PRIMENA INFRACRVENE TERMOGRAFIJE U RECIKLAŽI KRUNICA BUŠEĆIH GARNITURA

APPLICATION OF INFRARED THERMOGRAPHY IN THE RECYCLING OF DRILLING RIGS CROWNS

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U rudarstvu kao jednoj od najznačajnijih privrednih grana, izuzetno je bitna oprema koja se koristi pri iskopavanju ruda i minerala bilo da je reč o podzemnoj ili površinskoj eksploataciji. Alati (bušeće garniture) koji se koriste pri istraživačko-geološkim bušenjima moraju biti napravljeni od veoma tvrdih materijala koje karakterišu visoka tvrdoća, izdržljivost i visoka temperatura topljenja. Bogata nalazišta ovakvih materijala su retka, a proces dobijanja je veoma skup i povezan sa velikim ekološkim problemima. Reciklažom otpadnih materijala iz alata mogu se dobiti značajne količine sekundarnog resursa. Ovo je veoma značajno jer su u poslednjih desetak godina primarne sirovine višestruko poskupele, a troškovi električne energije potrebne za proizvodnju primarnih sirovina porasli za oko 30% u svetu. Shodno tome, poslednjih godina je reciklaža tvrdog metala u žiži interesovanja korisnika i proizvođača tvrdog metala. Danas postoje razne metode koje se koriste u procesima reciklaže otpadnih materijala iz alata ,a primena infracrvene termografije ih može u značajnoj meri olakšati. U radu su prikazane neke od prednosti korišćenja infracrvene termografije u procesima reciklaže krunica bušećih garnitura.

***Ključne reči**: Infracrvena termografija; reciklaža; tvrdi materijali*

In mining as one of the most important branch in industries, equipment used for mining , whether underground or surface exploitation is very important part. Tools (drills) used in research and geological drilling must be made of very hard materials characterized by high hardness, durability and high melting temperature. Rich inventories of such materials are rare, and the process of obtaining them is very expensive and associated with great environmental problems. Recycling of waste materials from the tool can generate significant amounts of secondary resources. This is especially important because in the last ten years primary raw materials prices have risen more and more, and the costs of electricity needed for the production of primary raw materials have grown by around 30% worldwide. Consequently, in recent years, recycling of hard metals has been a concern for consumers and hard metal producers. Today, there are various methods used in the recycling process of waste materials from the tools, and the use of infrared thermography can greatly make them easier. The paper represents some of the advantages of using infrared thermography in the processes of recycling crowns of drills.

***Keywords**: Infrared thermography; recycling; hard materials*

1 Introduction

Diamond crowns for exploration-geological drilling, obtained by sintering of tungsten carbide (WC), cobalt, and iron particles with diamonds, are widely used in geology and mining. The crowns of the drill sets contain 80% tungsten, 5% cobalt and 3% diamonds. Tungsten carbides are widely used in the hard metal industry for the production of wear-resistant tools as they are characterized by excellent characteristics such as high hardness, durability and high melting point. They consist of powders of tungsten carbide and cobalt in the ratio of 70-97% of the total mass, and the rest is made of binder (cobalt, nickel, iron, etc.). The primary raw materials are minerals like the tungsten, shellite,

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ferberite and gubernite . The deposits of these minerals are rare, and the processes and production costs are more expensive than the cost of recycling waste materials from tools [1-3]. Recycling of waste materials from tools has income in raw materials where tungsten concentration is 40-90%, while in the primary raw materials the tungsten concentration is 7-60%. The amount of tungsten produced from recycling processes is constantly increasing, but has not yet exceeded 25% of total production, which is a consequence of different physical forms as well as the chemical composition of waste materials. There are plenty methods used for the recycling of tungsten carbide from waste materials, such as hydrometallurgy, pyrometallurgy, electrometallurgy, and combinations thereof [4-6]. The use of infrared thermography in recycling processes can greatly accelerate and facilitate the mentioned methods and some possible applications are presented in this paper.

2 Equipment for infrared thermography measurements and monitoring

Figure 1. Infrared camera- Flir Ex [6]

The Flir company was founded in 1978 and is currently the leader in designing, manufacturing and marketing thermovision systems that are used in various spheres of human society. An infrared camera measures and images the emitted infrared radiation from an object. The fact that radiation is a function of object surface temperature makes it possible for the camera to calculate and display this temperature. However, the radiation measured by the camera does not only depend on the temperature of the object but is also a function of the emissivity. Radiation also originates from the surroundings and is reflected in the object. The radiation from the object and the reflected radiation will also be influenced by the absorption of the atmosphere. To measure temperature accurately, it is therefore necessary to compensate for the effects of a number of different radiation sources. This is done on-line automatically by the camera. The infrared camera contains a specially designed software package that provides an easy way to update the camera and create a thermogram [7].

3 Application of infrared thermography in the processes of recycling

The experimental research were carried out at the Institute of Mining and Metallurgy in Bor. Three samples of crowns of drilling sets were used :

Sample 1 ..... New, unused crown,
Sample 2 ..... Used crown, prepared for recycling and
Sample 3 ..... Recycled crown after dissolution in acid.

Figure 2. Sample 1

Figure 3. Sample 2.

Figure 4. Sample 3.

The samples were heated to a certain temperature and temperature changes were observed during cooling of the samples using a thermal imaging camera.

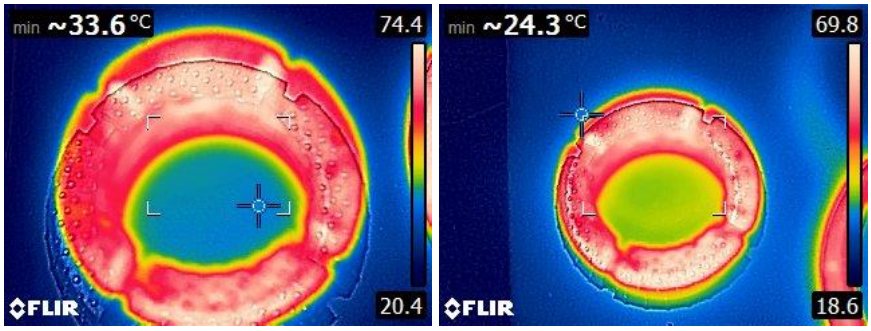

Figure 5. Thermograms of sample 1. at the start of cooling

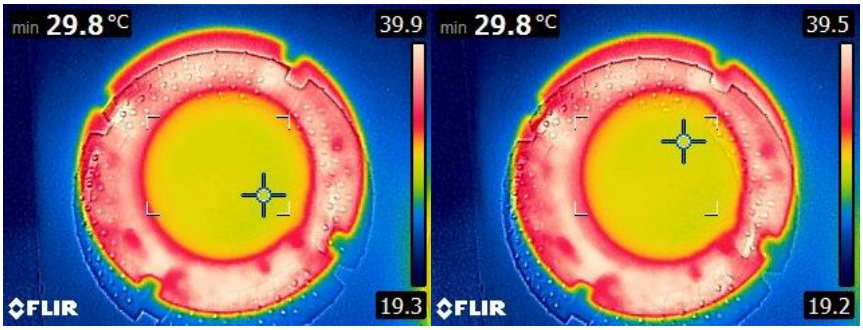

Figure 6. Thermograms of sample 1. at the end of cooling

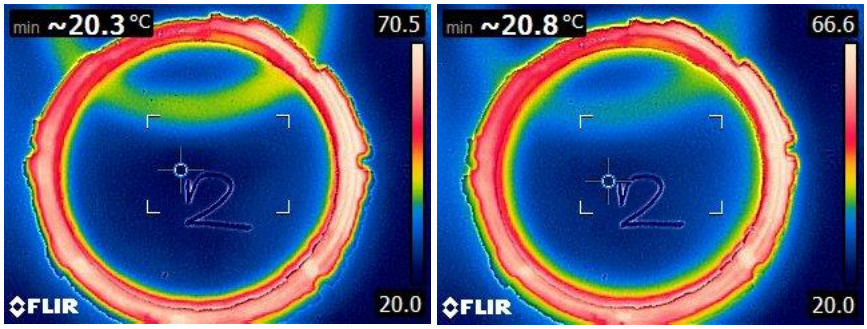

Figure 7. Thermograms of sample 2. at the start of cooling

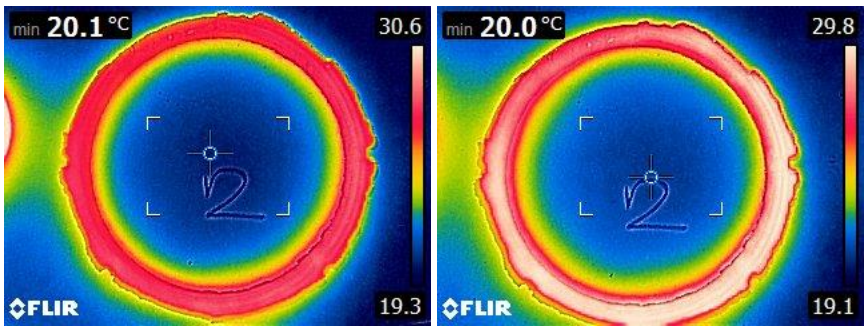

Figure 8. Thermograms of sample 2. at the end of cooling

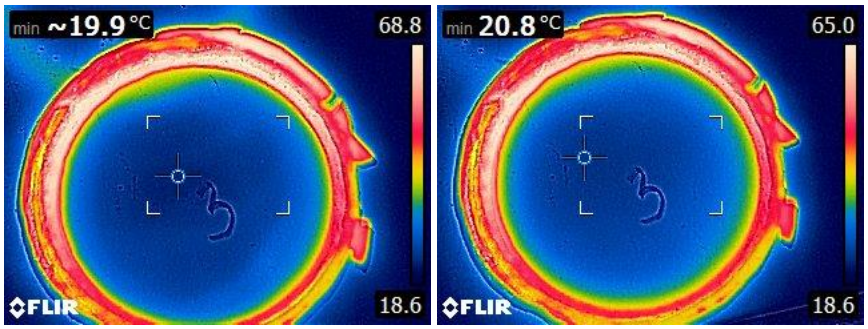

Figure 9. Thermograms of sample 3. at the start of cooling

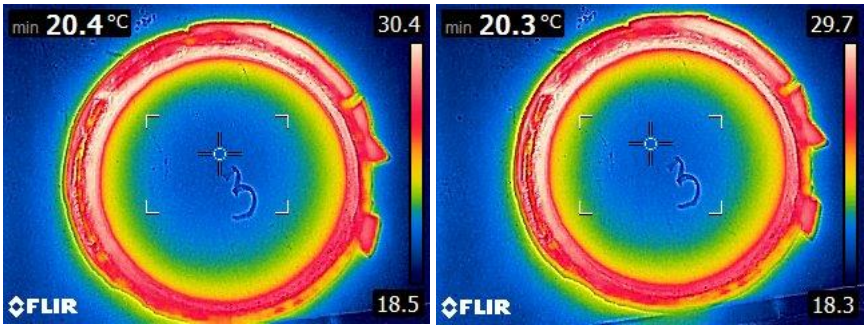

Figure 10. Thermograms of sample 3. at the end of cooling

The following diagram shows the change of temperature depending on the time where it can be observed that sample 1. cools down slower compared to samples 2. and sample 3.

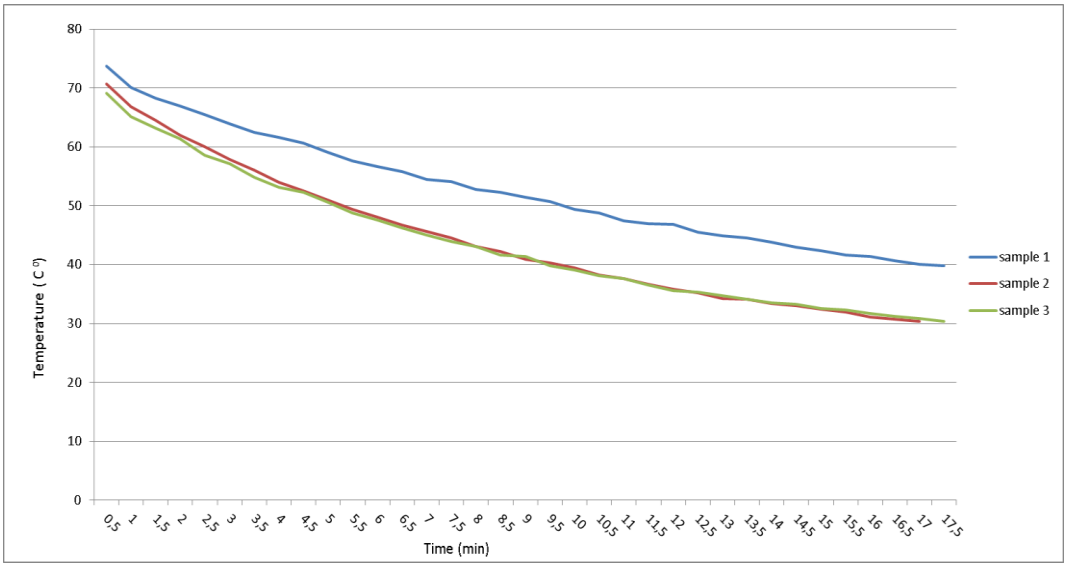

Figure 11. Temperature dependence in time

The reason for these results lies in the heat capacity of the elements from which the crowns are made. Namely, the quantity of required elements (tungsten, cobalt, diamond) is higher in the new

than in the used and recycled sample, and therefore the heat capacity in the unused sample is higher which prolongs the cooling time of the sample. A very simple process of measuring the temperature of samples with infrared camera can accelerate the rather long and complicated methods of recycling processes.

4 Conclusion

The cost of obtaining elements such as tungsten, cobalt and diamonds from recycling processes is many times lower than the cost of obtaining them from natural resources. However, many methods used in recycling processes are very complex and require combining several to produce satisfactory results. The use of so called easy-to-use devices such as a thermal imaging camera can significantly speed up recycling processes, and with even less cost, achieve the desired results.

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6 References

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