GLASSMAN LYON 2017

Requirements for glass conditioning systems & HORN solutions for production demands in the future

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HORN Glass Industries AG is a German specialist in the design, supply and service for glass melting technology and a solution partner for the worldwide glass industry with more than 130 years of experience. HORN is experienced in the design, manufacturing and supply of different kind of furnaces and glass conditioning systems for almost types of glass and is able to provide complete turnkey projects with approx. 300 employees and a yearly turnover from 40 to 80 million EUR.
Glass conditioning - **distributor & FH systems**

### Milestones in the development of gob feeding systems – short historical overview

**end of 19th century**
- First attempts to mechanically imitate the manual removal of glass portions from lateral openings in melting furnaces, the functional principle was already similar to today's ball feeder systems.

**1903**
- Invention of the Owens machine, the removal of glass posts took place directly from the glass bath by suction into a pre mould, followed by the cutting off residual glass and final blowing, for the first time the production of weight-resistant glass portions were possible, the production capacity was already up to 18,000 bottles daily.

**1911**
- 1. Patent for a drop feeder with vertical outlet opening by Karl E. Peiler with paddle and needle, the continuous production of constant gobs weight was possible for the first time independently from the subsequent forming process.

**1923**
- 1. Patent of the gob feeder according to the current design of Karl E. Peiler / British Hartford by using a rotating tube, plunger and shear, a further improvement of the weight constancy as well as an increase in the gob speed was possible.

**1924**
- 1. Patent for an IS machine by Henry Ingle.

**1944**
- Invention of the gas-heated FH (K-series), this was the first time for a targeted adjustment of the glass temperature or glass viscosity over pull- and temperature range.
1. Patent for a gob feeder with a vertical outlet opening by Karl E. Peiler in 1911

over 100 years old development of the first gob feeder!

The continuous production of constant gobs weight was possible for the first time independently from the subsequent forming process, this was the most important precondition for the development of machine glass production!
State of art for gob feeding systems

The main target of a gob feeding systems are single or several parallel arranged gobs adapted to the following forming process with a constant shape, weight, viscosity- and temperatur distribution. The Higher the demands for the molding process the higher are the requirements on the gobs!

Today arround 2/3 of the world wide glass production are produced with gob feeding systems.
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What are the main tasks & requirements for glass conditioning in general?

- transport of glass between riser and several gob points
- temperature level change to required gob- & forming temperature
- homogeneously temperature distribution in the glass (required for gob shape)
- stable glass temperature and viscosity (required for stable gob weight)
- stable glass level with an acceptable head loss
- glass quality improvement by different tools (stirrers & drain systems)
- improve the final refining process (reabsorption of rest gases)
- avoid glass defects by overheating or to cold glass (reboil or devitrification)
- avoid changes in redox state, vaporisation and dropping condensate
- distributors & FH’s performance are increased by higher production requirements
- high flexibility with respect to temperature-, pull range and job change flexibility
- high job change frequency, colour changes, multi gob systems, press & blow
- high glass quality without defects with reduced and uniform wall thickness distribution
- long live time and less refractory corrosion
- low energy consumption and less maintenance costs

Glass conditioning starts after riser and ends at the gob!
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Why is glass conditioning so important?

the **first half** of the bottle is making by the glass conditioning system

the **second half** of the bottle is making by the forming machine

glass conditioning is more or less a "premolding" in form of a gob

optimal wall thickness distribution allows a reduction in article weight

**Optimal wall thickness distribution improve the production efficiency and save money!**
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What are the real requirements today and in the future?

- high pull range up to a relation of 1 : 5 with generally pull ranges between 5 ... 200 tpd
- multi gob production at one and the same machine with SG / DG / TG / QG
- up to 500 gobs per minute with weights from 10 gram to 2500 gram generally possible
- high job change frequency up to 3 times weekly with job change time up to 2 hours
- high thermal flexibility required with fast reaction of cooling and heating systems
- colour changes up to 3 or 4 times yearly
- high thermal homogeneity index especially for press & blow process required
- high requirements to the glass articles with constant weight and wall thickness distribution
- changes in heating gas supply possible with different sources of natural gas and bio gas
- limited space in glass factories available
- by the way a less maintenance and energy consumption is additional required

All this requirements are strong influenced by the market conditions!
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How can you take all this factors into account?

- detail analysis of the planned production
- required FH pull for each line (min. & max.)
- required temperature range (min. & max. / gob- or equalizing section temperature)
- pull or job distribution for each line (see chart next page)
- job change frequency (information about changes per week or month)
- knowledge about forming process (B&B / P&B) and number of gobs (SG/DG/TG/QG)
- maximum riser temperature and furnace pull
- available space between riser and FH connections
- available FH length and gob point position (factory layout)
- based on this information the necessary cooling capacity are calculated
- pull range and temperature stability in the furnace
- possible pull and temperature distribution in distributor (worst case scenario)
- glass properties like viscosity curve, colour and thermal conductivity
- available fuels (heating value etc.)
- use all available and necessary tools

Please use our customer questionnaires as base for optimal engineering solution!

Engineering of glass conditioning systems are not only a simple calculation of residence time!
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Why is the gob temperature important for the engineering?

required gob temperature as a function of gob weight for soda lime container glass

- typically average values for press & blow process, NNPB approx. 10 - 30 K higher
- temperatures in front of spout are normally 20 – 30 K higher than gob temperatures

The gob temperature is important for calculation of required cooling capacity and head loss!
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Why is FH pull and job distribution important for the engineering?

example for annual pull distribution

- FH pull from 20 – 100 tpd with a range of 1 : 5 / required FH dimension 30‘ 43“ / RT approx. 46 min.
- pull ranges within 1 : 3 are normally controllable
- out of this range limitations in distributor temperature are required!
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What is the importance of glass thermal conductivity for glass conditioning?

- heat transfer and temperature equalizing occurs mainly about radiation
- thermal conductivity depends on concentration of Fe and Cr and the redox state
- amber and reduced green (UVAG) with high Fe content is most difficult

Low radiation conductivity creates higher temperature differences!
Low radiation conductivity needs slower cooling velocity and longer equalizing time!
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What is the thermal homogeneity and how is the calculation?

Definition of thermal homogeneity index according Emhart calculation (used by Horn):

- Difference in temperature index (THI) calculation:
  - THI = 100 - \( \frac{30}{1170} \) = 97.4%

Vertical differences:
- Difference 1-3 = 3 K
- Difference 4-6 = 1 K
- Difference 7-9 = 8 K

Horizontal differences:
- Difference 1-4 = 0 K
- Difference 2-5 = 3 K
- Difference 3-6 = 2 K
- Difference 4-7 = 1 K
- Difference 5-8 = 4 K
- Difference 6-9 = 8 K

Summary of all differences = 30 K

Hottest temperature centre line = 1170 °C

Example for FH THI calculation:
- #1 = 1169
- #2 = 1167
- #3 = 1166
- #4 = 1169
- #5 = 1170
- #6 = 1168
- #7 = 1168
- #8 = 1166
- #9 = 1160
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How does the temperature distribution and TH index changed in a FH?

• calculation results of thermal homogeneity index in an amber glass FH with radiation cooling

source: TNO report - Seminar for mathematical modelling 2003
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How does the temperature distribution and TH index changed in a FH?

- temperature distribution influence:
  - temperature distribution in FH entrance
  - FH pull and velocity distribution
  - glass colour and thermal conductivity
  - cooling and heating systems
  - superstructure design
  - channel design
  - thermal insulation
  - temperature distribution in spout area changes drastically again dependend on the design and adjustments
  - it make less sense to keep the THI only in one line in front of the spout stable

source: HVG-DGG AIF spout
What are typically requirements to the thermal homogeneity?

The thermal homogeneity is an important pre condition for a good gob shaping, gob fall and the following forming process. The requirements to the thermal homogeneity depends mainly from the number of gobs and the forming process.

- lower requirements are necessary for blow & blow process:
  - typical THI range is between 90.....93 %

- higher requirements are necessary for press & blow process:
  - typical THI range is between 93.....96 %

For multi gob feeding systems are higher values necessary to be sure, that all gobs have same weight and shape and can be achieved only with small plunger and tube adjustments!

Highest requirements are necessary for TG/QG IS machines and press & blow process!
What are useable tools to achieve a high thermal homogeneity?

**in general:**

- optimal channel design (dependent on pull, temperature range and glass colour)
- use of suitable heating and cooling systems to avoid overheating / overcooling
- superstructure design with efficient heating of the outer glass surface areas
- good thermal insulation especially in equalizing section
- temperature measurement- and control equipment

**additional tools:**

- separated left-right heating systems in superstructure (especially in FH’s, alcoves)
- additional equalizing section boosting (amber and green)
- stirrer units for chemical and thermal glass homogenisation
- mixing effect in the spout can contribute also to a good glass homogeneity
What is the influence of the spout design and spout equipment to the gob?

Spout design- and equipment can contribute a lot to gob shape-, weight- and temperature stability. Improvements are possible with:

- special tube design with rills and long holes
- metering spout system (Emhart) / cascade bowl (BHF)
- spout rotor systems by Heye glass
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Why is the gob shape- and temperature important?

- manual watching by machine operator (weight, shape and temporary temperature measurement)
- continuously temperature- and shape watching by fiberoptic- and camera systems
- fully automatically gob control systems (especially for NNPB recommended)

Gob shape and temperature has much influence to the subsequent forming process!
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FH layout example for new installations
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FH layout example with limited space in building
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distributor GCS 100

- System GCS 100 is a special distributor design dependent on customer requirements
- Preconditioning of the glass to a lower temperature level
- Direct air cooling system in the middle part of the distributor for efficient cooling
- Radiation cooling by openings in the outer areas
- Different glass depth to achieve the necessary residence time
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distributor GCS 100
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FH type GCS 301

- system GCS 301 is for high pull range up to approx. 200 tpd and multi gob production
- application for channels size from 36” up to 54”
- conditioning of glass with high flexibility for pull and temperature changes
- superstructure design for efficient heating and cooling
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FH type GCS 301

- special shaped cover for optimal temperature distribution and high TH-index
- robust and stable cover plate design
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FH type GCS 200

- system GCS 200 is for low pull range up to approx. 60 tpd
- simple and robust design with flat roof for small size channels up to 26”
- final conditioning of glass with high flexibility
- superstructure design for efficient heating and cooling
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How can the FH flexibility improved?

- FH cooling zones are enlarged with a high flexible cooling system
- equalizing section with reduced channel width
- additional boosting in the equalizing section
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colouring FH’s

- subsequent colouring of white glass only in one FH line with colouring agents
- homogeneously colouring of glass by efficient mixing with stirrer systems
- wide colour range possible (blue, grey, green, amethyst, black)
- high production flexibility especially for small jobs
- high entrance temperature approx. 1280 °C required
- HORN supplies complete systems including feeding and mixing equipment
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Complete gas heating equipment – CORA System

- Complete heating equipment for gas-air heating system (type CORA)
- Constant gas / air ratio (+/- 0.1 %) with a wide control range (2 – 50 mbar)
- With frequency controlled combustion air supply
- Can be integrated in any existing mixture heating system
- Supply of all heating parts including combustion air and gas control stations
- Additional oxygen measurement and control system available (type EUROX)
- EUROX is especially recommended for instable caloric heating values and Wobbe-Index
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change of gas composition – measurements over 3,5 month in Germany

measured by a gas chromatograph

example 1 example 2

caloric heating value 36,1 MJ/m³ 36,6 MJ/m³
gas density 0,73 kg/m³ 0,79 kg/m³
Wobbe Index 48,0 MJ/m³ 47,0 MJ/m³
required combustion air 9,65 m³/m³ 9,78 m³/m³

This change leads into deviations in the gas-air ratio and flow control and changes in the combustion behaviour!
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possible change of Wobbe Index in Europa

- a indicator for the stability of a gas heating system is the Wobbe Index
- the Wobbe Index describes the amount of heat which is exiting from a gas nozzle
- especially in volumetric mixer systems this can lead into an instable combustion
- in case of changes of the Wobbe Index the air-gas ratio must be corrected until now manually

source: Marcogaz
EUROX oxygen measurement systems MPLS

- The heated extractive oxygen sensor MPLS is particularly designed for the O2 measurement of gas-air mixtures under rugged industrial operation conditions.
- The sensor is based on a special zirconia cell and is measuring the O2 content in oxidizing and reducing atmospheres.
- The “NERNST” equation allows a calculation of the lambda value based on a mV signal.

Benefits:
- Very short reaction time enables multiple samplings of up to 9 suction points with 1 unit only.
- Highest measuring accuracy and long-term-stability.
- Minimum maintenance and service required.
- Fluctuations in heating value will be determined and balanced automatically and allows a near stoichiometric combustion.
- This leads into a more stable temperature control, contributes to energy saving and stable atmosphere in the combustion space.
- Especially recommended for big changes in gas composition and for sensitive glasses.
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- measurement of lambda value by a special developed zirconium dioxide sensor

EUROX oxygen measurement systems MPLS
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EUROX oxygen measurement systems MPLS

- Lambda monitoring and / or control measurement in PLC
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energy consumption dependent on gas-air ratio and combustion temperature

- a stable ratio can be safe a lot of energy
- an air deficit and excess increase the consumption drastically

additional energy consumption
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FH electrical heating equipment

- additional boosting systems in the equalizing section in front of the spout
- more accurate temperature adjustments are possible
- especially recommended for amber and green glass with high necessary TH index
- normally 2 x 4 electrodes with 2 separate transformers
- supply of all heating parts including electrodes, transformers and control systems
- complete electrical heated FH’s (for special glasses, borosilicate etc.)
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Why is the head loss important?

- the head loss is a result of friction losses in the glass and has an impact to the gob weight
- most influence has the glass viscosity, pull and velocity and channel design (depth and width)
- normally a head loss of 25 mm is acceptable for standard FH’s with a slope of max. 20 mm
- in case of higher head loss and using a lifting unit a higher channel free board is necessary
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FH lifting system

- FH head loss is a result of friction losses in the glass and has an impact to the gob weight
- the head loss can be compensated manually by a FH lifting system after job changes
- more accurate and faster adjustments are possible
## Glass conditioning - distributor & FH systems

### FH drain systems – VARI DRAIN

<table>
<thead>
<tr>
<th>Product</th>
<th>Flow rate</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vari Drain</td>
<td>0.2 – 2.0 tpd</td>
<td>Forehearth</td>
</tr>
</tbody>
</table>
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FH drain systems – VARI DRAIN

- removal of contaminated bottom glass
- avoid glass defects by “cat scratches”
- installation of a drain channel block in front of equalizing section recommended
- continuously and temporary operation are possible
- works without a molybdenum counter electrode in the glass
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FH stirrer systems

<table>
<thead>
<tr>
<th>Product</th>
<th>Stirrer quantity</th>
<th>Feature</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stirring unit</td>
<td>2 / 3 / 4 / 5 / 6</td>
<td>swing out mechanism</td>
<td>FH / colouring FH</td>
</tr>
</tbody>
</table>
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FH stirrer systems

- application for chemical and thermal homogenisation of the glass
- recommended for high glass quality especially for flacons and table ware
- avoid glass defects with “cat scratches” by mixing the contaminated glass
- for cat scratches are normally paddle stirrers recommended
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FH control systems - PLC SIEMENS S7

example 150 tpd green  THI = 97,7%
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FH control systems examples

example 127 tpd green  NNPB-Process  THI = 98,1%
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FH control systems examples

example 128,5 tpd green without boosting  THI = 98,4 ... 98,9 %
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- today is each glass conditioning system more or less a special customer orientated solution and is dependent on the given boundary conditions
- the clarification of all necessary technical details between customer and supplier makes sure to work out the best technical and commercial solution
- it makes less sense to by only cheap standard products
- please consider, that the investment in a glass conditioning system is in the most cases less than 1 percent of the financial value of later production (standard glassware)
- please consider also, that it is not possible to have a high production efficiency and flexibility, low energy consumption and investment costs at one and he same installation
- for the future I think personally, that with the available technical solutions and technology are due to physical limitations no big innovations possible
- today it would be very helpful for the most glass producers to use the existing know how in a right way
- for further improvements is a complete cross thinking from glass producers and FH suppliers in other directions necessary
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MANY THANKS FOR YOUR ATTENTION I WISH YOU GOOD LUCK & SUCCESS FOR YOUR GLASS PRODUCTION AND BUSINESS!
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