pressure. This will cause the prolongation of the time of main lapping of the elements, as well as the time of dressing the active surface of a tool. In opposite case, one should consider technological breaks between operations. If lapping technology is applied during the assembly of machine unit, the intensity of using the lapping machines does not have a significant meaning.

The increase of the temperature can also be limited by minimizing the ratio of filling the separators with lapped elements and, as it was shown in previous research, by applying a constant (drip or flood) dosage of the abrasive. If the nature of lapped materials requires the application of super-hard abrasives, i.e. expensive ones, it is possible to apply a forced water cooling system of the lapping disc.

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