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Blown glass in Ukraine: Historical and technological features in comparison with Murano and Bohemian glass traditions

Abstract. *The purpose of this study is to identify the historical and technological characteristics of Ukrainian blown glass through a comparative analysis of Ukrainian, Murano, and Bohemian glassmaking traditions. The article examines the development of glass production in Ukrainian lands from the sixteenth century to the twentieth century and evaluates its place within the broader context of European glassmaking. The research is based on methods of historical analysis, comparative technological analysis, and material culture studies. The source base includes historical, archaeological, archaeometric, and art-historical publications devoted to glassmaking technologies, forest glassworks, artistic glass production, and the preservation of traditional manufacturing knowledge. Particular attention is paid to the technological aspects of glass production, including raw materials, glass compositions, furnace technologies, manufacturing practices, and mechanisms of technological knowledge*

transmission. The study demonstrates that Ukrainian blown glass developed under conditions significantly different from those that shaped the Murano and Bohemian traditions. Unlike the highly regulated and centralized production system of Murano, Ukrainian glassmaking evolved through a decentralized network of forest glassworks dependent on local resources and empirical knowledge. In contrast to the increasingly standardized and export-oriented Bohemian model, Ukrainian hutas remained closely connected to regional markets and adapted production technologies to local environmental and economic conditions. The research shows that the technological characteristics of Ukrainian blown glass, including chemical variability, visible inclusions, colour variations, and irregular forms, were direct consequences of the production environment and should be interpreted as material evidence of historical manufacturing processes rather than solely as indicators of technological limitations. The article further analyses the transformation of huta traditions during the twentieth century. It is demonstrated that many technological practices associated with historical forest glassworks survived within artistic glass production, educational institutions, and professional communities. As a result, huta technologies gradually evolved from a regional manufacturing system into a form of technological and cultural heritage. The study concludes that Ukrainian blown glass should be regarded as a distinct historical and technological trajectory within European glassmaking rather than as a peripheral variant of the Murano or Bohemian traditions. The comparative analysis highlights the diversity of technological solutions that coexisted in European glass production and contributes to a broader understanding of the relationship between technology, craft knowledge, natural resources, and cultural development in the history of material technologies.

Keywords: *Ukrainian huta glass; decorative arts; glassmaking technology; glass art; glassware design; museum glass collections*

Introduction.

Glassmaking belongs to the oldest technological activities in human history and has accompanied the development of societies for more than two millennia. Throughout this period, glass served not only as a material for utilitarian and decorative objects but also as a medium through which technological knowledge, manufacturing skills, and craft traditions were accumulated and transmitted. Although the basic principles of glass production remained relatively stable over long periods, the technological systems that emerged in different regions of Europe varied considerably according to available raw materials, fuel resources, production organization, and market conditions. As a result, historical glass objects provide important evidence for studying the interaction between technology, economy, and culture.

Among the best-known European centres of glass production were Murano near Venice and the glassmaking regions of Bohemia. Both achieved international recognition and exerted a lasting influence on the development of European

glassmaking. Murano became famous for the production of highly transparent *cristallo* and for a manufacturing system based on institutional control, technological specialization, and the protection of production knowledge. Research has demonstrated that the success of the Venetian industry depended not only on technological innovation but also on the ability of the Venetian Republic to regulate the movement of skilled craftsmen and maintain control over specialized manufacturing expertise (De Raedt, Janssens, Veeckman, Vincze, Vekemans, & Jeffries, 2001; Trivellato, 2006; Veronesi, 2024). Bohemian glassmaking followed a different path. Relying on forest resources and potash-based glass compositions, Bohemian producers gradually developed a technologically distinctive tradition that culminated in the emergence of crystal glass during the seventeenth and eighteenth centuries (Ogilvie, 2014; Pánová, Jílková, Rohanová, Lahodný, Galusková, & Míka, 2021). Recent archaeometric studies have confirmed the importance of potassium-rich glass systems in the formation of Bohemian glass technology and have highlighted significant differences between Bohemian and Venetian production traditions (Cílová & Woitsch, 2012; Pánová, Rohanová, & Randáková, 2020).

The history of glassmaking in Ukrainian lands evolved under different environmental and economic conditions. From the sixteenth century onward, numerous forest glassworks operated in Volhynia, Polissia, Galicia, and Podillia (Hoshko, 1991; Rozhankivskyi, 1959). These enterprises, commonly known as *hutas*, formed part of a broader Central and Eastern European tradition of forest glass production. Their operation depended on local deposits of silica sand, large quantities of wood fuel, and potash obtained from plant ash. Unlike the concentrated and highly regulated production systems of Murano, Ukrainian glassmaking developed through a dispersed network of relatively small workshops closely connected with woodland resources, estate economies, and regional markets.

The technological consequences of this production model were significant. Variability in raw materials, furnace conditions, and manufacturing practices frequently produced glass with visible bubbles, inclusions, colour variations, and asymmetrical forms. While such characteristics are often evaluated negatively from the perspective of modern industrial standards, they constitute valuable evidence for historians of technology because they preserve information about production environments, material constraints, and manufacturing practices. Historical glass therefore represents more than a finished artefact; it serves as a material record of technological processes and technological knowledge.

In recent decades, scholars have substantially expanded knowledge of historical glassmaking in Europe through the combined use of historical, archaeological, and archaeometric methods. Studies of Murano and Bohemian glass have generated extensive literature devoted to production technologies, raw materials, trade networks, and technological innovation. Research on Ukrainian glassmaking has likewise advanced considerably, particularly regarding the geography of glassmaking centres,

the economic role of forest glassworks, and the artistic characteristics of historical glass artefacts. Nevertheless, Ukrainian blown glass continues to be examined primarily within archaeological, ethnographic, or art-historical frameworks. Comparative studies that analyse Ukrainian glassmaking alongside the major European glass traditions from the perspective of the history of technology remain relatively limited.

This situation raises several important questions. To what extent did Ukrainian blown glass share technological characteristics with the better-known glassmaking traditions of Murano and Bohemia? How did differences in natural resources, production organization, and systems of knowledge transmission influence the development of these traditions? Can Ukrainian huta production be understood merely as a regional manifestation of broader European processes, or did it represent a distinct technological trajectory within the history of glassmaking?

The aim of this article is to analyse the historical and technological development of Ukrainian blown glass in comparison with the Murano and Bohemian glassmaking traditions and to determine the factors that shaped its distinctive trajectory within European glass production.

To achieve this aim, the study examines the origins and development of blown glass production in Ukrainian lands, analyses the technological characteristics of raw materials, furnaces, and manufacturing practices, investigates the organizational and technological features of the Murano and Bohemian glassmaking centres, and compares these traditions with Ukrainian glassmaking from the perspective of production systems, technological knowledge, and material technologies. Particular attention is also paid to the transformation of huta traditions during the twentieth century, when many elements of historical glassmaking survived within artistic production, educational institutions, and heritage practices.

Unlike most previous studies, which have examined Ukrainian glassmaking primarily through archaeological, ethnographic, or art-historical approaches, this article considers blown glass as a technological system. The novelty of the study lies in the comparative analysis of Ukrainian, Murano, and Bohemian glassmaking traditions through the lenses of production organization, resource use, technological knowledge, and manufacturing practices. Such an approach makes it possible to identify not only differences in the finished products but also the historical factors that shaped distinct models of glass production in different parts of Europe.

Methodology.

This study is situated within the field of the history of technology and combines approaches drawn from historical research, comparative technological analysis, and material culture studies. The objective is not to reconstruct the artistic evolution of glass objects but to examine the technological systems that shaped the development of glassmaking traditions in Ukraine, Murano, and Bohemia.

The research is based on the principle that glass artefacts can be examined as historical evidence of technological processes. In addition to written sources, information concerning raw materials, production methods, furnace technologies, and manufacturing practices may be derived from the physical characteristics of surviving objects and from archaeometric investigations of historical glass. Consequently, the study integrates evidence from historical documents, archaeological research, materials analysis, and scholarship on glass technology.

The source base includes several categories of materials. The first consists of historical studies devoted to the development of glassmaking in Ukraine, Venice, and Bohemia. The second includes archaeological and archaeometric publications that provide information regarding glass compositions, raw materials, and production technologies. Particular attention is paid to studies employing chemical analyses of historical glass because such investigations make it possible to identify technological differences between soda-lime and potash-based glass traditions. The third category includes publications devoted to artistic glass production and the preservation of huta traditions during the twentieth century. These materials provide evidence concerning the continuity and transformation of technological knowledge after the decline of traditional forest glassworks.

The methodological foundation of the study is comparative historical analysis. This approach allows the examination of similarities and differences between three major European glassmaking traditions while taking into account the specific environmental, economic, and institutional conditions in which they developed. The comparison is conducted according to several technological parameters, including the organization of production, sources of raw materials, composition of glass batches, furnace technologies, methods of knowledge transmission, and product specialization.

The study also employs elements of the systems approach frequently used in the history of technology. Rather than treating individual glass objects as isolated artefacts, glassmaking is considered a technological system composed of interconnected components. These components include natural resources, production facilities, skilled labour, technological knowledge, market structures, and institutional frameworks. Such an approach makes it possible to explain why similar technological objectives were achieved through different production models in Murano, Bohemia, and Ukrainian hutas.

Another important methodological principle is contextualization. Technological processes are analysed within their historical environment rather than evaluated according to modern industrial standards. This principle is particularly important when interpreting characteristics such as bubbles, inclusions, colour variations, and asymmetries in historical glass. Features that may be regarded as imperfections from the perspective of contemporary manufacturing are treated here as evidence of specific production conditions and technological choices.

The study further applies concepts derived from heritage studies and the history of material culture. This perspective is especially relevant for the analysis of twentieth-century developments, when traditional blown glass technologies ceased to function primarily as an economic production system and increasingly became part of cultural and technological heritage. The research therefore examines not only the manufacture of glass objects but also the preservation, transmission, and reinterpretation of technological knowledge.

By combining comparative historical analysis, the systems approach, and the study of material culture, the article seeks to reconstruct the technological logic underlying different European glassmaking traditions and to identify the distinctive features of Ukrainian blown glass within this broader historical context.

Historiography and Sources.

The history of glassmaking has attracted scholarly attention for more than a century and has generated a substantial body of literature spanning archaeology, economic history, art history, archaeometry, and the history of technology. However, research traditions have developed unevenly across Europe. While Murano and Bohemia have become central subjects of international scholarship, Ukrainian blown glass has more often been studied within regional archaeological and artistic contexts.

Research on Murano glass initially developed within the framework of art history and museum studies, focusing on stylistic development, workshop production, and the attribution of individual artefacts. Since the late twentieth century, scholars have increasingly approached Murano as a technological and economic system. Particular attention has been devoted to the organization of production, the circulation of skilled labour, the protection of manufacturing knowledge, and the relationship between technological innovation and state regulation. Francesca Trivellato demonstrated that the development of Venetian glassmaking cannot be understood solely through artistic achievements but must also be analysed through guild institutions, commercial networks, and systems of technological control (Trivellato, 2006). Her work substantially broadened the historiographical understanding of Murano beyond traditional art-historical narratives.

Recent archaeometric investigations have further expanded knowledge of Venetian glass technologies (Burkart, 2021; Verità, Lehuédé, Zecchin, & Bandiera, 2024; Veronesi, 2024). Analytical studies of medieval and Renaissance glass from Murano have revealed the importance of Levantine soda ash and highly purified silica sources in achieving the transparency characteristic of Venetian *cristallo*. These studies have also demonstrated the technological continuity of soda-lime glass production in Venice between the twelfth and fifteenth centuries (De Raedt, Janssens, Veeckman, Vincze, Vekemans, & Jeffries, 2001).

The historiography of Bohemian glass has evolved along somewhat different lines. Earlier studies focused primarily on the emergence of crystal glass and the

economic success of Bohemian manufacturers in European markets. During the last two decades, however, archaeometric and experimental research has transformed understanding of historical glass technologies in Central Europe. Particularly important have been investigations into the role of potash as a fundamental component of forest glass production (Ogilvie, 2014; Pánová, Jílková, Rohanová, Lahodný, Galusková, & Míka, 2021; Schmetzer, Gilg, & Ranz, 2023). Cílová and Woitsch demonstrated that potash derived from wood ash constituted a key raw material in Bohemian glassmaking between the fourteenth and seventeenth centuries and significantly influenced the chemical composition and technological properties of the finished glass (Cílová & Woitsch, 2012).

Further advances were achieved through the work of Pánová and colleagues, who reconstructed historical Bohemian and Moravian glass recipes using archaeometric modelling (Pánová, Rohanová, & Randáková, 2020). Their results clarified the relationships between quartz sources, beech ash, potash, and other components used in historical glass batches and provided new insights into the technological evolution of Central European forest glass production.

The historiography of glassmaking in Ukrainian lands developed under different circumstances. Archaeological investigations have long constituted the principal source of knowledge concerning early glass production. Excavations in Kyiv, Chernihiv, Halych, Volodymyr, and other historical centres revealed evidence of glass manufacture and consumption from the period of Kyivan Rus onward (Kalynychenko, 1947; Kis, 1968 Petriakova, 1975). Archaeological studies have also contributed significantly to understanding the distribution of glass artefacts, trade connections, and technological influences affecting Ukrainian territories.

Another important direction of research concerns early modern forest glassworks. During the last decade, substantial progress has been made in reconstructing the geography of glassmaking centres, ownership structures, and economic conditions of production within the territories of the former Polish-Lithuanian Commonwealth. Studies devoted to Volhynia, Galicia, and Polissia have demonstrated the close relationship between glassmaking, woodland exploitation, potash production, and estate economies (Kurdyna, 2015, 2019; Bokotei, 2024). These investigations have significantly improved our understanding of the environmental and economic foundations of Ukrainian blown glass production.

A separate body of literature has examined Ukrainian glass through the perspectives of decorative arts, museum collections, and artistic production. Such studies have documented regional stylistic traditions, artistic techniques, and the development of modern glass art in Ukraine. They have also preserved valuable information concerning the continuity of huta traditions during the twentieth century through artistic workshops, educational institutions, and professional communities.

Despite the substantial volume of existing scholarship, several important gaps remain. Most studies have examined Ukrainian glassmaking either as an archaeological

phenomenon, a branch of decorative arts, or a component of regional economic history. Comparatively little attention has been devoted to Ukrainian blown glass as an integrated technological system encompassing raw materials, furnace technologies, workshop organization, manufacturing practices, and mechanisms of technological knowledge transmission. Moreover, direct comparative analyses involving Ukrainian, Murano, and Bohemian traditions remain relatively rare.

The source base of the present study reflects its interdisciplinary character. It includes historical scholarship on European and Ukrainian glassmaking, archaeometric investigations of historical glass compositions, studies of production technologies, research on forest industries and potash manufacture, as well as publications devoted to artistic glass and technological heritage. By combining these categories of sources, the article seeks to examine glassmaking not merely as a form of artistic production but as a technological system shaped by environmental resources, manufacturing knowledge, economic structures, and cultural traditions.

Origins and Development of Blown Glass Production in Ukraine.

The history of glass production in Ukrainian lands extends considerably further back than the emergence of the forest glassworks traditionally known as hutas. Archaeological excavations conducted in Kyiv, Chernihiv, Halych, Volodymyr, and other centres of Kyivan Rus have revealed evidence of local glassworking dating from the tenth to the thirteenth centuries (Kalynychenko, 1947; Petriakova, 1975; Rozhankivskyi, 1959). Glass bracelets, beads, vessel fragments, window glass, crucibles, and production waste indicate that glass processing was already known within urban craft environments. However, these early workshops were relatively small and primarily served local needs. The formation of a widespread network of specialized glassmaking enterprises occurred much later, during the sixteenth and seventeenth centuries.

The rise of huta glass production was closely connected with economic developments within the Polish-Lithuanian Commonwealth. During the sixteenth century, growing urbanization, increasing demand for containers, window glass, tableware, and pharmaceutical vessels stimulated the expansion of glassmaking throughout Central and Eastern Europe. In regions rich in forest resources, glass production became part of a broader economic complex that included charcoal burning, potash manufacture, ironworking, and timber processing. Unlike Mediterranean glassmakers, who relied on imported soda ash, producers in Eastern Europe developed technologies based on potash obtained from wood ash. This difference had far-reaching consequences for the organization of production and the location of glassworks.

The term *huta* itself reflected the technological character of these enterprises. Derived from the German *Hütte*, meaning a furnace workshop or smelting establishment, the word became widespread throughout Central Europe together with mining and metallurgical terminology. By the early modern period, it was commonly

used to designate forest glassworks operating in woodland areas remote from major towns. Similar terminology appeared in contemporary Polish, Czech, Slovak, and Ruthenian sources, illustrating the existence of a shared technological vocabulary across the region.

The location of hutas was determined primarily by access to raw materials. A functioning glassworks required large quantities of fuel, silica sand, clay for furnace construction, water, and labour. Forests supplied both firewood and ash for potash production (Petriakova, 1975; Martyniuk, 2004). Historical estimates suggest that several hundred cubic metres of timber could be consumed annually by a medium-sized glassworks. As nearby woodland resources became depleted, many hutas were abandoned and rebuilt elsewhere. Consequently, unlike Murano, where production remained concentrated in a fixed location for centuries, forest glassworks in Ukraine often had a relatively short lifespan.

Research conducted by Yuliia Kurdyna has substantially expanded knowledge about the geography of glassmaking centres in the lands of the former Polish-Lithuanian Commonwealth (Kurdyna, 2014, 2015, 2018, 2019). Archival documentation indicates that by the late sixteenth and seventeenth centuries dozens of glassworks operated in Volhynia, Podillia, and Polissia. Particularly high concentrations have been identified in the territories of present-day Volyn, Rivne, Zhytomyr, and Lviv regions (Kis, 1968; Kurdyna, 2015, 2018).

Several production centres acquired regional significance. Historical records mention glassworks operating near Korets, Olevsk, Liubeshiv, Chortoryisk, Rokytne, Romaniv, and other settlements located within heavily forested areas. Many belonged to influential magnate families such as the Ostrozky, Zaslavsky, Wiśniowiecki, Radziwiłł, and Czartoryski families. Their estates provided access to timber, transportation routes, and labour resources necessary for maintaining production. Monastic institutions also participated in glassmaking activities, particularly in Volhynia and Galicia, where monasteries controlled extensive forest lands.

Archival inventories demonstrate that glassmaking formed part of broader estate economies rather than functioning as an independent industrial sector (Kalynychenko, 1947; Martyniuk, 2004). Landowners viewed glassworks as a means of converting forest resources into marketable products. Potash itself represented an important commercial commodity and was exported to Western Europe for use in glassmaking, soap production, and textile processing. In many cases, the economic viability of a huta depended as much on potash production as on glass manufacture.

The movement of craftsmen played a crucial role in the spread of technological knowledge. Documentary evidence indicates that glassmakers frequently migrated between Bohemia, Silesia, Poland, Lithuania, and Ukrainian territories. As a result, Ukrainian glass production developed within a broader Central European technological environment. Furnace designs, glass recipes, and manufacturing practices circulated across political boundaries together with skilled workers. This process explains why

certain technological features observed in Ukrainian archaeological glass closely resemble those found in contemporary Polish and Bohemian assemblages.

At the same time, local conditions produced distinctive adaptations. The quality of silica sand varied considerably from region to region, as did the composition of potash derived from different plant species. These variations affected the colour, transparency, and chemical stability of glass. Archaeological studies of early modern glass from Ukrainian territories frequently report green, olive, yellowish, and brownish hues resulting from iron impurities naturally present in local raw materials. Complete transparency, characteristic of Venetian cristallo, remained difficult to achieve under such conditions.

The product range manufactured by Ukrainian hutas was broader than is sometimes assumed. Excavated materials and museum collections include window panes, bottles, flasks, goblets, stemmed drinking vessels, bowls, pharmaceutical containers, ink bottles, and decorative objects. Window glass became increasingly important during the seventeenth and eighteenth centuries as glazed windows spread among urban residences, administrative buildings, and religious institutions (Petriakova, 1975). The expansion of demand for window glass created stable markets that supported the continued operation of regional glassworks.

By the eighteenth century, some Ukrainian glassworks had begun to exhibit signs of increasing specialization (Rozhankivskyi, 1959). Production volumes expanded, trade networks widened, and contacts with neighbouring regions intensified. Nevertheless, the industry remained fundamentally dependent upon forest resources. This dependence distinguished Ukrainian hutas from the emerging industrial glassworks of Western Europe, where technological modernization increasingly relied upon mineral fuels and centralized production facilities.

The nineteenth century brought profound changes. Industrialization transformed the economics of glassmaking throughout Europe. Coal-fired furnaces allowed higher and more stable temperatures, while improvements in transportation reduced dependence on local resource bases. Large industrial enterprises gradually displaced smaller forest glassworks. Many traditional hutas ceased operation during the first half of the nineteenth century, while others survived only by adapting to changing market conditions.

Despite their decline, hutas left a lasting technological legacy. Techniques of free-form shaping, direct furnace work, and close cooperation between craftsmen remained embedded within local traditions. During the twentieth century, these practices were partially preserved at artistic glass enterprises, particularly in western Ukraine. Researchers has demonstrated that many technological approaches characteristic of modern Ukrainian studio glass originated in much older huta traditions and survived through the continuity of practical knowledge transmitted among generations of glassmakers (Kalynychenko, 1947; Kurdyna, 2014; Bokotei, 2021).

The historical development of Ukrainian blown glass therefore cannot be reduced to a simple regional variant of either Venetian or Bohemian production. It emerged within a distinct environmental and economic context shaped by forest resources, estate ownership, mobile labour, and localized systems of technological knowledge. These conditions determined not only the organization of production but also the technological characteristics of the glass itself, which will be examined in the following section.

Technology of Ukrainian Blown Glass: Raw Materials, Furnaces, and Manufacturing Practices.

The technological characteristics of Ukrainian blown glass were determined primarily by the raw materials available to individual glassworks and by the capabilities of their furnaces (Petriakova, 1975). Unlike modern industrial production, where raw materials are standardized and technological parameters are carefully controlled, early modern glassmakers worked with resources that varied from one locality to another. The composition of sand deposits, the quality of potash, the availability of fuel, and the operating conditions of the furnace directly influenced the appearance and properties of the finished glass.

Silica was the principal component of the glass batch. Most hutas obtained sand from local deposits situated near the production site. The quality of these deposits differed considerably. Historical glass from Ukrainian territories often contains elevated concentrations of iron compounds and mineral inclusions, indicating that raw materials underwent only limited purification before use. As a result, many surviving vessels display green, olive, yellowish, or brownish tones rather than complete transparency. Such colours were not necessarily introduced intentionally but frequently reflected the natural composition of local sands.

The second major component of the glass batch was potash. Throughout much of Central and Eastern Europe, potash replaced the soda ash widely used in Mediterranean glassmaking. It was produced from wood ash obtained during the controlled burning of hardwood species. The manufacture of potash represented a technologically demanding process in its own right. Ash was collected, washed with water, filtered, and evaporated to obtain potassium-rich compounds suitable for glass production. The chemical composition of potash varied according to the species of wood used for ash production and the methods employed during purification. Consequently, even neighbouring glassworks could produce glass with noticeably different chemical characteristics.

The importance of potash for Central European glassmaking has been confirmed by archaeometric research (Pánová, Jílková, Rohanová, Lahodný, Galusková, & Míka, 2021; Rasmussen, 2019). Cílová and Woitsch demonstrated that potassium compounds formed the basis of glass recipes used in Bohemia between the fourteenth and seventeenth centuries and significantly influenced the properties of the finished

material. Similar technological principles operated in Ukrainian forest glassworks, which relied on the same raw material base and faced comparable production constraints (Cílová & Woitsch, 2012).

The third major component of the glass batch consisted of stabilizing additives, primarily lime-bearing materials. These were introduced either deliberately through limestone and chalk or indirectly through impurities present in ash and sand. Unlike Venetian workshops, where raw materials were selected and processed according to relatively strict standards, Ukrainian glassmakers adjusted recipes pragmatically according to local conditions and accumulated experience. Production knowledge was transmitted orally and through apprenticeship rather than through written technological manuals.

The preparation of raw materials constituted an important stage of production. Sand was washed and screened before melting. Potash required repeated purification whenever higher-quality glass was desired. Raw materials were mixed manually, and their proportions were adjusted according to the behaviour of previous melts. In practice, glassmakers relied less on precise measurement than on empirical knowledge acquired through long-term observation of furnace performance and glass quality.

The furnace represented the technological core of every glass hotshop. Archaeological investigations of early modern glassworks in Poland, Ukraine, Slovakia, and the Czech Republic reveal a number of common structural features. Most furnaces were built from refractory clay and consisted of a central melting chamber surrounded by firing spaces and auxiliary working areas. Ceramic crucibles containing the glass batch were positioned within the hottest zone of the furnace, where they remained exposed to continuous heating for extended periods.

Maintaining stable temperatures was one of the principal challenges of pre-industrial glass production (Petriakova, 1975). Forest glassworks depended entirely on wood fuel, which produced less predictable thermal conditions than the coal- or gas-fired systems introduced during later industrialization. Modern researchers generally estimate operating temperatures of approximately 1200–1400°C for most forest glassworks. Although sufficient for glass melting, these temperatures did not always ensure complete homogenization of the glass mass. Variations in fuel quality, air supply, furnace design, and worker skill could produce significant differences between individual melting cycles.

Many characteristics commonly observed in Ukrainian blown glass originated directly from these technological conditions. Small bubbles trapped within the glass often indicate incomplete refining of the melt. Mineral inclusions reflect impurities present in raw materials. Variations in colour may result from fluctuations in furnace atmosphere or differences in chemical composition. From the perspective of modern industrial manufacturing such features would be regarded as defects. For historians of technology, however, they provide valuable evidence concerning production methods and technological limitations.

Glass shaping was performed almost entirely by hand. The principal instrument was the blowpipe, which allowed the glassblower to gather molten glass from the crucible and gradually form the desired object. Additional tools included shears, pincers, paddles, wooden blocks, and simple moulds. Most vessels were produced through free-blowing techniques. This method allowed considerable flexibility but inevitably resulted in variations between individual objects. Even products belonging to the same type often differ in dimensions, wall thickness, and proportions.

Archaeological assemblages from Ukrainian territories indicate that glassworks manufactured a broad range of products. Bottles, flasks, drinking vessels, bowls, pharmaceutical containers, window panes, and storage vessels constitute the most frequently encountered categories. Production priorities were largely determined by local demand. Unlike Murano, which specialized in luxury goods intended for elite consumers and international markets, Ukrainian hutas primarily supplied regional markets with practical glassware (see Figure 1).

Window glass represented a particularly important product category during the seventeenth and eighteenth centuries. The spread of glazed windows in churches, monasteries, administrative buildings, and noble residences created stable demand for flat glass. Historical sources indicate that both crown-glass and cylinder-glass methods were employed in various parts of Central Europe. These techniques required substantial skill because the glass had to be expanded, spun, or flattened while retaining sufficient transparency for architectural use.

Chemical analyses conducted on historical forest glass from Central Europe demonstrate significant differences from Venetian soda-lime glass (Spagnolo, Gonella, Viglia, & Ulgiati, 2018). Murano manufacturers relied upon highly purified quartz pebbles and imported soda ash, allowing them to achieve exceptional transparency and optical quality. Ukrainian hutas worked under different technological conditions. Their products generally contained higher concentrations of potassium compounds and exhibited greater variability in composition. This variability should not be interpreted simply as evidence of lower quality. Rather, it reflected a technological system adapted to local resources and regional economic realities.

By the eighteenth century, technological differences between Ukrainian and Bohemian glassmaking became increasingly pronounced. While both traditions originated within the broader framework of forest glass production, Bohemian manufacturers progressively standardized glass compositions and improved refining techniques. These developments eventually enabled the production of high-quality crystal glass suitable for extensive cutting and engraving. Ukrainian hutas remained oriented primarily toward regional markets and therefore retained many characteristics of traditional forest glassmaking.

Figure 1. Representative examples of Ukrainian glass products from museum collections: a – Shtof – 1796. Colored glass blowing painting with enamels; b – Pitcher – 18th century. Colored glass enamel blowing sculpting painting; c – Jar – 18th–19th century. Colored glass blowing sculpting; d – Pitcher – 19th century. Colored colorless glass blowing sculpting corrugation (National Museum of Decorative Arts of Ukraine, n. d.).

The technological practices developed within Ukrainian hutas did not disappear with the decline of the forest glassworks during the nineteenth century. Knowledge

associated with furnace work, free-form shaping, and direct interaction with molten glass survived within artistic production and later became an important component of twentieth-century Ukrainian studio glass. In this sense, blown glass represents not merely an early stage in the history of glassmaking but a technological tradition whose influence extended far beyond the period of its original existence.

Murano and Bohemia: Two Alternative Models of European Glassmaking.

Although Ukrainian blown glass developed within the broader context of European glassmaking, the technological and organizational conditions under which it evolved differed substantially from those found in the two most influential glass-producing regions of early modern Europe: Murano and Bohemia. Both centres achieved international recognition and exerted a significant influence on the development of glass technology. At the same time, they represented two distinct approaches to organizing production, managing technological knowledge, and controlling product quality.

The rise of Murano as a glassmaking centre is traditionally associated with the decision of the Venetian government in 1291 to relocate glass furnaces from Venice to the island of Murano. Although concerns about fire hazards played an important role in this decision, the concentration of production also facilitated governmental supervision over an industry that had become economically significant. Over the following centuries, Murano developed into one of Europe's most important centres of luxury glass production (De Raedt, Janssens, Veeckman, Vincze, Vekemans, & Jeffries, 2001; Verità, 2021; Veronesi, 2024).

A defining feature of the Murano system was the institutional control of technological knowledge. Glassmaking techniques were regarded as valuable economic assets, and the Venetian authorities implemented measures designed to prevent the emigration of skilled craftsmen. Masters who left Venetian territory without authorization could face severe legal penalties, while members of their families sometimes remained subject to governmental pressure. As Francesca Trivellato has demonstrated, the protection of technological expertise formed an integral part of the broader commercial strategy of the Venetian Republic (Trivellato, 2006).

The technological success of Murano was closely connected with the production of *cristallo*, a highly transparent glass developed during the fifteenth century. Venetian manufacturers achieved exceptional optical clarity through the use of carefully selected quartz pebbles and purified soda ash imported from the eastern Mediterranean. The resulting glass contained relatively low concentrations of colouring impurities and became renowned throughout Europe for its transparency and brilliance. Unlike the potash-rich glasses produced in much of Central and Eastern Europe, Venetian soda-lime glass possessed properties particularly suitable for thin-walled vessels and complex decorative work.

Murano workshops also became centres of technological experimentation. Venetian craftsmen developed techniques such as *vetro a filigrana*, *latticinio*, enamel decoration, gilding, and multi-layered glass construction. Many of these methods required advanced control of glass viscosity, temperature, and colour compatibility. Consequently, Murano's reputation rested not only on raw material quality but also on a sophisticated understanding of glass behaviour during forming and decoration (Spagnolo, Gonella, Viglia, & Ulgiati, 2018; Verità, 2021).

The organization of labour in Murano differed markedly from that of Ukrainian forest glassworks. Production was concentrated in permanent workshops employing highly specialized craftsmen. Tasks associated with batch preparation, furnace operation, blowing, decoration, and finishing were often distributed among different specialists. This specialization contributed to greater consistency in product quality and facilitated the preservation of technological standards across generations.

A different model emerged in Bohemia (Schmetzer, Gilg, & Ranz, 2023). Unlike Murano, Bohemian glassmaking developed within heavily forested regions where wood fuel and potash were readily available. During the sixteenth and seventeenth centuries, numerous glassworks operated throughout Bohemia and neighbouring territories. Their technological foundations resembled those of other Central European forest glass industries, including those found in Ukrainian lands. However, by the late seventeenth century Bohemian manufacturers began to transform this traditional production system into a more specialized and commercially oriented industry.

One of the key factors behind this transformation was the refinement of potash-based glass compositions. Research conducted by Cílová and Woitsch has shown that Bohemian producers successfully exploited the chemical properties of potassium-rich glass, which possessed greater hardness than Venetian soda glass and was therefore particularly suitable for cutting and engraving (Cílová & Woitsch, 2012). These characteristics eventually contributed to the emergence of Bohemian crystal, one of the most successful glass products in European history.

The eighteenth century witnessed the consolidation of Bohemia's position within international markets. Improvements in refining methods, furnace technology, and quality control enabled manufacturers to produce increasingly homogeneous glass masses. At the same time, growing export networks connected Bohemian workshops with consumers throughout Europe. Unlike Murano, whose reputation was built largely upon luxury hand-crafted objects, Bohemian producers increasingly combined artisanal skill with larger-scale commercial production.

Technological innovation in Bohemia was also accompanied by a gradual rationalization of manufacturing processes. Although production remained dependent upon skilled craftsmen, greater attention was paid to recipe standardization, furnace efficiency, and the reproducibility of results. Recent archaeometric studies have demonstrated that Bohemian glass compositions became progressively more consistent

over time, reflecting increasing control over raw materials and production procedures (Pánová, Rohanová, & Randáková, 2020).

Viewed from a technological perspective, Murano and Bohemia represented two different solutions to the challenges of glass production. Murano relied on institutional control, technological secrecy, imported raw materials, and luxury markets. Bohemia built its success upon forest resources, potash-based glass chemistry, and progressive production rationalization. Both systems differed substantially from the decentralized structure of Ukrainian blown glass production, which remained more closely tied to local resources and regional markets.

These differences did not imply technological isolation. Craftsmen, techniques, and knowledge circulated throughout Europe, creating numerous points of contact between glassmaking regions. Nevertheless, the historical development of Murano and Bohemia demonstrates how similar technological goals could be achieved through fundamentally different organizational and material frameworks. Understanding these alternative models provides an essential basis for evaluating the distinctive features of Ukrainian blown glass within the broader history of European glassmaking.

Comparative Analysis of Ukrainian, Murano, and Bohemian Glass Traditions.

The comparison of Ukrainian huta glass with the Murano and Bohemian traditions demonstrates that these centres differed not only in the appearance of their products but also in the technological principles that governed production. Differences in raw materials, fuel resources, production organization, labour structure, and access to markets resulted in the emergence of three distinct models of glassmaking. While all three traditions shared common technological foundations based on the melting and forming of silica-based glass, they evolved under different environmental and economic conditions and therefore followed different developmental trajectories. Table 1 summarizes the principal characteristics of the Ukrainian, Murano, and Bohemian glassmaking traditions.

The comparison reveals that the most fundamental distinction concerned the relationship between production and resources. Ukrainian glassmaking remained closely tied to the immediate natural environment. The location of glassworks, the composition of the glass batch, and even the lifespan of individual enterprises depended upon the availability of timber, potash, and suitable sand deposits. This dependence created a flexible but highly variable production system. Glassmakers adapted continuously to changing local conditions, and technological knowledge developed primarily through practical experience.

Table 1. Comparative characteristics of Ukrainian, Murano, and Bohemian glassmaking traditions

Parameter	Ukrainian Huta Glass	Murano Glass	Bohemian Glass
Main period of development	16th–19th centuries	14th–18th centuries	16th–19th centuries
Production environment	Forest glassworks	Urban island workshops	Forest and semi-industrial workshops
Production organization	Decentralized	Highly centralized	Increasingly centralized
Ownership structure	Magnates, monasteries, estates	Guild-controlled workshops	Noble estates and private enterprises
Main fuel	Wood	Wood and imported fuel resources	Wood, later coal
Primary flux	Potash from wood ash	Soda ash	Potash
Main glass type	Potash glass	Soda-lime glass (*cristallo*)	Potassium-calcium crystal glass
Raw material strategy	Local resources	Carefully selected and partly imported materials	Regional resources with increasing standardization
Knowledge transmission	Apprenticeship and oral tradition	Guild-based secrecy	Craft tradition and technological standardization
Degree of recipe standardization	Low	High	Medium to high
Furnace permanence	Often temporary or relocatable	Permanent	Permanent
Product orientation	Regional markets	Luxury and export markets	Export-oriented commercial production
Typical products	Bottles, flasks, tableware, window glass	Luxury vessels, mirrors, decorative objects	Crystal tableware, engraved glass, decorative products
Dominant forming technique	Free blowing	Free blowing and advanced decorative techniques	Blowing followed by cutting and engraving
Optical quality	Variable	Very high	High
Typical inclusions and bubbles	Frequent	Rare	Limited
Suitability for cutting and engraving	Moderate	Limited	Excellent
Main technological advantage	Adaptability to local conditions	Transparency and decorative complexity	Hardness and reproducibility
Main production constraint	Resource variability	Dependence on imported materials	High production costs and competition

Murano followed a different path. The Venetian industry sought to minimize variability by controlling both materials and production processes. The use of carefully selected quartz pebbles and purified soda ash allowed manufacturers to achieve a level of transparency rarely matched elsewhere in Europe. At the same time, institutional mechanisms protected technological knowledge and promoted continuity within the production system. The result was not simply better glass but a manufacturing environment designed to maximize consistency and maintain commercial prestige.

Bohemia occupied an intermediate position between these two models. Like Ukrainian hutas, Bohemian glassworks originated within forested regions and relied heavily on potash-based technologies. However, beginning in the seventeenth century, Bohemian manufacturers increasingly pursued standardization. Improvements in furnace technology, refining methods, and quality control gradually reduced production variability. This process culminated in the emergence of crystal glass specifically designed for cutting and engraving, which became one of Bohemia's most successful export products.

The table also demonstrates that technological development did not follow a single hierarchical path. Traditional narratives often imply that glassmaking evolved from simple forest production toward increasingly sophisticated industrial forms. The evidence suggests a more complex picture. Murano achieved technological success through institutional control and access to international trade networks. Bohemia relied on process optimization and commercial specialization. Ukrainian hutas developed a decentralized system capable of operating effectively under conditions of limited capital investment and fluctuating resource availability.

Particularly revealing is the issue of product quality. If quality is defined exclusively through transparency, homogeneity, and chemical purity, Murano and Bohemian products appear superior. However, such criteria reflect the priorities of luxury and export production. Ukrainian blown glass fulfilled different economic and technological functions. Its primary objective was not the manufacture of elite objects but the supply of regional markets with practical and affordable glassware. Consequently, features such as bubbles, inclusions, colour variations, and asymmetries should be interpreted within the context of the production system that generated them.

From the perspective of the history of technology, these so-called defects are often more informative than perfectly standardized products. They preserve evidence of furnace performance, raw material quality, and manufacturing practices. In this sense, Ukrainian blown glass provides valuable information about the technological adaptation of craftsmen to local environmental conditions. Rather than concealing production processes behind uniformity, it reveals them directly in the material structure of the object.

Another important observation concerns the circulation of technological knowledge. Although Murano attempted to restrict the movement of craftsmen and protect production secrets, and Bohemian manufacturers increasingly relied on

standardized procedures, all three traditions participated in broader European networks of technological exchange. Craftsmen migrated between regions, furnace designs spread across political boundaries, and knowledge concerning glass composition circulated through both formal and informal channels. Ukrainian glassmaking therefore developed neither in isolation nor in direct dependence upon a single foreign model. Instead, it selectively incorporated external influences while preserving its own technological identity.

The comparison presented here suggests that Ukrainian blown glass should be understood as a distinct technological tradition rather than as a peripheral variant of Venetian or Bohemian production. Its historical significance lies in the successful adaptation of glassmaking technologies to the environmental, economic, and social realities of Eastern Europe. Examined alongside Murano and Bohemia, Ukrainian glassmaking reveals the diversity of technological solutions that coexisted within European glass production from the early modern period to the nineteenth century.

From Craft to Heritage: The Transformation of Blown Glass Traditions in Twentieth-Century Ukraine.

The decline of traditional forest glassworks during the nineteenth century did not result in the disappearance of Ukrainian huta traditions (Rozhankivskyi, 1959; Kurdyna, 2019). Although industrialization fundamentally altered the economic foundations of glass production, many technological practices developed within the historical hutas survived in new institutional settings. During the twentieth century these practices underwent a gradual transformation from components of a regional manufacturing system into elements of artistic production, professional education, and cultural heritage.

The process began under conditions of increasing industrialization. Throughout Europe, mechanized production gradually displaced many traditional forms of glassmaking. Large factories specializing in bottles, sheet glass, and technical products became economically dominant. Ukraine experienced similar developments. Nevertheless, the manufacture of artistic and decorative glass remained dependent on manual labour. The shaping of complex forms, control of molten glass, and execution of decorative details continued to require highly skilled glassblowers. As a result, technological practices originating in pre-industrial production survived within sectors that resisted full mechanization.

Following the Second World War, artistic glass production became integrated into the institutional framework of Soviet decorative and applied arts. State-supported enterprises provided access to furnaces, raw materials, and professional workshops. Although these enterprises operated within an industrial economy, artistic production remained largely dependent upon techniques associated with direct furnace work.

A particularly important role was played by the Kyiv Plant of Artistic Glass. During the following decades, the enterprise became one of the largest centres of

artistic glass production in the Soviet Union. The factory produced decorative vessels, exhibition pieces, commemorative objects, architectural glass, and experimental works created specifically for national and international exhibitions. Despite the industrial scale of the enterprise, many operations continued to rely on free blowing, hot shaping, and direct interaction between artists and master glassblowers. In technological terms, these methods preserved important elements of earlier blown glass practice.

Western Ukraine developed a somewhat different model (Kis, 1968; Kurdyna, 2014). In Lviv, artistic glass production became closely associated with educational institutions and experimental workshops. The Lviv Experimental Ceramic and Sculpture Factory provided opportunities for artistic work with molten glass outside the framework of mass production. Here, the furnace functioned not only as industrial equipment but also as a creative environment in which technological experimentation remained possible. This approach preserved many features characteristic of historical huta production, including the importance of manual forming and the continuous interaction between craftsman and material.

The institutionalization of blown glass traditions was reinforced through professional education. The Lviv National Academy of Arts became one of the principal centres for training glass and ceramics artists in Ukraine (Bokotei, 2024; Khyzhynskyi, Lampeka, & Strilets, 2024; Khyzhynskyi, Osadcha, & Nagirniak, 2025). Unlike traditional apprenticeship systems, educational programmes combined artistic instruction with technological training. Students studied glass composition, furnace technologies, hot-glass forming techniques, and the properties of molten glass. Consequently, technological knowledge that had once circulated primarily within workshops entered formal educational structures and acquired a more systematic character.

An important stage in the preservation of blown glass traditions occurred during the late 1980s with the organization of International Blown Glass Symposiums in Lviv (Chegusova, 2020, 2024). The first symposium, held in 1989, brought together artists, technologists, and glassblowers from different countries and created a platform for the exchange of practical knowledge. Unlike conventional exhibitions, symposiums emphasized the production process itself. Participants worked directly at the furnace, exchanged technical solutions, and demonstrated methods of shaping and decorating hot glass. In this respect, the symposium format reproduced certain aspects of historical craft communities in which technological knowledge circulated through observation and practical participation.

These developments coincided with the growing influence of the international Studio Glass Movement. Emerging in the United States during the 1960s, the movement challenged the separation between artist and production process that had become typical of industrial manufacturing. Small furnaces, independent workshops, and direct engagement with molten glass enabled artists to regain control over technological aspects of production. Similar tendencies appeared in Ukraine, where

artistic glass increasingly emphasized experimentation, individuality, and the creative possibilities of furnace-based work.

By the end of the twentieth century, attitudes toward traditional glassmaking had changed significantly. Features that industrial manufacturers had often regarded as evidence of imperfect production began to acquire new cultural value. Variations in form, traces of manual shaping, bubbles, and subtle colour differences came to be interpreted as indicators of authenticity and direct human involvement in the manufacturing process. This reassessment reflected broader changes in heritage studies and the history of technology, where increasing attention was devoted not only to finished artefacts but also to the skills and knowledge required for their production.

Within this context, huta glass became recognized as a form of technological heritage. The concept encompassed more than museum collections or surviving glass objects. It included furnace technologies, practical knowledge of glass behaviour, methods of shaping molten material, workshop traditions, and systems of skill transmission. Preserving such heritage required not only conservation of artefacts but also the continuation of technological practices themselves.

The twentieth century therefore transformed blown glass traditions from an economic activity into a cultural and educational resource. While the historical forest glassworks disappeared, many of the technological principles that had sustained them remained active within artistic workshops, educational institutions, and professional communities. This continuity ensured that huta glass survived not merely as a historical phenomenon but as a living component of Ukraine's technological and cultural heritage.

Conclusions.

The comparative analysis of Ukrainian huta glass, Murano glass, and Bohemian glassmaking demonstrates that these traditions developed within different technological, economic, and institutional frameworks despite sharing common principles of glass production. The differences between them were determined not only by variations in raw materials or manufacturing techniques but also by broader systems of knowledge transmission, production organization, and resource management.

The study has shown that Ukrainian blown glass emerged as a product of a decentralized forest-based manufacturing system that relied on local deposits of silica sand, potash derived from wood ash, and wood fuel. In contrast to the centralized and highly regulated production system of Murano, where technological knowledge was protected through guild institutions and state control, Ukrainian glassmaking developed primarily through dispersed workshops operating within estate economies. Unlike Bohemia, where glass production gradually evolved toward greater standardization and export-oriented specialization, Ukrainian hutas largely remained oriented toward regional markets and retained flexible production practices adapted to local conditions.

The technological characteristics of Ukrainian glass making reflected these conditions. Variability in raw materials, furnace performance, and manufacturing processes resulted in products that often contained bubbles, inclusions, colour variations, and minor asymmetries. Rather than being interpreted solely as indicators of technological limitations, these features should be understood as material evidence of a specific production environment and a distinct technological culture. They provide valuable information about the interaction between craftsmen, natural resources, and production technologies in early modern Eastern Europe.

The comparison with Murano and Bohemia demonstrates that the history of European glassmaking cannot be reduced to a single trajectory of technological progress. Venetian glassmaking achieved international prominence through institutional control, technological secrecy, and access to long-distance trade networks. Bohemian manufacturers built their success on the refinement of potash-based glass compositions, increasing standardization, and integration into international markets. Ukrainian huta glass followed a different path, characterized by adaptability, resource flexibility, and the preservation of locally transmitted technological knowledge.

The study also demonstrates that the significance of Ukrainian glass making extends beyond the period of the forest glassworks themselves. During the twentieth century, many technological practices associated with historical huta production were preserved within artistic glass enterprises, educational institutions, and international professional networks. As a result, blown glass traditions underwent a transition from an economic production system to a form of technological and cultural heritage. This transformation ensured the survival of practical knowledge and manufacturing skills long after the disappearance of the historical glassworks that had originally generated them.

The findings support the conclusion that Ukrainian blown glass should not be regarded as a peripheral or simplified variant of either Venetian or Bohemian glassmaking. It represented a distinct historical and technological trajectory shaped by the environmental conditions, resource base, and social organization of Eastern Europe. Examined within a broader European context, Ukrainian blown glass reveals the diversity of technological solutions that coexisted within pre-industrial glassmaking and contributes to a more nuanced understanding of the relationship between technology, craft production, and cultural development in the history of material technologies.

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Гутне скло в Україні: історико-технологічні особливості у порівнянні з муранською та богемською склярськими традиціями

Анотація. *Метою дослідження є виявлення історико-технологічних особливостей українського гутного скла шляхом порівняльного аналізу української, муранської та богемської традицій скловиробництва. У статті розглянуто розвиток скляного виробництва на українських землях упродовж XVI–XX ст. та визначено його місце в ширшому контексті європейської історії скла. Методологічну основу дослідження становлять методи історичного аналізу, порівняльного історико-технологічного аналізу та студій матеріальної культури. Джерельна база охоплює історичні, археологічні, археометричні та мистецтвознавчі праці, присвячені технологіям скловиробництва, діяльності лісових гут, художньому склу та збереженню традиційних виробничих знань. Особливу увагу приділено технологічним аспектам виготовлення скла, зокрема використанню сировини, складу скломаси, конструкціям скловарних печей, виробничим практикам і механізмам передачі технологічних знань. Встановлено, що українське гутне скло розвивалося в умовах, які суттєво відрізнялися від тих, що визначали формування муранської та богемської склярських традицій. На відміну від високоорганізованої та централізованої системи виробництва Мурано, українське склоробство формувалося на основі децентралізованої мережі лісових гут, діяльність яких залежала від місцевої сировинної бази та емпіричної передачі виробничого досвіду. На відміну від богемської моделі, що поступово набула рис стандартизованого та експортно орієнтованого виробництва, українські гути були переважно зорієнтовані на регіональні ринки та адаптували технології до локальних природних і господарських умов. Показано, що такі особливості українського гутного скла, як хімічна неоднорідність, наявність включень, варіативність кольору та певна нерегулярність форм, були безпосереднім наслідком виробничого середовища й повинні розглядатися як матеріальні свідчення історичних технологічних процесів, а не виключно як ознаки технологічної недосконалості. Окремо*

проаналізовано трансформацію гутних традицій у XX ст. Встановлено, що значна частина технологічних практик, пов'язаних з історичними лісовими гутами, збереглися у сфері художнього скла, системі професійної освіти та діяльності творчих спільнот. Унаслідок цього гутні технології поступово трансформувалися з регіональної виробничої системи у важливий елемент технологічної та культурної спадщини. Зроблено висновок, що українське гутне скло слід розглядати як самостійну історико-технологічну траєкторію розвитку європейського скловиробництва, а не як периферійний варіант муранської чи богемської традицій. Проведений порівняльний аналіз демонструє різноманіття технологічних рішень, що співіснували в європейському склоробстві, та сприяє глибшому розумінню взаємозв'язку між технологіями, ремісничими знаннями, природними ресурсами й культурним розвитком у історії матеріальних технологій.

Ключові слова: *гутне скло України; декоративне мистецтво; технологія скловиробництва; художнє скло; дизайн скловиробів; музейні колекції скла*

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