INFRARED THERMOGRAPHY METHOD FOR THE ASSESSMENT OF THE RISK OF BURNINIG

Assoc. Prof., Branko Štrbac, Zorana Lanc, M.Sc., Milan Zeljković, Full Prof., Aleksandar Živković, Asst. Prof., Miodrag Hadžistević, Full Prof.
University of Novi Sad, Faculty of Technical Sciences
Novi Sad

SUMMARY

Elimination of any risk of burning arising from contact with or proximity to machinery parts at high temperatures is one of the essential health and safety requirements for machinery. Because hot machinery parts can cause serious burns to operator the assessment of the risk of burning is crucial step in raising the level of work protection. This paper presents non-contact Infrared Thermography method for the assessment of the risk of burning. The proposed is simpler, faster and more efficient method than the standard contact method for assessing the risk of burning.

Keywords: Burn, Risk Assessment, Infrared Thermography

1. INTRODUCTION

Before placing machinery on the market or putting it into service, the manufacturer must ensure that any risk of injury arising from contact with or proximity to machinery parts or materials at high or very low temperatures is eliminated. This is one of the essential health and safety requirements from Machinery Directive 98/37/EC and therefore is mandatory.

When human skin comes into contact with a hot machinery parts, burns may occur. Whether or not they do depends on a number of factors, the most important of which are temperature and period of contact between the skin and the surface. The first part of European Standard ISO 13732 provides temperature threshold values for burns that occur in the case of contact with a hot metal surface. These threshold values are provided mainly based on scientific research, except for very short contacts of 0,5 s where these data are deduced by extrapolation or by reasonable conclusion using scientific results [1-5]. Standard also describes a method for assessment of the risk of burning when the unprotected human skin comes into contact with hot metal surfaces. This assessment consists of identification and measurement of the surface temperature, task analysis, comparison of the temperatures, determination of the risk of burning and repetition of the assessment. All this work is time-consuming and due to the lack of relevant data on burn threshold for short period of contact, it can be difficult to apply in practice. Therefore, the new method for the assessment of the risk of burning is proposed. The new method is based on measuring the surface temperature of hot metals using the infrared camera. Infrared camera is an instrument that converts the spatial variations in infrared radiance from a surface into a two-dimensional image, in which variations in radiance are displayed as a range of colors or shades.

In this paper, experimental work was conducted on the lathe in order to assess the risk of burning using the standard and new method. By comparing the results from booth methods, it was concluded that the new method is simpler, faster and more accurate method for risk assessment because of its ability to measures the temperature on the entire test surface in contrast to the standard method.

2. MATERIALS AND METHODS

Experimental work was conducted on the front side of main gearbox housing of the universal lathe PA 22 in two phases. In the first phase, measurement was performed during lathe idling at 1350 rpm in the heating period of 180 min. In the second phase, measurement was performed during the cooling period of 20 min after stopping the machine. The temperature was simultaneously measured using the ThermoProTM TP8S infrared camera and three K type thermocouples. Afterward, identified hot metal surfaces were classified into four groups. For each group, the risk level was evaluated using the Kinney method for risk assessment. Estimated risks were used for making the thermal maps of examined part of the lathe.

2.1. Experimental set up

Schematic representation of the position of thermocouples on the front side of main gearbox housing is shown in Fig. 1. Thermocouples were placed on the surface of housing at the level of the middle (1), front (2), and rear bearing (3) and connected to the TL-309 thermometer. The infrared camera was placed in front of the lathe, while the thermometer was placed on the top of the housing. The 10-min measuring interval was selected.

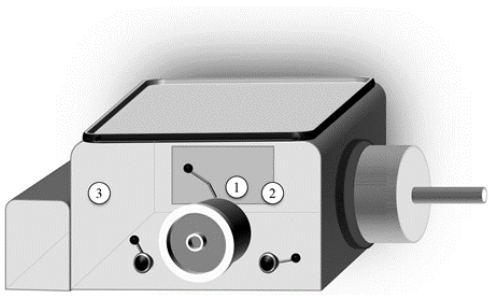

Figure 1. Position of thermocouples on the front side of main gearbox housing

2.2. Assessment of the risk of burning using Kinney method

Standard ISO 13732-1 doesn't define the risk level for hot metal surfaces, instead it only gives burn threshold values depending on period of contact. For this reason, the authors classified these surfaces into four groups, as shown in Table 1. In the case of contact periods of 0.5 s to 10 s, the burn thresholds are given as spreads due to the fact that for short contact periods the knowledge of the burn thresholds is uncertain and incomplete. For longer contact periods the uncertainties are less and they are given as an exact value for burn thresholds.

Table 1. Groups of hot metal surfaces.

Defined groups	I		II	III	IV
Contact period	0.5 s	10 s	1 min	10 min	8 h and longer
Burn threshold [°C]	67–73	55–60	51	48	43

Risk level for each group is determined using Kinney risk assessment. Kinney method is done considering three factors: the probability of an accident or damage occurrence, the exposure at risk frequency and the gravity of the induced consequence. Numerical values for the probability, frequency and gravity must be allotted to each of the three factors in order to calculate risk level by multiplying these factors. Based on the calculated risk levels it is possible to determine the risk classes. Risk assessment results are shown in Table 2. As it can be seen, risk classes are in good correlation with the expected results, since they show increases of risk level with temperature and shorter period of contact.

Table 2. Risk assessment for metal surface using Kinney method

Group of metal surface	Risk level	Risk class
1. 43 °C ≤ T < 48 °C	1	Very low
2. 48 °C ≤ T < 51 °C	10	Very low
3. 51 °C ≤ T < 55 °C	60	Possible
4. T ≥ 55 °C	200	Significant

2.3. Assessment of the risk of burning using thermal maps

Thermograms recorded after 60, 120, 180 and 200 min were processed using the software Guide IrAnalyser®. Temperature scale of each individual thermogram was modified according to defined temperature for different class of risk (Table 2). By adjusting the temperature scale only the surface temperatures within the desired range are displayed, while the other areas are presented in black or white.

3. RESULTS

The graph on Fig. 2 shows temperature higher than 43 °C obtained by the thermocouples in order to simplify the interpretation of the results.

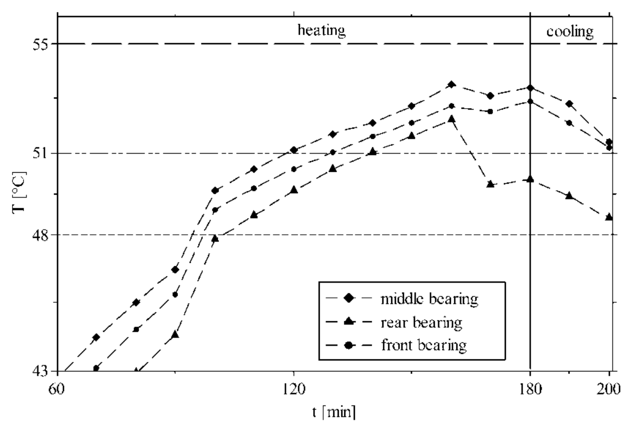

Figure 2. Experimental results obtained by the thermocouples.

As it can be seen from the graph above, throughout the first 60 min of the heating period there is no risk of burning on the front side of the main gearbox housing. In the interval from 60 min to 120 min risk of burning is very low. At 120 min there is a possible risk of burning but only near the middle bearing. Towards the end of the heating period risk of burning is generally possible near all bearings. During the cooling, the risk of burning is possible near the middle and front bearing, while near the rear bearing is very low. Thermocouples do not show a significant risk of burning on the examined housing.

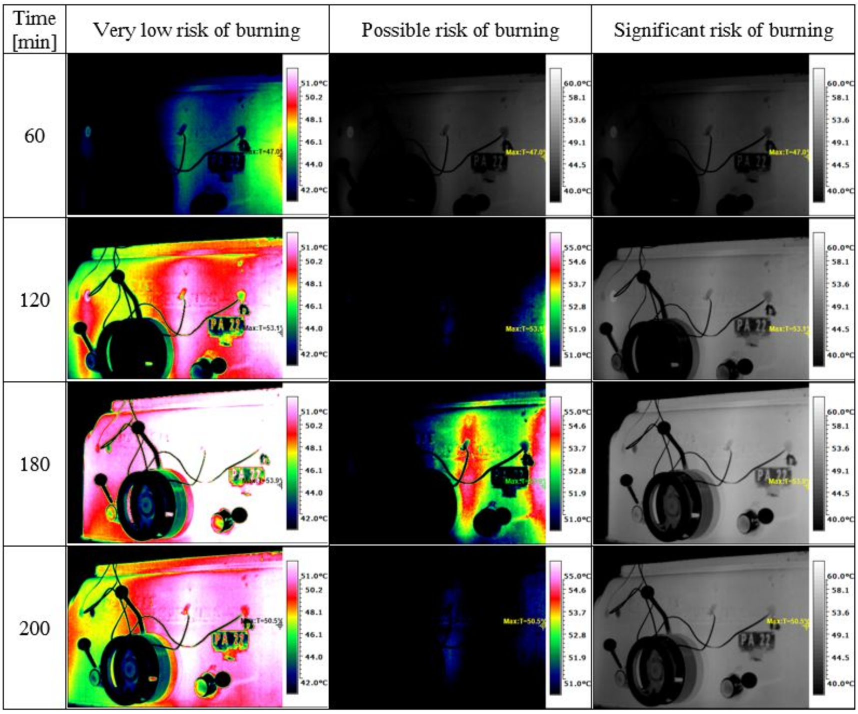

Figure 3. Experimental results obtained by the infrared camera.

Thermal map of the front side of main gearbox housing is composed according to the procedure described in 2.3 and is displayed in Fig. 3. The assessment of the risk of burning using the thermal map is based on observing the colored areas on the thermograms. For example, the thermograms in the last column indicate that there is no significant risk of burning on the front side of the main gearbox housing because the maximum temperature does not exceed 53 °C. The remaining thermograms not only show that there is low and possible risk of burning on the housing, but also the exact location of these areas. Possible risk of burning occurs around middle and front bearing after 120 minutes and becomes more pronounced after 180 minutes. Very low risk of burning occurs after 60 min and by the end of the experiment covers almost the entire surface of the housing.

Areas of low risk of burning do not require additional activities in the management of the operation. For the areas of possible risk, it is advisable to monitor these areas in order to act preventively if the risk of the burning increases during the time. In the case of areas of significant risk of burning, measures have to be taken to lower the estimated risk. This is achievable by wearing safety glows, but only after two hours of working on the lathe.

4. CONCLUSION

The proposed method has proven to be a useful and helpful method for assessment of the risk of burning. One of the advantages of this method is the ability to measure the temperature on the entire hot surface in contrast to the standard method. The areas of interest on thermogram are very noticeable and precisely defined giving this method a preference over the standard method. Moreover, the thermal map is easy to interpret and understand.

The new method can be used in the following cases:

- when workers could or might touch hot metal surfaces with their unprotected skin;
- only for a small area of the skin in contact, approximately less than 10 % of the skin of the whole body or of the head;
- when the surface temperature is essentially maintained during the contact either by the mass of the product or by a heating source;
- when contact periods is 0,5 s and longer.

The accuracy of the new method highly depends on the burn threshold data given in the mentioned standard. These data, in particular those for short contact periods, are subject to uncertainty. This is because the force of touching can vary, the skin can be dry or wet, the scientific determination of the burn threshold contains inaccuracies, and because the materials with slightly different thermal inertias have been combined into one group. Also, the method does not provide threshold values for the discomfort or pain. For this reason, authors will try to overcome the above limitation through the development and improvement of proposed method as well as by using burn threshold values from current research.

5. REFERENCES

[1] R. McLean, A. R. Moritz, and A. Roos, J. of Clinical Investigation, 26, 3, pp. 497-504 (1947)
[2] H. Siekmann, Applied Ergonomics, 20, 4, pp. 313-317 (1989)
[3] H. Siekmann, Applied Ergonomics, 21, 1, pp. 69-73 (1990)
[4] Y.C. WU, Journal of Materials, 7, 4, pp. 674 (1972)
[5] K.C. Parsons, Human Thermal Environments (Taylor and Francis, London, 1993)