GLASS SERVICE

Collection of Abstracts

16th INTERNATIONAL SEMINAR

ON FURNACE DESIGN – OPERATION & PROCESS SIMULATION

June 21 - 22, 2023

WELLNESS HOTEL HORAL | Velke Karlovice

Czechia

COLLECTION OF ABSTRACTS

16th International Seminar
on Furnace Design – Operation & Process Simulation

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FURNACE MODELLING - PROGRESS MADE AND FUTURE CHALLENGES

Graham Unwin
NSG, UK

Abstract:

Over the past 35 years tremendous progress has been made in the mathematical modelling of glass furnaces. This presentation briefly looks back at the modelling carried out in the late 1980's when 3D CFD models were just being developed. It contrasts this with the situation now where model runs can take only a few hours and time dependent calculations are possible. Modelling is now firmly embedded in the glass industry with examples given where modelling contributes within a manufacturing business. However, also highlighted are some areas where further progress is still required.

With the pressure to decarbonise, a pressure which will only increase in the future, model work currently being carried out in a couple of areas is described – namely electric melting / boosting and low carbon fuel firing. It demonstrates how models are vital in giving the confidence to try things out on a production furnace but also how important it is to know the limitations of any model. Having access to plant data and being able to interpret it is vital in this regard. A common thread through the recent work is that techniques developed years ago and not used in recent times suddenly become important again. This highlights the challenge of keeping knowledge accessible within an organisation over time.

SCHOTT'S TECHNOLOGICAL TRANSFORMATION PATH OF BECOMING CLIMATE NEUTRAL

Dr Wolfgang Schmidbauer*, Dr Sebastian Wolf*, Matthias Kaffenberger, Dr Stefan Knoche, Stefan Schmitt, Alexander Strobel, Rainer Eichholz, Dr Janina Costard and Michael Hahn
Schott AG, Hattenbergstrasse 10, 55126 Mainz, Germany
*Presenting authors

Abstract:

The transformation of fossil energy-based glass production to the use of Zero Carbon (ZC) energy within glass production is one of the most challenging tasks of today's R&D. The increased use of green electricity above 60 % under stable process conditions and increasing demands on the glass quality present us with major challenges. Furthermore, the affordable availability of green hydrogen is a prerequisite for a complete transformation. SCHOTT, as a global specialty glass manufacturer and leading company for ZC transformation, drives usage of green electricity in glass melting, for example, within the founded projects PLANET and PROSPECT, up to a maximum. Other alternative ZC energy sources like biofuel may act as bridging technologies for the later use of hydrogen. This talk will deal with some insights into the technological transformation path of SCHOTT's glass production toward our goal of becoming climate neutral.

ASSESSMENT OF IRREVERSIBILITIES IN THE PERFORMANCE OF GLASS FURNACES

Reinhard Conradt
uniglassAC GmbH Aachen, Germany

Abstract:

Any thinkable furnace concept obeys the simple overall balance $P_{in} = P_{ex} + P_{loss}$. The symbol P denotes powers in units of kW; index "in" denotes the power input by fuel and electricity, index "ex" denotes the useful or exploited power determined by the intrinsic energy demand of melting and the heat content of the melt at exit temperature T_{ex}, index "loss" comprised the cumulative losses. Both P_{in} and P_{ex} depend on the pull rate p, with a maximum efficiency P_{ex}/P_{in} reached at a specific pull rate p_{opt}. The above power balance reflects both the 1st and 2nd law of thermodynamics. In specific, P_{loss} corresponds to the "uncompensated heat" in *Clausius'* concept of entropy. It comprises both *pull independent* and *pull dependent* contributions. The former ones consist in the heat losses through the furnace periphery, while the latter ones are due to intrinsic entropy generation. The most important sources of intrinsic entropy generation are: the heat capacity flow imbalance between furnace atmosphere and melt, the resistance to heat transfer, and the chemical irreversibility of the batch-to-melt reactions. In the present talk, special attention is paid to the latter process. The corresponding effects are assessed via a *de Donder* affinity approach. This allows one, for a given furnace design and a given batch composition, to predict the pull rate for optimum of furnace operation.

THERMODYNAMICS OF GLASSES AND THE BATCH MELTING PROCESS

Malte Sander
GLASS SERVICE, a.s., Czech Republic

Abstract:

The complex nature of the glass melting process can be replicated in the virtual world using computational fluid dynamics simulations. For a realistic model, numerous input parameters have to be defined. However, not always all parameters are available and thus need to be estimated. For this purpose, GLASS SERVICE provides a glass property calculator. Currently, we are developing a new tool to predict additionally the thermodynamic properties of glasses based on the constitutional phase model. The tool helps to calculate the heat capacity and enthalpy of glasses as well as the energy demand to melt them from a selection of raw materials. In the future, we will use this tool to predict the impact of cullet preheating or different raw materials on the glass melting process in our Glass Furnace Model (GFM).

CASE STUDY FOR USING COMPUTATIONAL MODELING RESULTS TO BUILD A BUSINESS CASE FOR CAPITAL INVESTMENT COMPLETE WITH VALIDATION BY OPERATIONAL DATA

Donn Sederstrom
Johns Manville, Littleton, Colorado, USA

Abstract:

Extending glass melter campaign life can have a significant improvement on the financial return of a single melter campaign, but oftentimes additional financial investments are needed to allow the melter life to be extended. This work presents a case study demonstrating how modeling results from Glass Furnace Model were used to build the financial business case for raw material infrastructure improvements so the melter life could be extended with higher recycled cullet content. Glass Furnace Model was used to predict the energy reduction and melter temperature reduction at various levels of increased recycled cullet content within an all-electric melter. These energy and temperature reductions, in conjunction with laboratory test data, quantify the reduction in refractory wear and expected life extension. Furthermore, after the successful business case approval and implementation, operational conditions at higher cullet levels were measured and compared to the initial models used for the business case.

PYREX FURNACE: MODELING, EXPERTISE, PARTNERSHIP… PROGRESSING ON THE PATH TO DECARBONATION

Johann Brunie, La Maison Francaise du Verre (LMFV), France
Christoph Jatzwauk, F.I.C. Germany GmbH
Hans Mahrenholtz, GLASS SERVICE, a.s., Czech Republic

Abstract:

"La Maison Française du Verre » (LMFV) is producing borosilicate glass for cookware in its factory of Châteauroux (France).
Its hybrid furnace is melting around 160 tons per day and its design is improved during each rebuilt, every 5 years, focusing on glass quality and energy efficiency. Currently, the combustion space using oxygen and natural gas, combined with electric boosting within the bath of glass. This configuration has been successful in increasing the electrical energy to a high degree, resulting in significantly reduced CO_2 emissions.
To address the rebuilt needed in 2022, to face the realities of global warming and to tackle once gain CO_2 emissions, "La Maison Française du Verre", Glass Service a.s. and F.I.C worked together during three years to determine what could be the next step for this furnace and its forehearths.
The presentation will be divided into four parts:

- First, we will introduce the different steps used for 25 years and already validated for the decarbonation of its furnace.
- Secondly, we will present an overview of the initial data analysis and all the benefits obtained for the understanding of the furnace and its potential evolutions.
- Thirdly, we will describe a synthesis of the modeling and design work, for the furnace and one of its forehearth, to obtain a final recommendation.
- To conclude, we will show final results after the rebuilt led during summer 2022

Keywords:
Hybrid furnace, electric boosting, CO_2 reduction, furnace design, forehearth design, energy audit, modelling, alternative energies

CO_2 REDUCTION STRATEGIES: CASE STUDY TABLEWARE PLANT

Peter Vrabel
Rona a.s., Slovakia

Abstract:

Glass production as one example of industry exploiting rather high amount of energy (often connected to significant CO_2 emissions) was significantly affected by regulation in the last decade. Different strategies were proposed to escape from natural gas consumption in the standard processes, such as oxy-fuel, hybrid electric, all electric or hydrogen.

Data are presented from the last 5 years related to energy consumption and CO_2 production of melting process of RONA a.s. Future alternative strategies are proposed based on technical calculations. Specific options related to high quality tableware including hand made are discussed. The attempt to elaborate Hydrogen strategy for process of production of CO_2 free glass production for RONA a.s. project portfolio is shown. Constraints are defined and key economical parameters are explained. Also missing scientific and technological knowledge is discussed.

CFD SIMULATION OF FLOAT FURNACE USING NEW ACCURATE GLASS THERMAL RADIATION CONDUCTIVITY MODEL

Nicolas Bourgeois and François Bioul, AGC Glass Europe, Belgium
Anne-Jans Faber, Physica Fit Faber, The Netherlands

Abstract:

Next to density and viscosity, the temperature dependent thermal radiation conductivity of glass melts is an essential input parameter of CFD simulation models of glass melting tanks. In the first part of this paper, a new semi-empirical method for accurately predicting the Rosseland thermal radiation conductivity of industrial glass melts is described. In the second part, results of simulations of a real float furnace are presented. Comparison between the previously "standard" thermal conductivity and the newly developed model is achieved. Details about necessary adjustments to validate the furnace model when using the more physics-based thermal conductivity are given.

ADVANCED TECHNIQUES TO IMPROVE PROCESS EFFICIENCIES AND SUSTAINABILITY IN GLASS FIBER MANUFACTURING

B.A. Purnode, P.J. Prescott, J. Han, S. X. He
Owens Corning Science & Technology Center, Granville, OH – USA

Abstract:

With the focus on decarbonization, automation and the use of big data, there are major opportunities to increase production efficiency in the glass manufacturing industry. But a first step in developing such initiatives starts with a good understanding of the process and the need to provide timely responses. This includes the development and installation of new sensors and controls schemes that add new insights to the process, but also the development of modeling techniques for fundamental understanding. With ever increasing computing power and more sophisticated mathematical methods, numerical simulation has become a daily use in many processing industries. The glass industry has used those techniques and this paper reviews the practices involved in the mathematical modeling of transport processes in the glass fiber making sector.

The processes considered include various forms of glass processing techniques, with a focus on glass melting and conditioning. Besides, other process steps benefit from modeling as well, such as forming and drying, that are critical to product quality. Mathematical modeling is nowadays used extensively for applying technical expertise to glass fiber manufacturing. This includes troubleshooting, adjusting operational settings for improving performance, changing production levels, and for screening concepts for improved process design. Balancing model quality and its cost is a key choice that needs to be made early in the process and limitations of every approach needs to be well understood. This involves decisions on the material properties, physical/chemical phenomena present, process conditions and the levels of geometrical details. Validation of the techniques often rely on sensors and the development of such new sensors are critical. Those models also allow for simulation-based Digital Twins to be developed. Those provide real-time insights in the process through virtual sensors. A selection of results is presented to illustrate practical applications of modeling in design and operations.

DEVELOPMENT OF OXYGEN FIRED COMBUSTION FOR GLASS PRODUCTION AND THE CONTRIBUTION OF CFD MODELING

Aaron Huber
Johns Manville, Littleton, Colorado, USA

Abstract:

Many advances in the manufacturing of glass have been accomplished over the past 400 years as the combustion energy source proceeded from wood to coal to producer gas to fuel oil to natural gas. The oxidant has progressed from non-preheat air to preheated air to oxygen. The development of oxygen fired combustion will be overviewed along with the critical role CFD modeling played and continues to play. Examples of energy improvements and future developments will be discussed.

MODELLING AND IMPLEMENTATION OF AN OXY-FUEL COMBUSTION SYSTEM IN A RECUPERATIVE FURNACE WHILE IT IS IN OPERATION AND HAS TWO YEARS OF REMAINING CAMPAIGN

Masashi Yamaguchi*, Joaquín de Diego**, Yoshiyuki Hagihara***
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***Taiyo Nippon Sanso Corporation, 1-3-26 Koyama, Tokyo 142-8558, Japan

Abstract:

Decarbonization strategies are linked to the reduction of fossil fuels use together with the modelling of the implementation of new oxy-combustion technologies while in operation recuperative furnace who still has two years of remaining campaign.

Already well stablish oxy-combustion technology is helping to reduce CO_2 footprint to existing furnaces without the necessity to demolish existing furnace before the end of the campaign.

This paper will summarize how with the support of modelling technology it is possible to substitute old air-fuel technology by state of the art oxy-combustion technology without stopping production and maintaining or improving the furnace's campaign.

Modeling helped decide where to implement oxy-fuel burners in order to maintain glass production and quality while drastically reducing natural gas consumptions and greatly reducing CO_2 emissions at the site; responding to the demands of customers and consumers while increasing profitability for shareholders.

NUMERICAL MODELING OF HYDROGEN COMBUSTION FOR GLASS FURNACE COMBUSTION ATMOSPHERE DESIGN

Canalp Kulahli, Modeling and Simulation Department
Şişecam, Turkey

Abstract:

Hydrogen combustion has gained significant attention as a decarbonization strategy for industrial processes. Hydrogen has great potential to reduce CO_2 emissions in a glass furnace, while also presenting several challenges related to furnace design, material selection, fuel delivery, and safety. To implement hydrogen fuel as an energy source, design parameters of a conventional combustion atmosphere must be reevaluated due to hydrogen's different combustion characteristics compared to natural gas. The focus of this study is to develop a Computational Fluid Dynamics model that can be employed for parametric design work of a glass furnace. Three different combustion sub-models have been numerically implemented and assessed for their accuracy and computational cost. To achieve certainty, grid independence and comparison with experimental data provided in the literature were performed. The non-premixed reduced combustion model outperformed the other investigated models, namely the Eddy Dissipation Model and Eddy Dissipation Concept Model, for both temperature and concentration results, while also maintaining a low computational cost. The proposed model was then implemented for initial design study of a combustion atmosphere with hydrogen fuel.

ADVANCING DECARBONISATION IN GLASS PRODUCTION: INDUSTRIAL-SCALE HYDROGEN UTILISATION FOR AIR- AND OXY-COMBUSTION

Tilen Sever[1], Gorazd Krese[1], Špela Polak[1,2], Tilen Varlec[1], Sašo Fekonja[1]
[1] Steklarna Hrastnik d.o.o, Cesta 1. Maja, 1430 Hrastnik, Slovenia
[2] University of Ljubljana, Faculty of Chemistry and Chemical Technology, Večna pot 113, 1000 Ljubljana, Slovenia

Abstract:

The glass industry faces challenges in achieving CO2 reduction targets set by the European Climate Law, as energy-related emissions contribute significantly to its environmental impact. Innovative decarbonising technologies, such as hydrogen combustion and electrical melting, are promising for reducing emissions from glass production [1,2]. Hydrogen, a carbon-free fuel, is gaining global momentum due to increasing regulations and commercial projects [3].

This presentation highlights a hydrogen pilot demonstration that integrates renewable energy sources (solar cells), green hydrogen production and storage, and partial replacement of natural gas feed to enhance renewability in the glass industry. We will showcase a system prototype in an operational environment, demonstrating a full fuel transition from non-renewable natural gas to hydrogen under air- and oxy-combustion conditions. A Cradle-to-Gate Life Cycle Assessment (LCA) study comparing low-carbon melting with 100% recycled cullet and green hydrogen fuel will also be presented.

We will investigate glass production decarbonisation through hydrogen use under various combustion conditions and assess the potential for implementing 100% hydrogen in industrial-scale glass production with 120 MTPD oxyfuel and 170 MTPD hybrid furnaces. The presentation will cover the impact of hydrogen combustion on energy efficiency, emissions, product quality, and future plans for expanding green hydrogen use in the glass industry.

[1] M. Zier, Energy Conversion and Management: X, volume 10, 2021, 100083.

[2] P. D'Aprile, Net-Zero Europe, Decarbonization pathways and socioeconomic implications, McKinsey & Company, 2020.

[3] IRENA (2022), Accelerating hydrogen deployment in the G7: Recommendations for the Hydrogen Action Pact, 2022.

USE OF MODELLING IN DECARBONISING THE GLASS INDUSTRY WHAT ARE WE MISSING?

Stuart Hakes, F.I.C. (UK) Limited
Christoph Jatzwauk, F.I.C. Germany GmbH
Erik Muijsenberg, Marketa Polachova, Tomas Denk, GLASS SERVICE, a.s.

Abstract:

The talk will look at how modelling has advanced the decarbonisation process in both melting and conditioning. It will show how the use of modelling has been key to persuading people that there is confidence in change. It will also investigate some of the areas where modelling is perhaps not comprehensive enough and where modelling needs to go in the future.

USE OF VARIVOLT FOR ELECTRIC MELTING IN THE GLASS INDUSTRY AND OPTIMIZED BUSBARS FOR HIGH AMPERAGE

Philippe Bernard
Bernard Bonnefond, France

Abstract:

Presentation will start by introducing BB company as a familial team focused on special electrotechnical equipment since 1925. Turnover is around 24 M€ and main product is the VARIVOLT widely used for glass melting.

The design of VARIVOLT is then explained with main technical advantages concerning efficiency, power factor and perfect sine wave without any distortion. Some slides show the principle of sliding contact running along the secondary winding and the magnetic circuit with rotating magnetic cores. Additional photos of a recently developed semi-automatic molding shop to increase production capacity to cope with expanding market for glass and hydrogen.
Presentation will remind use of The VARIVOLT in the glass industry for more than 40 years. This starts in the 80’s with SAINT-GOBAIN GLASS and VERALLIA. The main steps are detailed with developments up to 10.000 A and SCOTT or three-to single-phase combination.

A second part will explain problem with magnetic field greater than 1mT around secondary cables or bars when current is above 4 or 5.000 A. This concerns safety regulation for people and local hot spots on the steel structure. The main problem concerns single-pole bars to feed opposite electrodes. An additional “reaction loop” allows to reduce this magnetic field, reduce the voltage drop and improve global efficiency. Calculation and practical measurements on an all-electric melter are given.

ALL-ELECTRIC MELTING: CTVM FURNACE ROAD TO UPSCALING - CHALLENGES TO OVERCOME

Sergio Silva
FIVES STEIN, UK

Abstract:

All-electric melting furnaces provide a viable and highly energy-efficient solution to glass melting without producing CO_2 (from combustion). However, due to rapid changes in the energy and consumer markets, today's technology needs to evolve further to accommodate new players such as container producers that are looking to replace their gas furnaces for a greener alternative and reduce their CO_2 footprint.

This presentation aims to give background as to why all-electric melting technologies will play a major part in the future of Glass Melting; we will review where electric melting is now in terms of furnace size, advantages, and limitations; and we suggest the possible next steps for increasing furnace capabilities and how best to control the risks associated with designing and operating large scale units (200+ TPD).

Our key message here, is to highlight the challenges in developing this technology to suit to the needs of the market, protecting investment and eliminating risk from changing environmental legislation and ever-increasing consumer demands.

However, the conclusion is clear; once installed, and with the implementation of proper monitoring, control, and maintenance, electric furnaces will run with a stability and energy efficiency that surpasses (by far) any type of fuel-fired alternatives and offers the best road to CO_2 free glass production.

ELECTRIC MELTING OF GLASS - A PARAMETER STUDY

Max Kallert, HORN Glass Industries AG

Abstract:

All electric glass melting is anything but a brand new invention. The glass industry has a rich history of only using electricity to produce a glass melt. Nowadays it is mostly used for high quality and speciality glass. Some restrictions in the process and setup are still inhibiting a more regular use in the container glass production. A limited maximum pull of around 200 to/d, a rigid flexibility regarding the pull and the cullet fraction and a rather short lifetime are the main culprits for this.

HORN has been developing concepts to push these barriers forward and make all electric furnaces a more intersting solution for container glass production. Because in the wake of emission reduction and more independency from the fossil energy market, the glass industry is exploring all ways to achieve these goals. Besides the substituion of fossil fuels with more substainable alternatives (e-fuels, hydrogen, …) and the incorporation of more electric energy into the melting process, the full switch to electricity is a logical step.

One main topic of the HORN concept is the possibility of upscaling the furnaces to meet the requirements oft he container glass producers regarding the pull rate. The current „barrier“ of around 200 to/d is on the lower end compared to fossil furnaces.

A second topic is the increase of flexibility. In most all electric furnaces changes in pull rate and cullet fraction can only be done in rather small steps and only to a smaller degree. By changing the setup HORN is increasing this window of flexibility and alongside is introducing the possibility of lowering the corrosion impact and increasing the lifetime of the furnace.

HYBRIDISATION OF THE END-FIRED REGENERATIVE FURNACE CONCEPT

Gorazd Krese, Tilen Sever
Steklarna Hrastnik d.o.o, Cesta 1. Maja, 1430 Hrastnik, Slovenia

Abstract:

In an effort to combat climate change, the EU set to become climate neutral by 2050. This implies that energy intensive sectors, such as the glass industry need to start innovating now, as 2050 in only 3 furnaces away. Steklarna Hrastnik (SH) aims to decarbonize the end-fired regenerative furnace design, which is the current state of the art in EU's production of packaging glass, by combining it with the more energy efficient all-electric furnace concept into a hybrid regenerative furnace. Particularly, SH will demonstrate a first-of-a-kind hybrid end-fired regenerative furnace with a more than 40% electrical melting share and throughput capacity of 170 tons of glass per day. The furnace will replace the existing end-fired regenerative furnace for extra-white flint glass production, thereby resulting in a more than 50% reduction of natural gas consumption and up to 40% of GHG emissions

In this contribution, the end-fired hybrid regenerative furnace concept is presented and compared against the current state-of-the-art glass melting technologies. Different hybrid operation strategies are evaluated in terms of energy consumption and efficiency as well as greenhouse gas (GHG) emissions, considering various scenarios for electricity generation. Depending on the carbon intensity of utilized energy sources, the hybrid regenerative furnace presents a viable option to decarbonise the container glass sector.

ON THE EFFECT OF TURBULENCE MODEL ON THE PREDICTION OF FLOW FIELD AND PRESSURE DROP OF BUOYANT FLOW IN REGENERATOR CHANNEL

Vojtech Betak, Tomas Krobot, Miroslav Trochta, Tomas Denk
GLASS SERVICE, a.s., Czech Republic

Abstract:

In this paper, we derive coefficients for a simplified model of heat regenerator based on a porous wall approach which allows simulation of whole furnace including regenerators without a significant increase in computational power demands. To determine these coefficients, detailed knowledge of the velocity, pressure and temperature fields is necessary. These quantities are usually obtained by experimental measurement which is very difficult for complex geometry and high temperatures such as those in heat regenerator. As a remedy, detailed CFD simulations with detailed geometry were performed. To capture important physical phenomena, such as turbulent anisotropy induced by buoyancy flow, more advanced physical and numerical methods are required. Instead of the commonly used k-ε or k-ω model of turbulence, explicit algebraic Reynolds stresses model is employed which improves the capability of the two-equation turbulence model in the highly turbulent flow field. The derived coefficients are used to simulate the heat exchanger model in in-house developed Glass Furnace Model (GFM) SW and results are compared to the detailed model.

HOW NUMERICAL SIMULATION OF REFRACTORY CORROSION CAN SUPPORT GLASS FURNACE SOLDIER BLOCK MONITORING

Stéphane Schaller, Michel Gaubil, SEFPRO Refractory Solution dept., Le Pontet, France
Zi Kang Low, Emile Lopez, SGR Provence, Cavaillon, France

Abstract:

In the challenge of glass furnace decarbonization and consecutive glass melting technology evolutions, soldier block temperature monitoring on dedicated digital platform will bring additional information to follow up and optimize glass furnace lifetime. With this technology developed by SEFPRO, to secure and provide reliable temperature data, unexpected short-term events can be detected and also long-term temperature evolution can provide indication regarding corrosion evolution. We will also particularly discuss during the presentation how predictive numerical simulation of soldier block corrosion, can make the link in between temperature evolution and refractory corrosion profile. Based on a practical case we will present UpToDate results of glass furnace follow up.

APPLICATIONS OF MATHEMATICAL MODELLING IN THE GLASS INDUSTRY

Jose Oskar Torres Perez
Nikolaus Sorg GmbH & Co. KG

Abstract:

Company Nikolaus Sorg is designing and engineering glass melting furnaces and offers a series of additional services to its customers.

Therefore the company uses different type of numerical methods, such as computational fluid dynamics (CFD), finite element methods (FEM) and discrete particle method (DEM), in order to gain better insight about known technologies and to investigate new concepts.

The paper illustrates some problem solving pathways, validation and tuning processes and gives a short introduction to a new application for training purposes.

FURNACE SIMULATIONS TO ASSIST IN DAILY OPERATION

Andries Habraken, Rui Carneiro, Johan Lötter
CelSian Glass & Solar B.V., Eindhoven, The Netherlands

Abstract:

CelSian developed simulation software for glass furnaces. This simulation software, named GTM-X, is similar to the software used for the weather forecast or the one used in the automotive and airplane industries, but it is equipped with dedicated models that allow it to accurately describe the phenomena inside a glass furnace.

Solid inclusions, bubbles, and blisters are investigated in a laboratory, and their source of origin can be traced via computer modeling. Once the cause of a defect is known, possible solutions are safely tested in the computer model, leading to the safest and most promising solution to be applied in the real furnace. This approach has been proven in hundreds of projects.

In this presentation, modeling of industrial furnaces will be presented, and the result of the calculations will be compared for different situations. The impact on furnace design and furnace operation will be discussed as well as the value for a glass producer to have the capability to accurately predict temperatures and product quality in his furnace.

Keywords: CFD modeling, glass melt quality optimization, redox calculations, bubble prediction, glass melt chemistry.

FULLY RESOLVED MULTIPHASE MODELING OF BUBBLE CHAINS IN GLASS MELT

Engin Deniz Canbaz, Researcher
Şişecam R&D, Turkey

Abstract:

In this study, multiphase CFD model of a bubbler is developed to investigate resulting bubbling properties, such as bubbling frequency, bubble diameter, and rise velocity. Transient multiphase CFD model consisting of glass and air phase is established and the bubbling properties is extracted from its solution via time averaging. The geometry utilized for the multiphase model is an axisymmetric cylindrical shape with a single air inlet and free surface that allows bubble escape. Considering the strong mixing effect of bubbler flow, constant temperature field, therefore constant viscosity, is assumed in the model. Temperature and gas flow rate are parametrically changed to determine behavior of bubbling properties over the operating range for a bubbler in a glass furnace. Determined properties form parametric simulations are fitted into polynomial equations depending on temperature and gas flow rate, which can be applied in single phase glass tank simulations to accurately model the pneumatic mixing effect.
Keywords: Bubbler, Multiphase Flow, CFD, Pneumatic mixing, Glass Melt

MODERN TOOL FOR ENERGY SAVINGS AND GLASS QUALITY IMPROVEMENT - SIMULATION AND ANALYSIS OF FG MIXING ELECTRODE

Bartlomiej Kubera, Kasper Kaczmarek
Forglass, Poland

Abstract:

Necessity of the decarbonization and sustainable use of energy does not bypass the glass industry. It is obvious that the main object requiring the new solutions is the glass melting furnace. Innovations among others results in the increasing usage of electrode boosting as an energy source. The operational flexibility of furnaces adapted to alternate use of two energy sources is not only a design challenge, but also a technological one. In order to maintain the same number of holes in the bottom and reduce the amount of sensitive equipment used in the unfavorable environment as the melt tank is, the mixing electrode is introduced. Number of simulations and sub-models were carried out to determine the performance characteristic of the innovation. Thanks to the high elasticity of the operational settings such as a boosting power and bubbling gas flow, the energy released in the vicinity of the mixing electrodes initialize and drives the glass melting processes more effectively.
Mixing electrode has a meaningful impact on the melt tank performance, which can lead to eighter specific pull rate increase or reduction of the specific energy consumption while improving the quality of the glass as well.

ENHANCED ACCURACY IN BUBBLER APPROXIMATION FOR GLASS FURNACES USING DETAILED SIMULATIONS

Vaclav Heidler
GLASS SERVICE, a.s., Czech Republic

Abstract:

Bubblers are commonly used in glass furnaces, as they enhance the quality of glass due to their positive impact on glass flow patterns. However, altering the flow field by placing the bubblers can also have unintended negative consequences. Therefore, accurate modelling of bubblers is desirable in glass furnace design.

Precise modelling of the bubbling is very computationally demanding, requiring the solution of unsteady partial differential Navier-Stokes equations for multiphase flows for quite a long period of time. Therefore, this approach is very ineffective within the real glass furnace simulations which are quite complex in themselves. This study focuses on developing a simplified mathematical model for bubblers based on detailed Computational Fluid Dynamics (CFD) simulations. The set of detailed simulations of an isolated bubbler were performed for various values of three parameters: glass viscosity, depth of the glass, and incoming air flow. From the results obtained, a simple multilayer-perceptron artificial neural network was trained to predict the average force for the aforementioned parameters as an input.

To overcome the challenges of detailed bubbling simulation, we utilize the effective lattice Boltzmann method (LBM) to simulate the glass flows. It is based on the concept of mesoscopic description of the continuum, where the fluid is viewed as a collection of interacting particles rather than a continuous medium. LBM is a powerful computational tool that has gained popularity in recent years due to its ability to accurately simulate complex fluid dynamics problems while being computationally efficient. LBM tracks the evolution of a probability distribution function, which represents the density and velocity of the fluid particles, to simulate fluid flows. This approach has been successfully applied to a wide range of physical and chemical problems, including multiphase flows. To capture the bubble's surface a method similar to the volume of fluid method (VOF) algorithm is used. In our approach the treatment of liquid-gas two-phase flow is simplified by neglecting the gas phase, making it more computationally efficient and avoiding issues with high density ratios that limit other multiphase approaches.

The results of this study demonstrate the effectiveness of the simplified mathematical model developed for bubblers using detailed LBM simulations. Our approach has the advantage of being computationally efficient, while still being able to capture the effect of bubblers in glass furnaces. By validating our approach through physical and numerical experiments, we have shown that the developed model can be used to simulate bubblers in real furnace scenarios.

CO_2 REDUCTION IN THE FLUE GAS - HOW TO IMPLEMENT AN EFFICIENT ORC AND GENERATE ELECTRICITY

Dipl. Ing (FH) Matthias Hagen
DÜRR Systems AG, Germany

Abstract:

The reduction of the specific energy consumption of a furnace helps to reduce CO_2 emissions, but in most cases, will not reduce total emissions, as the size of new furnaces will increase in most cases.
Also alternative fuels like Hydrogen are not available yet, which makes a reduction of CO_2 emissions a difficult task. One possibility is the use of an ORC in the flue gases, which could generate electricity and save CO_2 emissions.

Classic flue gas treatment systems are using an electrostatic precipitators or the more modern bag filters. In these applications the use of an ORC requires an additional heat exchanger, which is often, in order to recover much energy, located in the dusty flue gases. This configuration leads to clogging of the heat exchanger and additional losses due to the energy transfer, which decreases the payoff.
The use of a direct evaporator in the flue gases ensures highest efficiency and so maximum CO_2 savings. For this it is required to have the flue gases nearly dust free, so to use an efficient filter upstream. In order to maintain a high flue gas temperature this filter needs to work at high temperatures, which is possible by using ceramic candles.

The presentation shows this solution and the achievable energy production as well as the CO_2 savings. Also an example for subsidiaries is presented, based on a typical 400t/d furnace.

COMPLETE DE-CARBONISATION OF A GLASS FURNACE

Gurhan Dural and Dr. Reha Akcakaya
7Cbasalia Global AG, Turkey

Abstract:

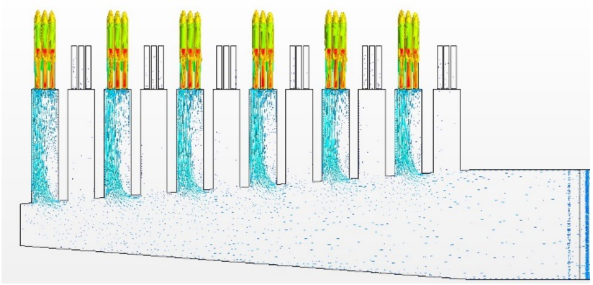
The impact of Green Deal and similar initiatives on the glass industry will be substantial, mainly due to the impossibility of reducing combustion energy beyond a certain point, unavailability of full-electric mass technologies and sufficient green electricity, infancy and ineffectiveness of hydrogen energy, as well as low profit margins that cannot sustain high process costs. The only robust, economic, and green solution for the carbon crisis the glass industry is facing, is the revolutionary *Basalia Bio-circular Technology*, through which CO_2 and all other pollutants and greenhouse gasses in the chimney stack, namely NOx, SOx and hydrocarbons can be completely eliminated without creating additional waste. The Basalia invention by *Mr. Ahmet Basal* is based on restoring the element cycles of nature broken by linear economies using tools of nature itself. A culture of microorganisms trained to survive and thrive in all sorts of solid waste is used to ferment a random mixture of organic and inorganic waste, releasing hydrogen rich Basalia gas and the Basalia solid. Basalia solid can subsequently be used in aqueous and solid state systems to convert all chimney gasses into stable natural compounds. In this decarbonisation process, no additional energy or chemicals are used.

ABOUT PROCESS DESIGN AND THE INFLUENCE OF DAY-NIGHT VARIATIONS ON MOULD COOLING OF IS MACHINES

Harald Zimmermann, Andreas Hanninger
THD, Germany

Abstract:

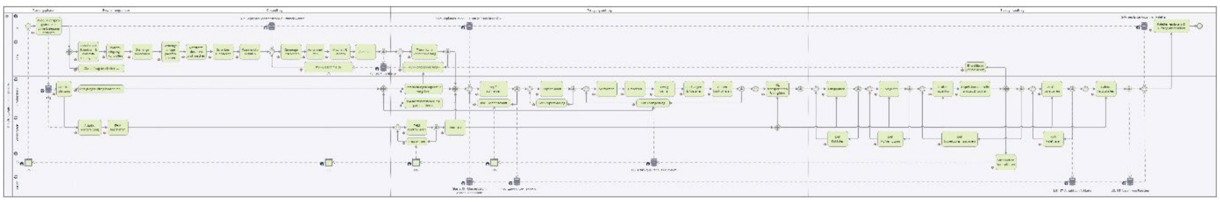
Simulations are an established tool in industry for many different applications. The use of a digital copy allows the optimization of equipment and processes in the system at low cost. In the glass industry this method is mainly used for furnaces. But it has a lot more potential.
For example, the auto control of the mould cooling process in IS machines. In this case, the essential process parameters and their significance in the system are not sufficiently clear, as it is a difficult-to-access system with many interrelationships. One issue is the temperature fluctuation caused e.g. by the day/night change. The system must be adapted to these new settings. It has to be clarified with which parameter this problem could be easily solved.



Process Simulation with a model

Mr. Hanninger would present an example of an simulation. In this case a model for the airflow distribution for an IS machine. In addition, he would like to show an outlook of the ideas we would like to pursue and realize with the Star CCM+ program with electric melting furnace.

To give the big picture of process optimization, Prof. Zimmermann is going to present process design as a basic method.



Value chain of the container glass industry

THE HISTORY OF SUPERBOOSTING IN CZECHOSLOVAKIA FROM 1992 TO THE PRESENT

Karol Skultety
Glass Boosting Technology, Slovakia

Abstract:

1. History of the GBT company from 1975 to 2002.
   - The company started in Skloobal n.p. Nemšová since 1975 with a focus on the gradual improvement of existing electric heating systems, at first only in Skloobal.
   - Gradually, under the auspices of Tatraskl, it focused on technical and professional assistance in the introduction of new electric heaters for the glass factories of Tatraskl in Trnava (Nemšová, Lednické Rovne, Skloplast Trnava, Poltár, Katarínska Huta, Techniké sklo Bratislava, Utekáč, Nová Baňa).
   - During this period, it focused on the gradual research and development of electric heating technology, the most significant benefit of which was increased energy efficiency and the gradual achievement of the so-called superboosting effects in melting aggregates.

2. Use of physical models in practice and verification of model designs with reality using the so-called of flushing trajectories in the melting unit.

3. The dilemma of using mathematical models in real conditions of melting aggregates. The necessary confrontation of the operation of the mathematical model in a discontinuous environment (discontinuum) in the so-called nodes of the 3D network, in which modeled melting processes are displayed, with melting processes in reality, which are in a continuous environment (continuum), which can be easily verified on a real melting aggregate using e.g. isotope of sodium and other components of the glass stem. Therefore, physical models of melting aggregates, which also work in a continuous environment (continuum) and can therefore eliminate some distorting effects of mathematical models, are also a good help, e.g. unrealistic interactions of multiple zone electric heating with each other, including spatial distortion of the shape of electric fields from the action of melting electrodes in melting aggregates.

4. References of the activity and research of the employees of G.B.T s.r.o. from 2002 to the present.

5. The future of glass melting aggregates in relation to a significant reduction in emissions from the action of suberboosting (also hybrid melting aggregates) and the replacement of classic natural gas with hydrogen.

ROLE OF MELT FLOW CHARACTER IN GLASS MELTING PROCESS

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Lubomír Němec[1]

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Abstract:

The T-melter was mathematically modelled by GFM with a batch model (DEB) taking into account a complex batch with primary foam. The theoretical background of melting phenomena was introduced – involving the role of batch conversion, foaming, melt flow character, sand dissolution, and bubble removal for the process.
The optimizing of the energy distribution led to favourable melt flow when the space utilization and the melting performance achieved their maximal values.
A few model cases were examined to optimize the melt flow, the space utilization, and the melting performance.