Technical Report

Evolution of the ceramic welding application for the maintenance and repair of glass furnaces[1])

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1. Introduction

The principle of the ceramic welding process, which was first introduced to the glass industry several years ago, is based on the projection in an oxygen stream of a mixture of refractory and metallic powders onto the area being repaired. The most commonly used metallic fuel particles are silicon, aluminium and magnesium, whose oxidation reactions are shown in the following equations:

$$Si + O_2 \rightarrow SiO_2 + 880\ kJ/gramatom\ fuel, \quad (1)$$

$$Al + 3/4\ O_2 \rightarrow 1/2\ (Al_2O_3) + 838\ kJ/gramatom\ fuel, \quad (2)$$

$$Mg + 1/2\ O_2 \rightarrow MgO + 603\ kJ/gramatom\ fuel. \quad (3)$$

The art of the technique is to provoke an adjusted exothermic reaction, which partially or totally melts the projected particles and creates instantaneously a refractory bonding with the damaged refractory.

In order to convert the simple equations (1–3) of the oxidation reactions into a practicable process, there is an obvious need for efforts in various directions:

a) the design of the machine;
b) the safety aspects of the technique;

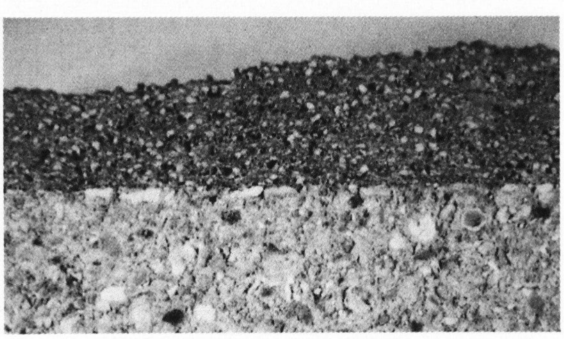


Figure 1. Ceramic welding on a silica brick.

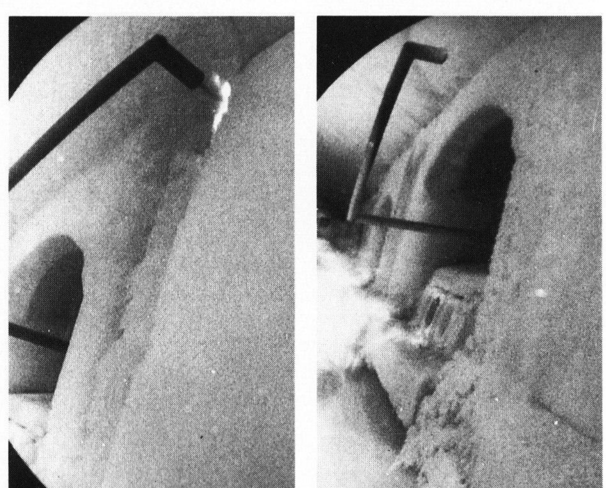
[1]) Presented in German on 31 May 1988 at the Annual Meeting of the German Society of Glass Technology (DGG) in Würzburg (FRG).

c) the design and construction of water-cooled lances which are resistant to wear and tear;
d) the elaboration of various lance techniques.

In previous papers [1 to 3] the elements have been discussed on which this process is based, as well as the effects with regard to the thermal and mechanical properties of the resulting welding mass.

The figures 1 and 2 are characteristic illustrations of this process and some of its products.

Figure 2. Ceramic welding and drilling on an electrofused AZS refractory.



Figures 3a and b. Repair work under endoscope control. A lance is pushed through the port neck; a) beginning of repair work, b) end of repair work.

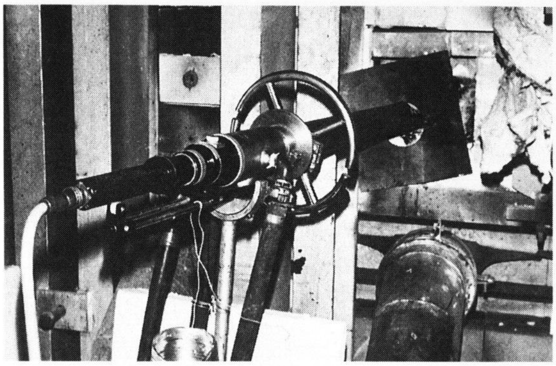
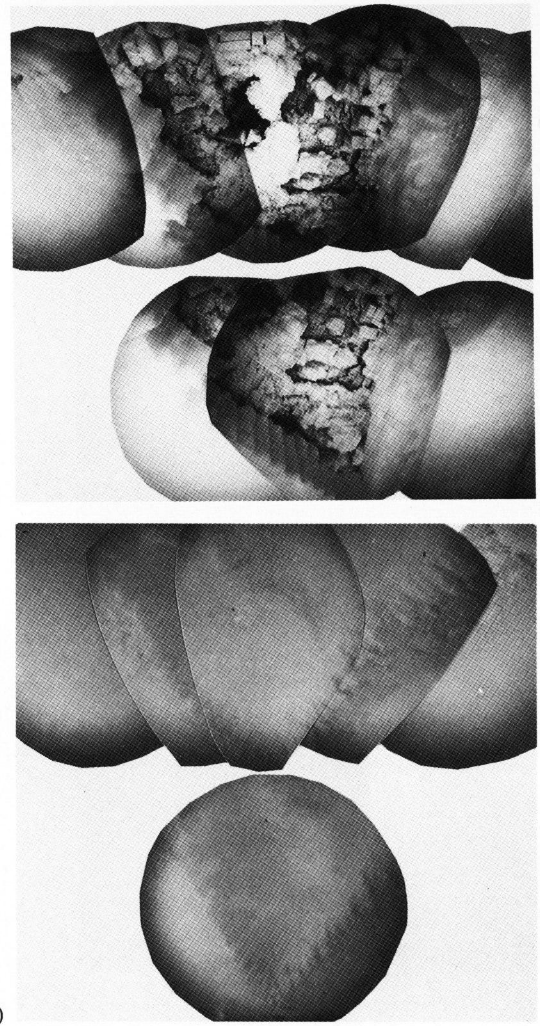


Figure 4. Installation of endoscope in furnace wall.



a)

b)

Figures 5a and b. Silica crown repair of an area which could not be ▶ observed directly and therefore the repair was carried out under endoscope control; a) before repair, b) after repair.

2. Practical results of the ceramic welding repair technique inside the glass tank

2.1. Repair work under endoscope control

The present paper deals with the practical results of this unique repair technique and aims to explain the innovations which have been introduced.

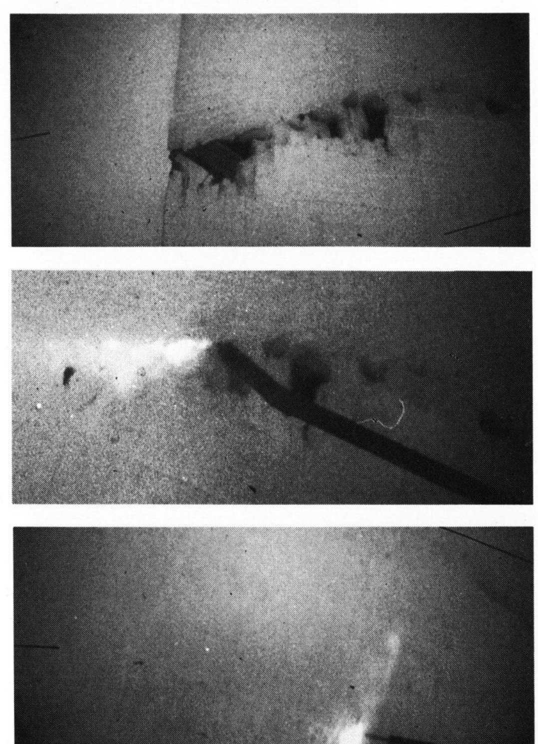
The latest development in the field of ceramic welding on glass tanks is the use of an endoscope equipped with a video camera and monitors. The endoscope permits a considerably better view of the area being repaired, and the welder is able to watch and control his work on the monitor. A repair can be carried out partially or totally by using an endoscope and monitor control, depending on the type of area in need of repair.

Figure 3a shows a 12 m lance being pushed through the port neck and demonstrates how precisely the whole repair work is under control. The endoscope was introduced via a neighbouring underport burner. Figure 3b shows the same area after repair work has been completed and the lance has been pulled back.

Three different types of endoscopes were employed, each with a different observation angle and adjusted visual fields, which means that virtually any point in the furnace can be inspected. The decision which endoscope is to be used depends on the position of the area in need of repair and the position of the opening through which the endoscope can best be inserted into the tank. The connected video camera projects a picture onto the monitor screen, enabling the welder to check the distance between the lance tip and the refractory. The figures 4 and 5 show a silica crown repair which was carried out only partially under endoscope control.

The use of an endoscope has also increased the application possibilities of the ceramic welding process, particularly in cases where the lances have to cross the flames or where the welder does not have a sufficiently good view of the repair zone because of the changing length of the flame. The figures 6a to c show the repair of a large gap between the crown and the front wall of an end-fired furnace. The lance and the endoscope are on opposite walls.

The use of an endoscope, moreover, allows welding which is less dependent on cycle time and facilitates the training of new welders.

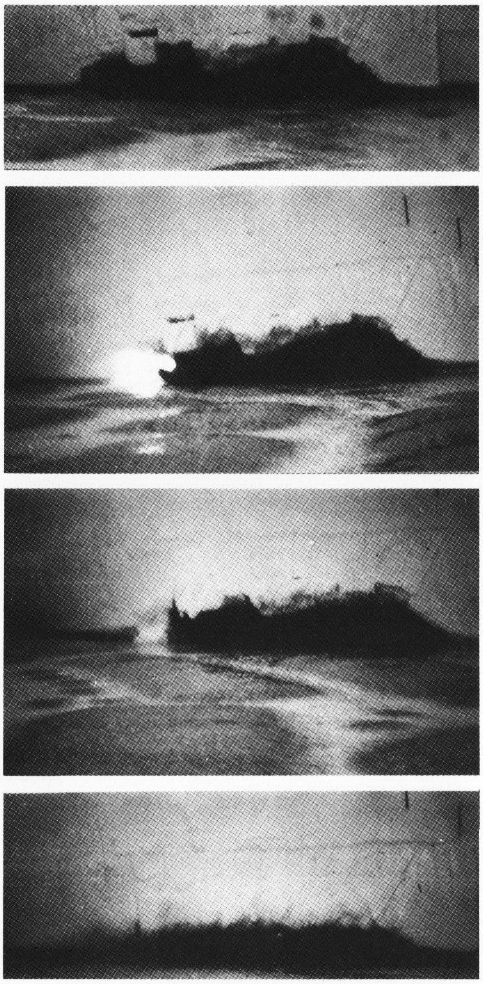


a)

b)

c)

Figures 6a to c. Repair of a large gap between the crown and the ▶ front wall of an end-fired furnace under endoscope control; a) view before repair, b) view during repair, c) view after repair.



a)
b)
c)
d)

Figures 7a to d. Sequence of operations of a non-insulated AZS doghouse arch; a) before repair work, b) and c) intermediate stages, d) after repair work.

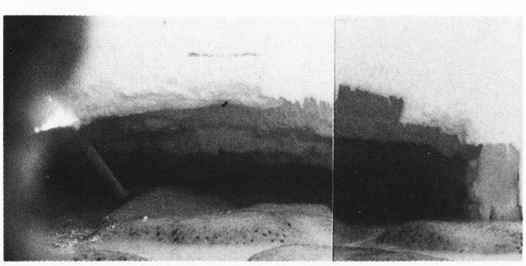


Figure 8. Insulated doghouse arch repair being controlled by endoscope (on right-hand side of figure).

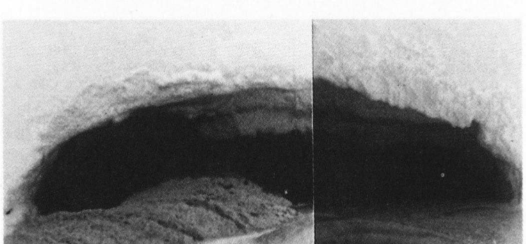
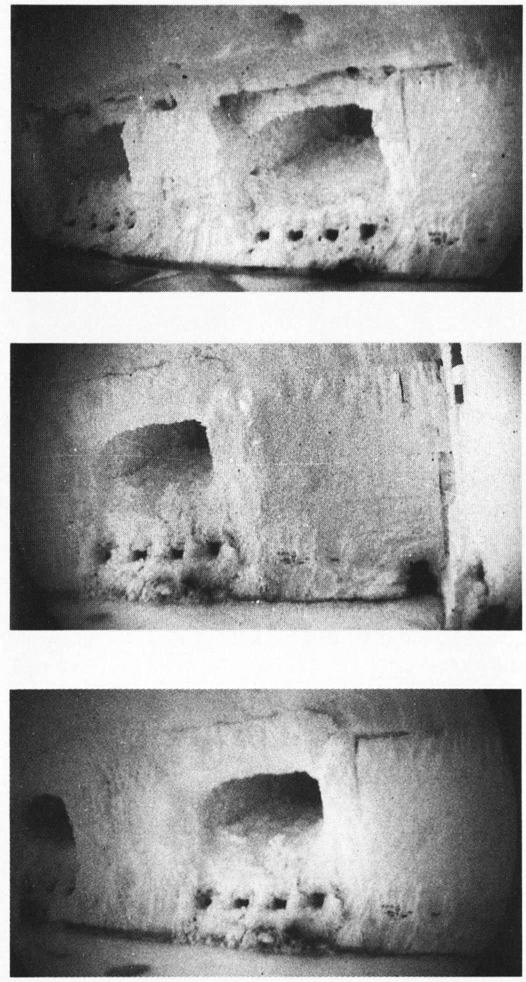


Figure 9. Insulated doghouse arch repair being controlled by endoscope (after completion of repair).



a)
b)
c)

Figures 10a to c. Illustration of repair work on the port bridges; a) state of port arches no. 1 and no. 2 before the repair, b) repair of port arch no. 1, c) repair of port arch no. 2.

2.2. Employment of different AZS masses

Another type of innovation was introduced by developing different AZS (Alumina-Zirconia-Silica brick) masses, rather than working with just one single AZS composition. The aim is to find specific solutions to defects on AZS burner ports, insulated or non-insulated doghouse arches, breastwalls, tuckstones, etc.

In general, the following features must be taken into account: the quality of the existing bricks, the temperature of the refractories to be repaired, the fluctuations in temperature, any possible mechanical stress and exposure of the damaged area to corrosive furnace atmosphere. By corrosive furnace atmosphere, alkalis, batch carry-over, waste gas velocity and the type of fuel used are understood.

The figures 7 to 12 demonstrate four different kinds of AZS repair, with the AZS mass adapted to suit each separate case, as follows:

a) Non-insulated AZS doghouse arch.

The figures 7a to d illustrate the sequence of events during the repair of a doghouse arch, as observed through the endoscope. Doghouse arches show a very irregular destruction pattern and observation by an endoscope is necessary in order to control the exact distance between the lance and each separate refractory brick. Endoscope inspections often reveal that the doghouse arches are much more severely damaged than normally expected, especially when inspected from underneath the arch.

b) Insulated doghouse arch.

Figure 8 illustrates the exothermic reaction being surveyed from the other side of the doghouse. Figure 9 shows the doghouse arch shortly before completion of the repair work.

c) Port bridges.

The figures 10a to c illustrate repair work on the port bridges (in this case port 1 and 2 on this tank). Figure 10a shows the completely vanished AZS port arch and the badly corroded superstructure. There is a pronounced joint between the AZS superstructure and the silica crown. A hole can be observed in the silica crown in front of the first port. Figure 10b shows the repair of port arch no. 1 using an AZS mix, while the joint and the hole were welded with a silica mix. The repair of port arch no. 2 using an AZS mix is illustrated in figure 10c.

d) Tank walls.

The next case refers to serious defects in a superstructure wall where the AZS blocks between the burners of an end-fired tank collapsed. Only the fireclay bricks behind them remained in place. Figure 11 shows the destruction of the backwall and figure 12 illustrates how the wall is completely restored by an AZS repair.

3. Practical results of the ceramic welding repair technique outside the glass tank

Defects on glass tanks are not restricted to the inside of a tank. Defects such as instability of the breastwalls with blocks sliding inwards, assault of waste gases on the metal anchorage and corrosion due to porous joints can make everyday life very difficult for the tank personnel. Defects which arise in places where the temperature is low can also be repaired by ceramic welding using a silica mass or a low temperature AZS mass which is another recent development. These masses are very effective at temperatures of 800 °C and above, and can be applied by means of uncooled lances from outside the tank.

The repair of a joint in the crown using a silica mass applied from outside, and a repair done from the outside on a non-insulated AZS doghouse arch using a low temperature AZS mass are possible too. By using this type of low temperature AZS mass, AZS breastwall blocks could several times be stopped from moving.

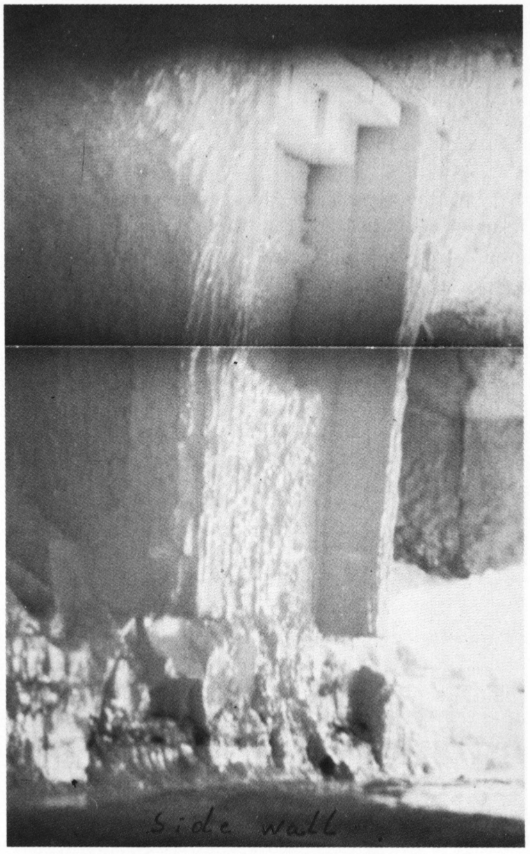


Figure 11. Collapsed AZS wall between both burners.

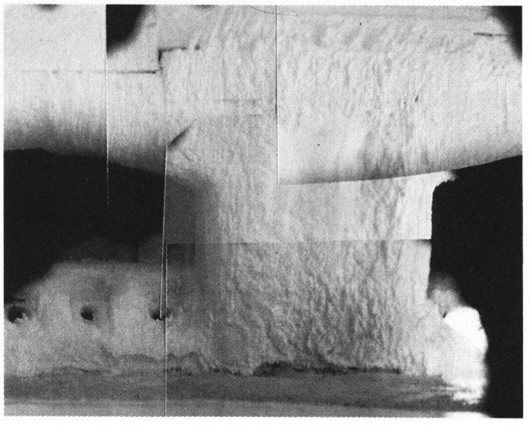


Figure 12. The completed AZS repair.

4. References

[1] Plumat, R.; Deschepper, P.; Robyn, P.: Application du procédé d'oxythermie à l'entretien et la réparation des fours de verrerie. Riv. Stn. Sper. Vetro **12** (1982) no. 5, p. 172–180.

[2] Deschepper, P.; Robyn, P.: Application of the ceramic welding process to maintenance and repair of glass furnaces. Interceram **35** (1986) Special issue, p. 70–72.

[3] Deschepper, P.; Robyn, P.: Application of the ceramic welding process to the maintenance and the repair of glass furnaces. Ceram. Eng. Sci. Proc. **7** (1986) no. 3/4, p. 506–528.

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Scientific/Technical News

2nd International Symposium on Ceramics in Medicine

This symposium will take place in Heidelberg (FRG) on September 10 to 11, 1989 in conjunction with and immediately following after the 8th European Conference on Biomaterials, both meetings being organized by the European Society for Biomaterials.

It is the aim of this 2nd symposium to continue bringing together those actively contributing to the field of bioceramics and to offer the possibility of an exchange of most recent results and discussion of the conclusions to be drawn from the present day knowledge. In accordance with the standards set by the first symposium at Kyoto (Japan) in 1988, the papers for oral presentation have been selected and composed to cover the more basic and general aspects of research, testing, application and on results of clinical follow-up studies. The poster sessions are intended to provide ample opportunity for detailed discussions on more special problems, systems, and devices.

Glasses and glass-ceramics will be topics of the surveying session as well as of one of the poster and one of the paper sessions.

For more information please contact: Deutsche Keramische Gesellschaft e. V., Attn. Prof. Dr. G. Heimke, Frankfurter Str. 196, D-5000 Köln 90 (FRG).