Safe aluminium dosing in AAC plants

Daan R. van Boggelen

Aircrete Europe B.V., Oldenzaal, The Netherlands

Abstract: Aluminium handling and dosing in AAC plants has always been a complicated subject in terms of safety. In the last decade this safety issue has gained increased recognition in among AAC producers and equipment suppliers. Although there has been increased development and adoption of EU safety guidelines for explosive atmospheres, presently no clear guideline exists for aluminium dosing systems in AAC plants. Practically every AAC plant in the EU has a different aluminium dosing system in operation. Over the years, these systems have often been modified by plants themselves for safety improvement reasons. This article provides a path to improve safety on this specific application which applies to all AAC producers.

Keywords: AAC, autoclaved aerated concrete, aircrete europe, aluminium dosing, atex, safety, aircrete world

1. INTRODUCTION

For the production of autoclaved aerated concrete, aluminium is required. By adding aluminium to the raw slurry in the process, a chemical reaction takes place. This causes the gas bubbles in the aerated concrete slurry. Because aluminium powder is highly flammable, it needs to be added to the aerated concrete slurry through a special 'aluminium dosing system'. Nowadays, many relatively old aluminium dosing systems are operational worldwide. These systems do, on a large scale, not suffice to current safety regulations.

During the past three years, Aircrete Europe has conducted an extensive research on the use of aluminium within AAC plants. Over 30 different AAC plants were visited worldwide. The primary focus within this research was safety. Additionally various forms of aluminium were tested in order to increase product quality and optimize production efficiency.

2. PROBLEM BACKGROUND

Aluminium is used as a foaming agent in AAC production worldwide and it is widely proven as the best solution for its purpose. When aluminium is added (usually at about 0,2% to 0,5% by dry weight of cement) to the mixing ingredients, it reacts with hydroxide of calcium or alkali which liberates hydrogen gas ($3H_2$) and forms bubbles (1).

The speed at which the air bubbles form is critical to the success of the final aerated concrete product [4].

$$2Al + 3Ca(OH)_2 + 6H_2O \rightarrow 3CaO \cdot Al_2O_3 \cdot 6H_2O + 3H_2 \quad (1)$$

However, for as long as AAC has been manufactured, there have been problems regarding the dosing of batches of aluminium.

Fires and dust explosions are therefore no exceptions. Because of these problems, especially in western Europe, an increasing pressure from local authorities exists to improve safety. Plants within the EU will be obliged to respect safety regulations in the near future.

Aluminium is available in various forms. For the AAC industry the most used forms are powder and paste. Either one of these has its specific advantages and disadvantages regarding the production of autoclaved aerated concrete and will be described in the following subsections.

2.1. Aluminium powder

Aluminium powder can be divided into three classifications: atomized, flake and granules. In case of an atomized particle, its length, width and thickness are all of approximately the same order where the length or width of a flake particle maybe several hundred times it thickness [1]. Aluminium powder in the AAC industry is often made from foil scrap and exists of microscopic flake-shaped aluminium particles [5].

Aluminium powder with grain size less than 100µm and particularly with fractions less than 50µm, can easily form highly flammable aero suspensions (dust clouds) during pouring, on vibration, under shock, and so on [3]. This can cause dust explosions within the presence of an ignition source. In order to increase safety, it is advisable to use coarser aluminium powders with larger grain sizes (from 0,1 to 0,5 mm) [3].

However, the production of AAC requires aluminium powders that contain fractions finer than 100 or 50µm. This is important in order to obtain required mechanical properties of the aerated concrete. The finest aluminium powder for AAC production that is used by Aircrete Europe even has an average grain size of 20-45µm. A major advantage of using powders is that its reactivity is preserved when kept dry. This takes out much uncertainty from the casting process, since the required aluminium can be accurately dosed.

2.2. Aluminium pellets

In the case of very small grain sizes it is advisable to use micro-encapsulation (phlegmatization) techniques whereby a non-contaminating (organosilicon) binder is used to create bigger aluminium pellets from the small grain [6]. This phlegmatized powder is less liable to explode or catch fire. Micro encapsulated powder is safer in handling and use than powders, but care is still necessary due to the flammability of its organic solvent. Although safety in handling and use is increased, a major disadvantage of pellets, apart from increased cost, is that they negatively affect the quality of the end product significantly. AAC blocks do not show a homogeneous pore structure as is obtained by using powder [7]. This is due to the fact that micro encapsulated aluminium cannot be dispersed so finely through the slurry and does negatively affect homogeneity in the mechanical properties (eg. compressive strength) of the blocks produced. For the reasons mentioned above, this technique has been tested in the past but has never become widely used.

2.3. Aluminium paste

Another option is to use aluminium paste. Aluminium paste is made from powder and generally consists of microscopic flake-shaped aluminium particles finely dispersed in an organic-solvent or aqueous-based carrier. Just like pellets, aluminium paste is safer in handling and use than powders. Also here care is still necessary, especially when paste based on a (flammable) organic-solvent is used. Unlike powders and pellets, it is not possible to dose aluminium paste in batches without mixing the complete drum with water first. This is due to the fact that paste is very sticky which makes it impossible to dose without watering it down. Another problem with aluminium paste is that the quality of the aluminium brings uncertainty in the process. Aluminium in paste already reacts with its solvent at the moment it is mixed. From this moment until the moment it is mixed in the AAC production process, the aluminium slightly loses its reactivity. This makes that the amount of aluminium paste needed becomes uncertain for each casting and drum and can result in a high amount of aluminium waste and therefore high cost.

3. SAFETY AND GUIDELINES

Explosion or fire hazards in aluminium dosing systems in AAC plants can occur when several requirements are met. These requirements are shown in the explosion triangle in Fig. 1. A substance (eg. aluminium powder, hydrogen gas) is needed which forms an explosive mix with oxygen from the environment. Combined with a source of ignition (eg. fire, hot surfaces, mechanical sparks, static electricity, electrical sparks) this can lead to fire or a gas or dust explosion.

For the prevention of explosions, recent European safety regulations require newly built aluminium dosing systems to suffice to certain guidelines. These safety guidelines are referred to as the ATEX (ATmospheres EXplosibles) guidelines which are an addition to the machine guideline (2006/42/EG). Within these ATEX guidelines we distinguish the ATEX 95 and ATEX 137, whereby the ATEX 95 applies to the equipment and the ATEX 137 applies to the protection of health and safety of employees that operate in explosive atmospheres. Since the 1st of July 2003, all new jobs within the European Union need to be in compliance with the European ATEX 137 guidelines. In the Netherlands, the ATEX 137 guideline is part of the 'ARBO' regulations.

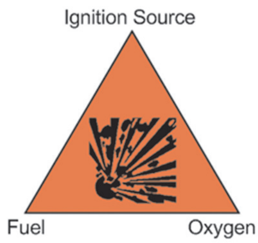

Fig. 1. Explosion Triangle

Table 1. Zone classification as meant in ATEX 137

Zone Classification	Gas/ Vapor	Dust
Continuous Hazard Source (≥ 1000 $\frac{hr}{yr}$ explosive atmosphere presence)	Zone 0	Zone 20
Primary Hazard Source (10 > and < 1000$\frac{hr}{yr}$ explosive atmosphere presence)	Zone 1	Zone 21
Secondary Hazard Source (≤ 10$\frac{hr}{yr}$ explosive atmosphere presence)	Zone 2	Zone 22

Figure 2 shows the relevance of ATEX regulations in a flow diagram. With respect to an aluminium dosing system, a possible explosion hazard exists since generally none of the three factors in the explosion triangle can be 100% eliminated. This makes that the ATEX 137 applies and that the aluminium system and its direct environment need to be classified in different hazard zones. The classification of zones can be conducted by using the EN60079-10 standard for gas explosion hazards and the EN50281-3 standard for dust explosion hazards. Possible zones from the ATEX 137 guideline are given in table 1 wherein zone 0 or 20 demand the highest explosion safety requirements. In relation to the aluminium dosing system, both ATEX 95 and ATEX 137 guidelines apply. Although the ATEX 137 guideline is the responsibility of the end user (the AAC plant), the system supplier will need to provide the zone classification and a detailed operating manual according to these guidelines.

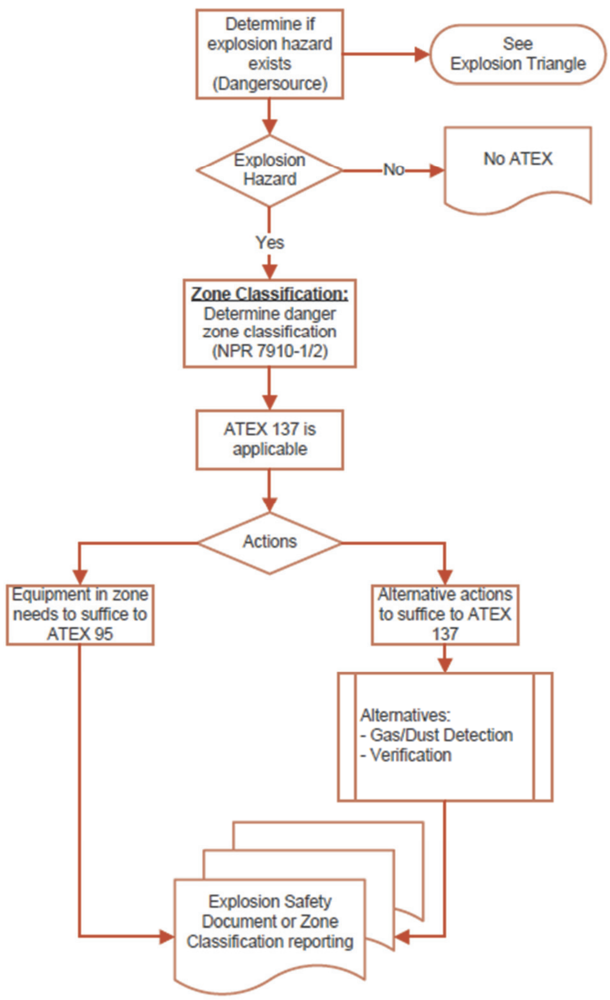

Fig. 2. ATEX Flow Diagram

In relation to the ATEX 95 guideline, other European standards like EN13463 (Non-electrical equipment for use in potentially explosive atmospheres) and EN61241 (Electrical apparatus for use in the presence of combustible dust) apply to the aluminium dosing system. In relation to the ATEX 137 guideline, the German 'Gesamtverband Der Aluminiumindustrie' has, in compliance with European standards, developed a detailed safety instructions manual for handling and processing aluminium powder [3].

4. CONCLUSIONS

Aluminium is used as a foaming agent to produce AAC. It can be concluded that aluminium powder is the best performing form of aluminium for AAC production when product quality and production costs are the most important performance measures. Use of powder results in the best and most homogeneous mechanical properties of AAC. Furthermore use of powder is more economical than paste since it gives less waste and brings more flexibility due to the fact that different powders can easily be used through one another.

A universal problem within AAC plants is the aluminium dosing system. Practically all plants around the globe have different systems in operation that are often modified by themselves or 3rd parties throughout the years. Due to the flammable properties of aluminium, especially within the EU, plants are more and more subject to stricter safety regulations regarding its use. These regulations include the ATEX 95 and 137 standards. Several plants have already modified their own aluminium dosing systems for safety reasons, but these systems rarely function well and do without exception not suffice to the latest safety regulations.

Aircrete Europe has conducted extensive research on the handling and dosing of aluminium in AAC production and has created a clear framework for AAC plants in improving safety, optimizing aluminium use and improving production quality. This enables AAC plants to make a step forward, and get rid of existing problems with aluminium installations.

BIBLIOGRAPHY

[1] The Aluminum Association. 02-2006. Recommendations for storage and handling of aluminum powders and paste. 4th edition. The Aluminum Association Inc., 1525 Wilson Boulevard, Suite 600, Arlington, VA 22209.

[2] Gesamtverband der Aluminiumindustrie, 2007. Safety instructions for handling and processing aluminium powder. http://www.aluinfo.de

[3] Gopienko V.G., 1999. Methods of reducing explosion hazards for aluminum powders, dusts, and pastes. Powder Metallurgy and Metal Ceramics, 38(9), 529-531.

[4] Holt E., Raivio P., 2005. Use of gasification residues in aerated autoclaved concrete. Cement and Concrete Research, 35(4), 796-802.

[5] Hong S.H., Kim B.K., 2001. Fabrication of aluminium flake powder from foil scrap by a wet ball milling process. Materials Letters, 51(2), 139-143.

[6] Neikov O.D., 2001. Reducing the danger of explosions in the production of powders of iron and its alloys by methods that involve mechanical comminution. Powder Metallurgy and Metal Ceramics, 40(1):90-95.
[7] Van Boggelen, D.R., 2010. Optimizing the use of aluminium in AAC production. Aircrete Europe. Oldenzaal.