Cracks as Curiosity: Replicating the Production of Historic Spiral-Crack-Glasses Based on Source Texts

ABSTRACT

Spiral-crack-glasses from the 14th-19th century, found sporadically in Central Europe, are drinking glasses that were furnished with a circulating crack in the form of a spiral. These objects were produced to demonstrate flexibility, a property usually not associated with glass, and thus to elicit one's curiosity. Further source research on production techniques for these vessels led to a wider insight into their cultural-historical context and the identification of several 'recipes' originating from the 16th-19th century. The given instructions were categorised according to tools mentioned and their application, prior to setting up experimental series to test their practicality. Spiral-cracks in glass vessels are accurately reproducible by applying heat following a pre-scribed line, with simple tools, and in an uncomplicated manner. Questions concerning the historical background and the manufacturing techniques of spiral-crack-glasses were answered, while new ones were established.

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KEYWORDS

Cutting glass · Flexible glass · Glass cracks · Spiral-crack-glass

INTRODUCTION

In a recent review, Krueger (2018) discusses the cultural-historical background and the state of research concerning spiral-crack-glasses. These are drinking glasses that, after the manufacture of the vessels themselves, were furnished with a circulating crack, appearing like a spiral when reflecting the light. With no force applied to the object, liquids within the glass cannot penetrate the crack. By pulling up on the rim, the glass has enough elasticity that the crack can open and the liquid can pass through. As a result of this behaviour, spiral-crack-glasses soon became more than mere trick glasses for entertainment, but objects that evoke curiosity. The glasses were likely produced from the 14th century until the end of the 19th century. Despite this long production period, preserved examples seem to be very rare. Most known and published objects are from excavations and collections in Austria, the Czech Republic, and Germany (Figures 1 and 2). These are mostly of small diameter, with rather steep to vertical walls with spiral-cracks following a straight, wavy, or zig-zag line. The distance between the cracks varies from 0.5 cm to 2.0 cm. Earlier objects have a wall thickness of approximately 1.0 mm, while examples from the 19th century tend to have slightly thicker walls. Spiral-crack-glasses have been the subject of cultural-historical research since the late 19th century. The known text sources that mention them and their production are a sermon of reformer Johannes Mathesius from 1562, as well

Figure 1. *Spiral-crack-glass, ca. 17th century CE, H 8.0 cm. Museum Lüneburg, Inv. No. 34 · Courtesy of Ingeborg Krueger*

Figure 2. *Spiral-crack-glass, ca. 19th century CE, H 9.0 cm. Museum of Decorative Arts, Prague, Inv. No. 10360 · Courtesy of Gabriel Urbánek*

as an entry in the encyclopaedia of Johann Georg Krünitz from 1779. Nevertheless, not much is known about the techniques to produce these objects. By further research and experimentation based on primary sources, the present work aims to study this aspect of a noteworthy type of glass vessel.

SOURCE TEXT RESEARCH

The earliest known text describing spiral-crack-glasses is Mathesius's (1562, 278) sermon 'Of Glassmaking': 'One can also crack up drinking glasses with a hot iron / like window makers cut their glass panels / when they wet the warm glass / that they can be stretched / and nevertheless when you let them go again / hold wine.' Though brief, the description provides some information. The tool applied is a hot iron, usually used to cut glass panes for their assembly in stained-glass windows. It is notable that Mathesius must have seen the process and the product himself, such that spiral-crack-glasses must have been familiar at least to some people.

Detailed instructions to produce spiral-cracks in beer glasses can be found in a 1676 compilation of magical tricks, *Sports and Pastimes*: A 'well dried matchcord' with a 'good coal' is used to heat up the glass rim, which thereafter is abruptly chilled with a wetted finger, causing an initial crack to form. To elongate the crack the ember should be held in the ever same distance to the end of the crack, directing it in 'screw fashion' to the bottom of the glass. It is noted that the procedure can be carried out forming a waved crack line as well. The instructions are followed by a description on how to use the glass. When it is held at the bottom and turned upside down, the spiral opens. Turned around again, 'you may drink a glass of Beer in it and not spill a drop.' The passage ends with the note: 'This I learnt from an ingenious German.' (M. 1676, 31). While the glasses were seen here as objects for amusement and entertainment, their properties were considered in the context of the natural sciences in *Arts Improvements* (S. 1703, 219-220).

Schröder and Hoffmann's 1693 pharmaceutical text *Vollständige und Nutzreiche Apotheke* describes various ways to cut off unpleasantly formed rims of alembics and other glass vessels. According to the first variant, to cut thinner glasses, a glowing iron is held to the glass rim to heat it up before cold water is spilled on the spot to create an initial crack. It is subsequently steered and elongated by application of a glowing coal. Following the second variant, which is proclaimed to work even better than the first, it is necessary to notch the glass surface at the rim where the initial crack is intended, using a flintstone. On the inside of the glass, the spot is wetted with spittle, whilst a burning slowmatch is placed on the outside. By blowing steadily on the ember, a crack will form and follow the slowmatch as it is pulled over the glass. Afterwards spiral-crack-glasses are mentioned: 'Besides this beneficial use one can for delight use this manner of cutting glasses / for one can cut drinking glasses / that they hang like a chain and yet / when they fall into themselves / hold beverages' (Schröder and Hoffmann 1693, 38).

The famous natural scientist Robert Boyle (1627-1692) experimented with the flexibility of a spiral-crack-glass himself, pointing out that motions in stiff bodies are illustrated by these very vividly (Shaw 1738, 491-492).

The text on how to produce spiral-crack-glasses, formerly related to Krünitz (1779, 750), is, in fact, found in several encyclopaedic sources or collections of magical tricks and alleged miraculous remedies from the 18th and 19th centuries. The oldest of these sources is the *Onomatologia Curiosa Artificiosa et Magica* by an anonymous author from 1759. Lecturing about the properties of the material, the first of almost 20 entries under the heading 'Glas' describes the production of spiral-crack-glasses. The instructions in 'To artificially cut a glass from top to bottom' start with the drawing of the intended 'scroll-line' on the cup of a pure glass goblet using ink. With the area where the line begins, the rim is then held to a 'burning light'. To provoke the initial crack, the spot is chilled by tapping a spittle-wetted finger on it, but it is also mentioned that others create this crack using a diamond. Afterwards, two burning slowmatches are used alternately to direct the crack along the drawn line. One slowmatch is used until it is dull, while the other is hung upside down to regenerate a pointy ember for further use. The explanations are followed by the hint to create a 'diagonally line' at the end of the crack 'to hold the glass firmly together', as well as by the advice to keep a distance of about one or one and a half fingers to the bottom of the glass to preserve its strength. The function of the glass is explained afterwards: 'After this the cut glass hangs together so tightly, that it can hold beverages, and when empty, can be drawn as a curiosity, which then by itself, because it is elastic, will get together again, that one can drink out of it.' The subsequent two paragraphs in the *Onomatologia* also describe the making of spiral-crack-glasses: the first technique utilises a turpentine-soaked thread tied around the glass, ignited and extinguished with 'several drops of water'. The second description reads, 'one can take a glass filled with brandy, ignite such, and when the flame has gone out, wash the glass all around.' (Anon. 1759, column 728). In fact, both instructions can be predated at least to Simon Witgeest's *Neueröffnete Raritäten- und Kunst-Kammer*, a German translation that clearly refers to both as techniques to cut off broken glass rims (Witgeest 1702, 646). While the application of a burning thread to create spiral-crack-glasses seems improbable, the technique involving the glass filled with brandy is unimaginable.

In 1801, an English translation of M. L. Despiau's *Choix d'Amusements Physiques et Mathématiques* provides instructions to create spiral-crack-glasses under the headline 'Method of Cutting Glass by the means of Heat.' A 'lighted match' is used to create and direct the crack to 'form a sort of scroll'. Glass tubes can be cut by notching them with a file and afterwards using 'a piece of angular iron made red hot.' (Despiau 1801, 273)

In his textbook on chemistry, Jöns Jacob Berzelius sees the production of the spiral-crack-glasses as a 'common trick in which beginners practice' and describes the application of a cracking coal made according to his own recipe: 'At the beginning of the spiral one makes a file mark into the rim of the glass, of which one cuts the spiral further with

	TEST A	TEST B	TEST C	TEST D
Series 1 Slow-burning materials: incense sticks	No pre-treatment	Rim and crack end notched	Crack course scored over entire length	-
Series 2 Intensely heated materials: soldering iron	No pre-treatment	Rim and crack end notched	Crack course scored over entire length	-
Series 3 Combustible materials: turpentine-soaked thread	Rim and crack end notched	Crack course scored over entire length	Horizontally notched	-
Series 4 Crack course: wavy or zig-zag	Rim and crack end notched		Crack course scored over entire length	
	Soldering iron	Incense sticks	Soldering iron	Incense sticks
Series 5 Smallest possible distance between adjacent cracks	Approximating two linear cracks	Approximating wavy and zig-zag cracks	-	-
Series 6 Effect of a redirected crack end	Crack end not altered	Crack end vertically redirected to the top	Crack end vertically redirected to the bottom	-

Table 1. *Experimental series 1 to 6*

cracking coal'. At the end, Berzelius gives another explanation of the function: 'A so cut glass can be filled with water, however if one tries to lift it up, the spiral opens, without breaking, and the water runs out.' (Berzelius 1831, 879)

Spiral-crack-glasses appear in Heinrich Leng's *Vollständiges Handbuch der Glasfabrikation nach allen ihren Haupt- und Nebenzweigen*, a book addressed to glass workers. For the initial crack, the glass rim is heated up with a flame and then wetted with water. A pencil-like chip of beech wood is ignited at the tip forming an ember, which can be drawn slowly over the glass 'in a screw-fashioned or another crooked line'. Following on, Leng declares that the crack might also be achieved by applying the cracking coal as described by Berzelius. (Leng 1835, 49)

Generally, forming the crack, as described in text sources, is always carried out by introducing heat into the glass, leading to high local variations in temperature. The way in which the heat is provided differs, however, and allows categorisation of the techniques based on their effective principles. One has to distinguish between tools such as hot or glowing irons, which are intensely heated prior to application to the glass, and materials which provide heat via combustion. The latter can further be divided into glowing, or slow-burning, materials such as wood chips, charcoal, slowmatches, and cracking coal, and materials that burn with an open flame, namely turpentine-soaked burning threads and brandy inside the glass. In some cases, notching the glass as a preparatory step is described, utilising flint or diamond. Source texts mentioning files for notching were not found until after the experimental methods for this research were already established, hence this tool was not included.

EXPERIMENTAL SERIES

Preliminary tests with common wine goblets were carried out to evaluate the application of tools and materials mentioned in the source texts. The goal was to assign a representative method for the formation of a crack to each category defined in advance. In addition, tools were tested for their effectiveness in notching the glasses prior to the heat treatment.

Following the analyses of the source texts mentioned above, and after evaluating the preliminary test results, six experimental series were designed (Table 1). Industrially produced glasses were chosen as samples for testing because of their uniformity and dimensional similarity to the historical examples. Cylindrical tumblers with a height of 10.5 cm and a diameter of 6.5 cm were selected (Figure 3). In a deviation from the above mentioned principle, the walls of the industrially produced glasses were thicker than those of the historic ones, being 1.5 mm thick at the rim and increasing slightly to 2.5 mm at the base. The variation in wall thickness was accepted in order to demonstrate possible differences in efficacy of the various techniques.

The first three series focused on the practicality of methods using a representative tool from each category (Figure 4). In series 1, test glasses were treated with incense sticks as an example of a slow-burning material considered to have similar properties to slowmatches or cracking coal. In series 2, a soldering iron was used as the representative intensely heated material, as this was considered to be a good substitute for a hot or glowing iron. In series 3, a burning thread was used as the combustible material, burning with an open flame. The crack at the rim of the glass was initiated by placing a small drop of water on the object's exterior immediately after heating the interior at the intended location.

Taking into account that most of the historical spiral-crack-glasses show cracks that follow a wavy or zig-zag line, series 4 was conceived to determine if these patterns are reproducible by applying techniques described in the source texts. The burning thread method was excluded from this series because it would not be possible to arrange the turpentine-soaked thread suitably before most of the solvent evaporated and the thread lost adherence to the glass.

In addition, series 1 through 4 were planned to indicate the effect of notching or scoring the glasses following the predetermined line in preparation for creating the crack. Series 1 and 2 were therefore subdivided into tests a, b, and c. The setup for the a-tests used samples without any preparation except for the drawn crack line. For the b-tests, the origin of the initial crack and the terminus of the crack were notched, prior to creating the crack. For the c-tests, the intended crack line was preliminarily scored over its entire length. The glass for test 3a was prepared in the same way as described for tests 1b and 2b; the glass for test 3b was prepared as described for tests 1c and 2c. Test 3c was intended to evaluate the suitability of the method for cutting off the rim of a glass by creating a horizontally circulating crack; therefore, the glass was notched approximately 2.5 cm below the rim. While the glasses in tests 4c and 4d were scored over the full length of the crack course, in tests 4a and 4b, only the origin and terminus of the crack were notched. In tests 4a and 4c, the glasses were treated with the soldering iron, and in tests 4b and 4d, incense sticks were used. A diamond cutter was used to notch the glass immediately prior to applying heat to create the crack.

To ensure comparability of results of series 1 through 3, the dimensions of the sample glasses and the predetermined courses of the cracks were the same . For series 4, the overall crack course was the same as in series 1 through 3, with the upper section of the helix having a wavy pattern, and the lower section having a zig-zag pattern (Figure 3).

The results of series 1 through 3 were used to inform the tool selection for series 5 and 6.

Series 5 investigated how tight a spiral could be maintained without the adjacent cracks converging, thus breaking the glass; this series was inspired by historic examples of spiral-crack-glasses with intervals between cracks of only 0.5 cm in width. In test 5a, two cracks were initiated beginning on opposite sides of the glass rim. Test 5b focused on wavy and zig-zag lines (Figure 3).

Series 6 was designed to evaluate how a diagonal crack end could influence the mechanical stability of a spiral-crack-glass, as implied in the *Onomatologia* (Anon. 1759, column 728). Each sample glass was given a crack with a course of 1.0

Figure 3. *Prepared sample glasses for series 1 and 2 (above left), 4 (above right), test 5a (below left), and 5b (below right)*

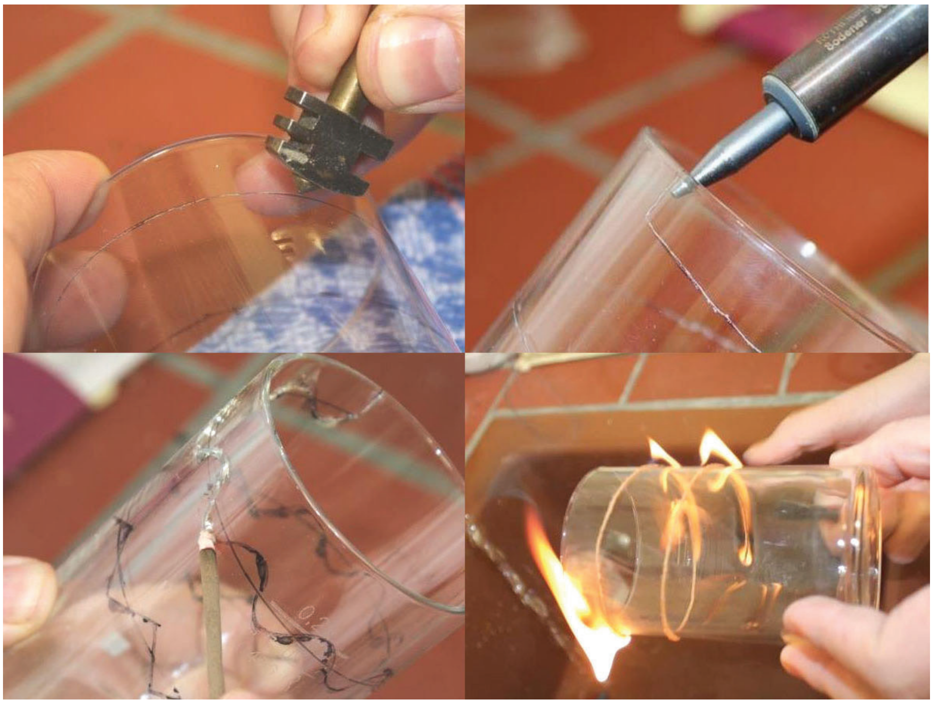

Figure 4. *Notching the glass with a diamond point (above left), forming an initial crack with a soldering iron (above right), and crack propagation with an incense stick (below left) and with a turpentine-soaked thread (below right)*

cm vertically down from the rim and a subsequent course of 6.0 cm with an inclination of 8° to the horizontal, totalling a vertical distance of 1.6 cm from the rim to the end of the crack. In test 6a, the end of the crack was not further altered. In test 6b, the beginning of the crack was redirected vertically over 2.0 mm to the rim of the glass. In test 6c, the end of the crack was redirected 2.0 mm vertically toward the bottom of the glass. With a distance to the initial crack of 1.0 cm down from the rim, a loop made of iron wire was fixed using Araldite 2020. After polymerisation of the epoxy resin, a spring tension force scale was hooked to the loop. The value displayed when the glass broke was recorded.

RESULTS

The experimental series answered several questions about production techniques for spiral-crack-glasses. Sample glass wall thickness and whether or not the surface was notched prior to heating influences the efficacy of creating a crack. With thinner walls, the glasses from the preliminary tests were cracked without prior notching. The slightly thicker sample glasses used for the actual examination series required pre-treatment of notching in order to propagate a crack. Scoring the glasses along a straight, predetermined crack course in series 1 through 3 was achieved with only few deviations from the drawn line. As expected, creating a spiral-crack with a turpentine-soaked burning thread in series 3 was not achievable; however, despite some small irregularities, separating the rim of the glass using this technique worked reasonably well in test 3c. The incense sticks and soldering iron used in series 1 and 2, respectively, proved to be effective instruments for creating and controlling a spiral-crack (Figure 5). Applying a soldering iron was faster than using incense sticks; however, this manifested clicking sounds and occasional small splinters, suggesting more abrupt release of internal tensions in the glass. Generally, both methods proved effective, with the soldering iron achieving results closest to the predetermined line. Incense sticks caused a slightly less precise result, likely because of their wider contact points with the glass. A crack course scored over its entire length led to the crack propagating significantly faster, especially when using the soldering iron. It did, however, also produce a less precise result. Notching the glass prior to heat treatment did not accelerate crack propagation in experiments using incense sticks.

In series 4, the creation of a crack following a wavy or zig-zag line was achieved by applying either a soldering iron or incense sticks (Figure 5). For the glasses which were not further scored, crack formation was controllable with only small deviations from the predetermined line (Figure 6). Compared with creating cracks following a straight line, zig-zag cracks propagated more slowly. Producing cracks following a wavy line proceeded significantly more slowly, and progress was jerky and less smooth, occasionally resulting in rough curves. It was not possible to score the crack course over its total length without major deviations from the line and frequent slipping of the diamond cutter, causing undesirable scratches over the glass surface. In addition, the subsequent heat treatment was less effective, as the crack was difficult to control and followed neither the drawn nor the scored line, particularly for the wavy pattern. Thus it was found that the time-consuming pre-scoring of the crack course for zig-zag lines provided no advantage. This was even more pronounced for wavy lines. It prolonged the work process and led to an unaesthetic object with scratches, irregular crack lines, and even broken-out shards (Figure 6).

It was assumed that closely adjacent cracks would conjoin, causing the glass to break, thus limiting the possible tightness of the spiral. In fact, this was not the case, as demonstrated in experimental series 5. In test 5a, it was possible to create cracks separated by only 4.0 mm, twice the wall thickness of the glass, before there was any negative effect on crack formation. Attempts to further reduce the distance between adjacent cracks resulted in slow and unsteady crack formation on the inner wall of the glass. A minimum distance of 2.0 mm between cracks was achieved, after which the second crack 'escaped' by diverging from the first (Figure 7). A similar behaviour was observed in test 5b, in which the crack was directed to a distance of 3.0 mm from the above crack, twice the thickness of the glass (Figure 5). This crack stopped in the area of the wavy crack and could not be further propagated.

The results of series 6 suggest that redirecting the end of the crack might influence the mechanical

Figure 5. *Glasses from tests 2b (left) and 5b (right)*

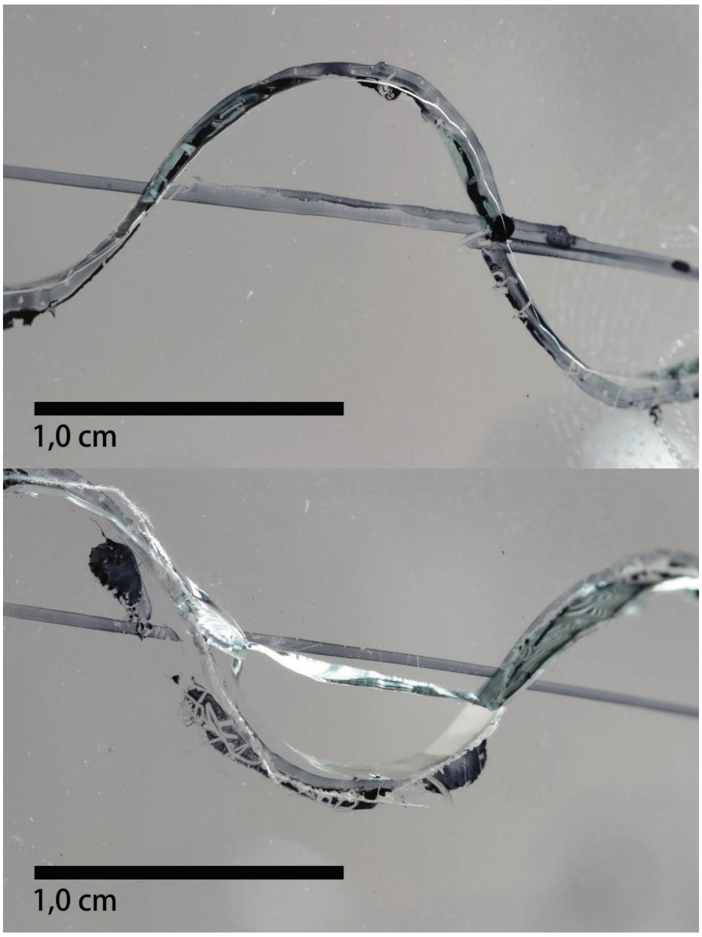

Figure 6. *Detail of the crack lines from tests 4a (above) and 4c (below)*

Figure 7. *Test 5a, adjacent cracks*

stability of spiral-crack-glasses. The test 6a glass, whose crack was not further altered, and the test 6b glass, whose crack was redirected vertically to the rim, withstood approximately the same strain before breaking. As measured with the force scale, the strain needed to break the test 6c glass was four times higher as compared to the test 6a and 6b glasses. It should be noted that the end of the crack in test 6c was farther from the rim than in test 6b; however, the same is true of test 6b as compared to test 6a, where no significant difference in ultimate strain was noted.

CONCLUSIONS

Spiral-crack-glasses can be reproduced following the instructions from primary source texts in a relatively short time by novice practitioners using simple tools and materials, leading to a high level of accuracy even for complicated crack courses. Filled with water in subsequent tests, the experimentally reproduced examples performed just as described in the source texts. With the exception of Leng (1835, 49), explanations in primary sources were not addressed to professionals working in glass manufacturing, suggesting that lay people were producers of spiral-crack-glasses, at least until the 19th century. Spiral-crack-glasses appear in source texts from various contexts and different countries. As Krueger (2018) has previously asserted, these objects must not be seen only as trick glasses for common amusement, but as objects whose properties fascinated people and sparked interest even among early natural scientists. As few historic examples survive, a survey documenting properties of existing pieces would facilitate further study of these objects. In addition, we assume there are spiral-crack-glasses that may not yet be known as such, particularly in countries without already known examples. Further investigation may lead to a more comprehensive understanding of the technical and historical aspects of these astonishing pieces made for contemplation and delight.

ACKNOWLEDGEMENTS

Our heartfelt thanks go to art historian Dr. Ingeborg Krueger, whose passionate enthusiasm on the matter provided the impetus for commencing upon this work.

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