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## Aluminum alloy impact sparking

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### Abstract

The cast machine parts are widely used in many branches of industry. A very important issue is gaining the appropriate knowledge relating to the application of castings in places of explosion risks including but not limited to mining, chemical industry and rescue works. A possibility of explosion risks occurrence following the impact sparking of the cast metal parts is still not solved problem in scientific research. In relation to this issue, in this article, the results of the study are presented, and relating to the tendency to impact sparking of the aluminium alloys used in machine building. On the grounds of the results obtained, it was demonstrated that the registered impact sparkles bunches of feathers from the analyzed alloys: AlSi7Mg, (AK7); AlSi9Mg, (AK9); AlSi6Cu4, (AK64) and AlSi11, (AK11) show significant differences between each other. The quantitative analysis of the temperature distribution and nuclei surface area performed on the example of the alloy AK9 (subjected to defined period of corrosion) allows for the statement that they are dangerous in conditions of explosion risk. Following this fact, designers and users of machine parts made from these materials should not use them in conditions where the explosive mixtures occur.

**Keywords:** Innovation materials and casting technologies, Silumins, Percussive sparking, Analysis sparks

### 1. Introduction

Cast aluminium alloys are widely used in machine building for manufacturing complex parts produced in large series. Extremely important problem is to obtain proper knowledge on the application of aluminium castings in places with explosion risk.

Hot metal particles produced during the impact sparking [1-3] are the reason for many fires and ignitions of explosive mixtures. This issue has been addressed in many research studies [1- 8].

The main objective of the carried out research was to find construction material featuring low tendency to sparking or non-sparking material which could be used in explosive conditions [1-5].

The sparkles following impact occur as a result of mutual interactions of two materials:

- metal – metal,

- metal – ceramic material through impactand friction.

The ignition of the explosive mixtures from hot metal particles depends mainly on the quantity of heat energy obtained from sparkle in the bunch of feathers following the impact [1,2,7]. The mechanism of ignition depends mainly on the minimum ignition energy for a given mixture and energy of impact [1,2].

The studies of metal sparking which have been carried out hitherto related mainly to determination of the probability of the explosive mixtures ignition in defined conditions of mechanical contact [1-3]. There is scarcity of theoretical studies in the available scientific literature which refers to visualization and digital registering of the impact sparkle generation phenomenon and processes of explosive mixtures ignition from the hot particles of burning metal.

## 2. Methodology of the study and results

The study of the impact sparking has been carried out for the following aluminium alloys, the grade: (AK7), EN AC- 42000, EN AC - AlSi7 Mg; (AK9), EN AC 43300, EN AC -AlSi9Mg; the grade( AK11), EN AC - 44000, EN AC - AlSi11; (AK64); EN AC - 45000, EN AC - AlSi6Cu4, which were re - melted directly from the pig sows and cast to the permanent mould.

From the above-mentioned alloys the smears were made on the corroded steel samples.

In the Fig.1 there are the smears with visible traces after the impact with the striker in order to initiate the phenomenon of impact sparking.

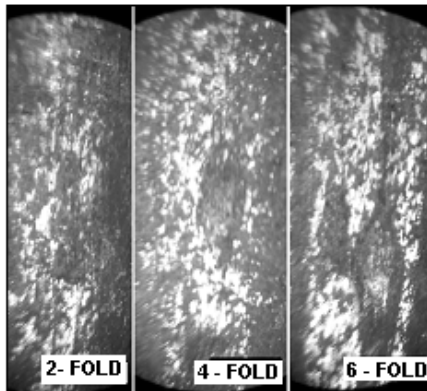


Fig. 1. The views of smears made from the alloy AK9 brought over the sample after 30- day corrosion

The samples were prepared with: 2 - fold, 4 - fold and 6 - fold smear of the analyzedaluminium alloys and they were subjected to impact sparking on the testing stand described in the previous studies [4-6]. Following the impact contact of the metal striker with the aluminium alloy (e.g. AlSi7Mg) smear the impact sparkle (mechanical) is generated.

In the impact-frictional process, in a very short time, energy is delivered which is sufficient to cause the ignition of the metal particle (in the smear) and start the process of intensive burning. Following this process, the particle assumes a form of spherical droplet of metal wrapped in the layer of oxides.

The simplified model of the hot metal particle burning is shown in Figure 2.

Having blown using the striker, in the smear brought on steel plate, the burning particles are generated which produce various shapes of the bunch of feathers from the impact sparkles.

The influence of the aluminium alloy grade on shape changes in bunches of feathers obtained from 2 - fold smears on the steel samples after the period of seven days exposure to the atmospheric corrosion is shown in Figure 3.

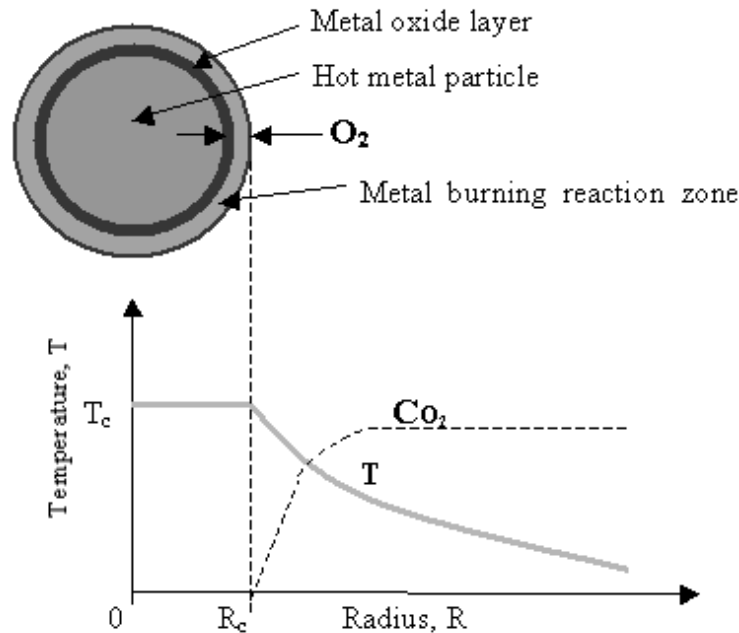


Fig. 2. The Model of metal particle burning [2]

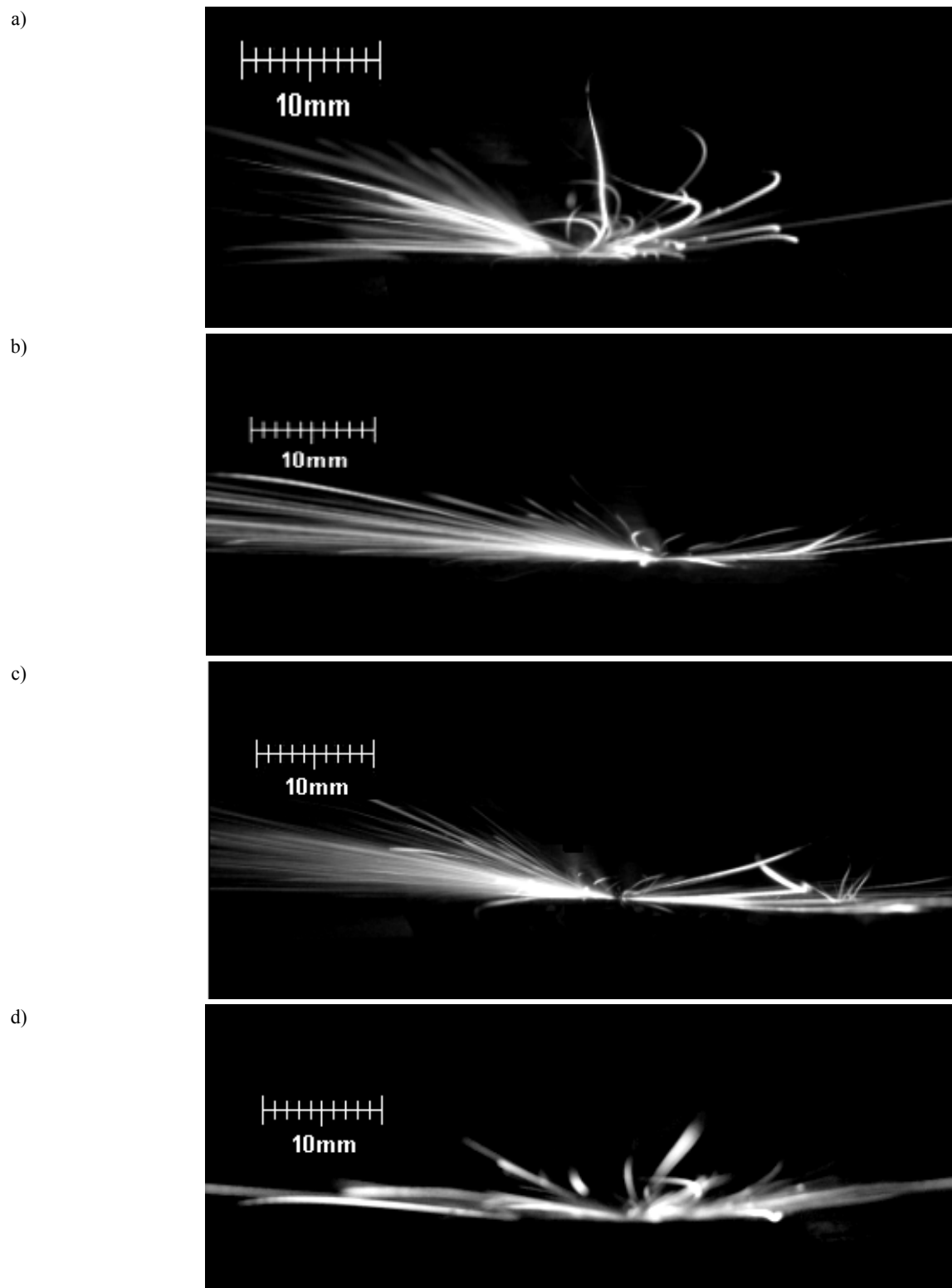


Fig. 3. The views of the impact sparkle bunches of feathers: a - the alloy AK7, b - the alloy AK9, c - the alloy AK64, d - the alloy AK11

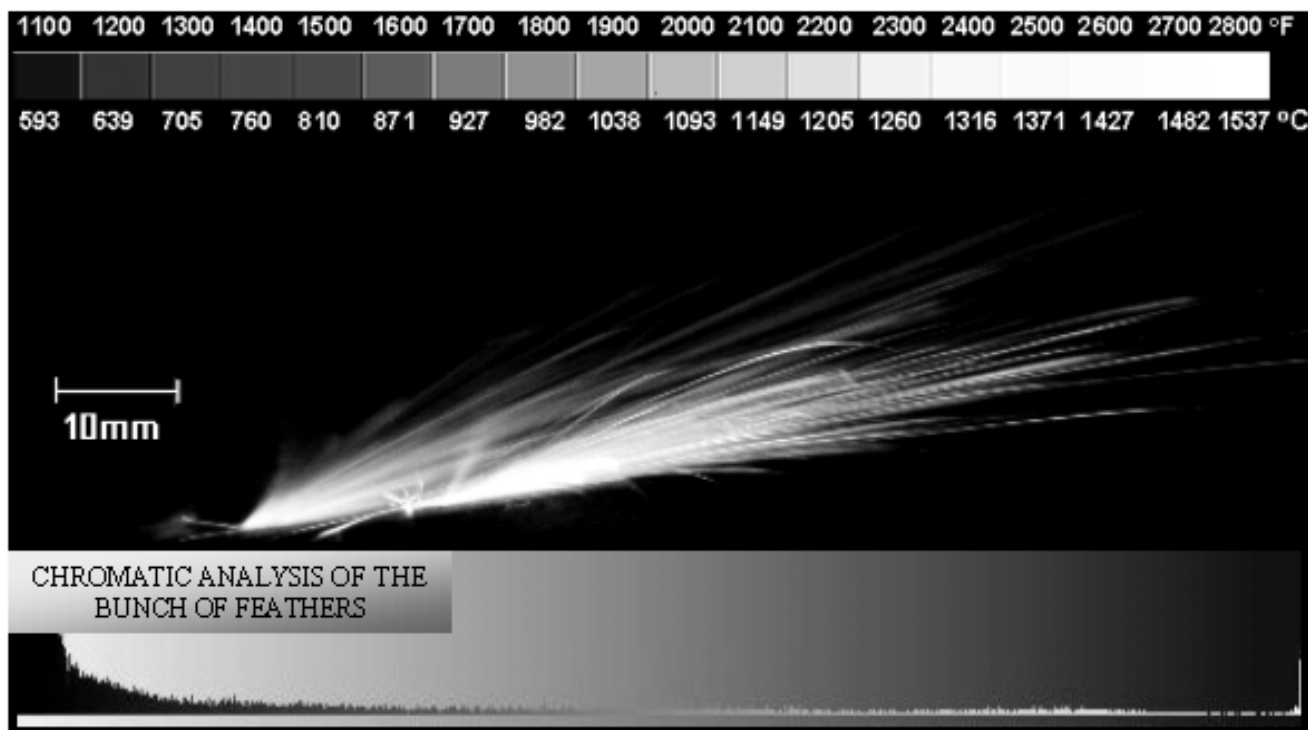
The generated sparkles from the analyzed aluminum alloys vary between each other significantly with regard to surface area, shape and dynamics of the registered nuclei and bunches of feathers.

For the digitally registered pictures of bunches of feathers from sparkles for each particular analyzed alloy the attempt was undertaken to provide the quantitative description of the obtained results referring to the process of impact sparkling.

On the grounds of the developed colour scale and using suitable graphic software the distribution of temperature and surface area of nuclei as well as bunches of feathers for the registered sparkles were made.

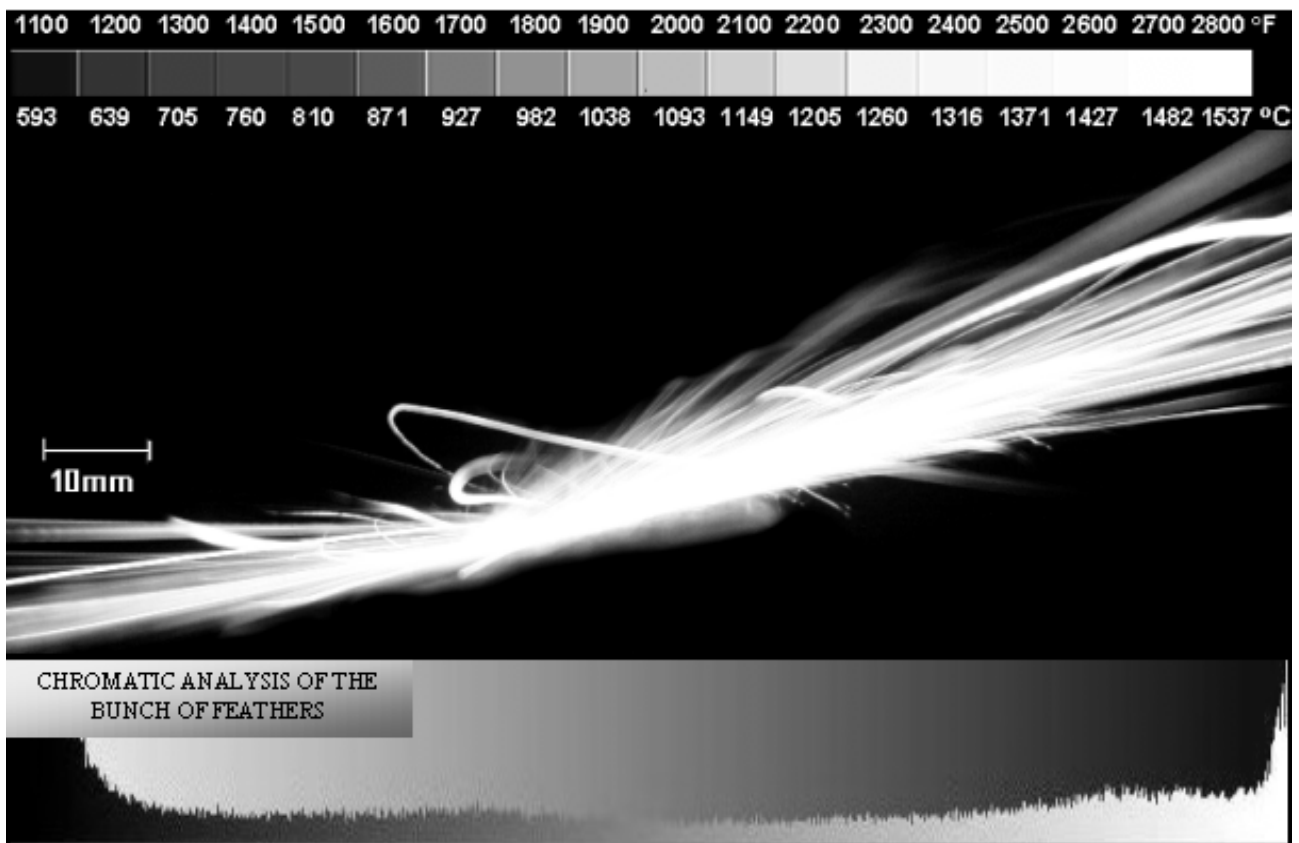
Figures 4 and 5 show the obtained pictures of bunches of feathers and the results of the quantitative analysis of impact sparkles. The chromatic analysis of the impact sparkle in the bunch of feathers is shown in form of bar diagram. This diagram illustrates the proportions between the points in the pictures of sparkles in the bunch of feathers having different temperatures.

The height of the ordinate (of the bar) in the selected temperature point of the analyzed bunch of feathers defines proportionally the picture magnitude corresponding to the given temperature.



Sample: <b>Steel St3</b>	Smear: <b>AK9</b>	Striker: <b>St 3</b>	Description: <b>Medium - sized sparkle with double bunch of feathers and small nucleus</b>	Sparkle surface area: <b>421mm<sup>2</sup></b>
Corrosion period: <b>7 - days</b>	Smear multiplicity: <b>2</b>			Nucleus size: <b>63mm<sup>2</sup></b> ( 15% of bunch of feathers surface area )

Fig. 4. The view and the analysis of the bunch of feathers and the nuclei of the impact sparkle for the alloy AK9 after seven day corrosion



Sample: <b>Steel St3</b>	Smear: <b>AK9</b>	Striker: <b>Grey cast iron</b>	Description: <b>Largesized sparkle with bunch of feathers and large nucleus on both sides</b>	Sparkle surface area: <b>2650 mm<sup>2</sup></b>
Corrosion period: <b>30 - days</b>	Smear multiplicity: <b>4</b>			Nucleus size: <b>864 mm<sup>2</sup></b> ( 33% of bunch of feathers surface area )

Fig. 5. The view and the analysis of the bunch of feathers and the nuclei of the impact sparkle for the alloy AK9 of 300day corrosion

### 3. Conclusions

Following the carried out study we have demonstrated that:

- Shape change in the obtained impact sparkle bunches of feathers is essentially dependent on the grade of the analyzed aluminium alloy:
  - The sparkle bunches of feathers obtained from the sub - eutectic aluminium alloys (AK7, AK64 and AK9) feature very dynamic and defragmented form of detached hot particles.
  - The sparkle bunch of feathers obtained from the peri - eutectic aluminium alloy AK11 features lack of the compact nuclei made up from hot particles. This bunch of feathers is made from small number of detached burning hot particles.
- Most defragmented bunch of feathers is made from the burning hot particles obtained from the smear made from the alloy AK7.
- Impact of the multiplicity of the smears made from the analyzed aluminium alloys and length of the corrosion period for the steel plate have significant influence on the form of the impact sparkle bunch of feathers.
- The quantitative analysis performed for the digitally registered pictures of impact sparkles makes possible to determine the distribution of temperature and the surface area of the bunches of feathers and nuclei for the analyzed aluminium alloys.

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