
ARNOLD
GRUPPE
SINCE 1950
GLASS TUBE PROCESSING
WITH
LASER
RADIATION

LAB GLASS

- joining
- forming
- cutting
- calibrating
- glazing
- marking / engraving
- drilling

LAMP GLASS

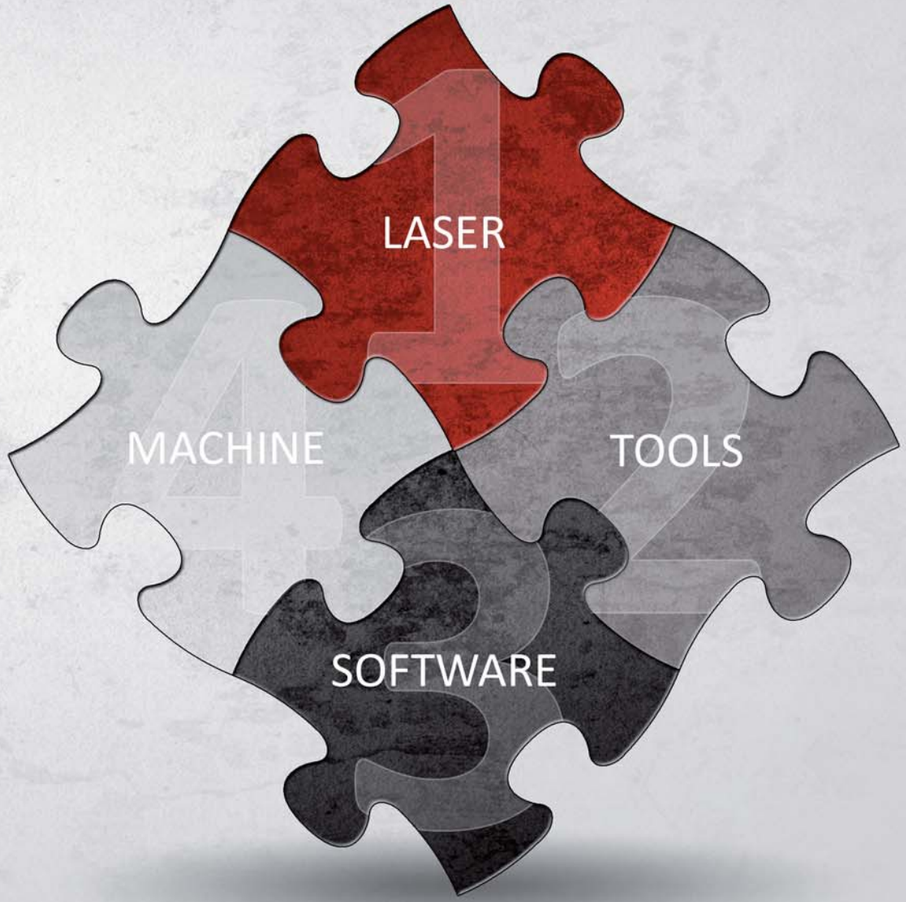
- joining (also glass metal sealing)
- forming
- cutting
- calibrating (wall thickness, diameter)
- marking / engraving
- drilling
- polishing

SOLARTHERMICS

- joining (also glass metal sealing)
- forming
- cutting

The ARNOLD modular system

Our concepts are based on our standard modular design for glass processing machines. Upon request, the basic machines can be supplied with respective forming tools, automation concepts for automatic loading and unloading of machines. According to customer's application a suitable laser source is chosen and implemented. Of course, we also quote solutions perfectly adjusted to your individual production process.

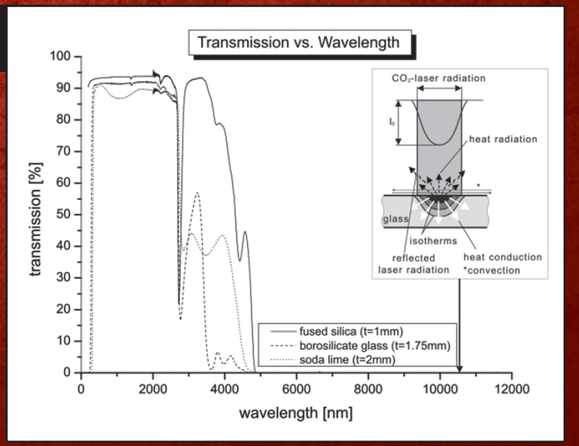


1 LASER

Introduction

When processing glass by means of lasers, in principle several kinds of lasers are applicable. Glasses behave transparent in the visible range of light and in the near-infrared (possible laser wavelengths of about 500nm to 1100nm) respectively. Therefore, they can be marked within the volume by means of solid-state lasers that emit radiation in this wavelength range. This method is known as volume engraving (e.g. for design applications).

If glass has to be heated (e.g. for subsequent forming or joining processes), CO2 lasers are recommended. They emit radiation in the mid infrared range; a typical CO2 laser wavelength is 10600nm. The chart clarifies that glass, regardless of the kind of glass, behaves opaque and not transparent when irradiated with this wavelength. Thus, the laser radiation is absorbed and / or reflected at the glass surface. The ratio of the reflection depends on the radiation situation and the angle of incidence and is about 20%. Consequently, 80% of the emitted laser radiation is absorbed on the glass surface and is used to heat the glass.



Applications

Nowadays, the compensation of production costs is one of the crucial aims to survive in the global market. This also applies to the glass processing industry. An effective means to meet this objective is to increase the level of automation in production and to reduce labor costs respectively. At this point the laser, having been successfully used in the automotive and metal industries for decades, can also be of use in the glass industry. One of the most important benefits in this field is the excellent automation of production processes. Furthermore, the “tool” radiation is extremely flexible. Thus, e.g. by focusing the laser radiation, cutting of quartz or scratching of borosilicate glass for a subsequent thermal shock is possible. At using larger laser beam diameters glass heating for possible forming – and joining processes is effected. Finally, each type of glass from quartz to soda-lime glass can be processed with one laser source.

Overview of the most important benefits at use of a laser:

Fully automated working processes
- several processes with „one tool“
- focused cutting, defocused heating
- possibility of production starting from initial tube and not with pre-cut tube segments

Precise temperature control at heating processes
- independently adjustable temperature profiles, adapted to the process
- high reproducibility: „same process sequence – same process result“
- force-free processing – no flame pressure

No chemical influence to the glass during the process
- no condensation water or soot
- no remaining residual stresses (which are caused by chemical influence) in the glass after annealing

Defined and efficient energy transfer to the glass
- fast heating
- no /low heating of the machine periphery

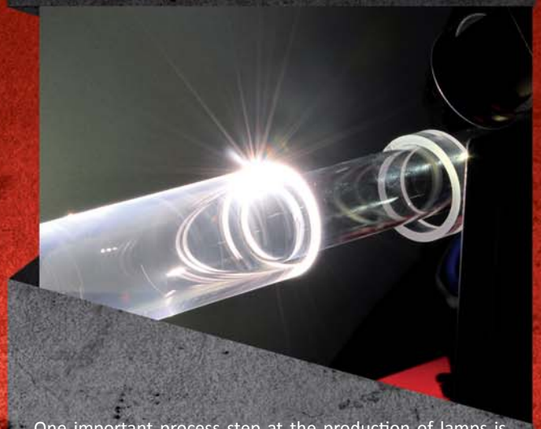
Adjustable intensity distribution in the heating zone
- heating zone on the glass surface can be adapted (in terms of heat distribution and/or shape)
  e.g. linear, circular, elliptical, etc.

High cost-efficiency
- by system flexibility
- short process times
- multiple use of one laser source on several work stations possible
- low maintenance resp. maintenance-free

Laboratory glass

Several process steps are often necessary to achieve the final product of the requested laboratory device. For instance, at the production of thermometers the glass tubes are initially tapered, separated in the tapered zone, and then joined at this position with smaller glass tubes that match the tapered diameter. Both ends of the thermometer have to be sealed during the subsequent manufacturing process. Thus, several hot glass processes such as forming, cutting and joining have to be performed to reach the final geometry. Here, the laser with a temperature control can be used to provide reproducible and continuously constant process results. The glass temperature is measured by means of a pyrometer and processed in a control loop. The laser gets continuously new power values from the control loop in order to heat the glass following the given temperature profile.
Thus, it becomes possible to reproducibly reach the glass working temperature without breakage within a few seconds, which significantly shortens the process time. After the laser forming (tapering) the cut in the tapered zone can be performed inline the production process. The laser beam is focused by means of a focusing lens mounted on a motorized axis and is used to evaporate the glass where it has to be cut. Finally, the tapered and cut front edge is joined with a tube having a corresponding tube diameter by means of the laser.
Since all required processes can be successively performed by a laser system working with initial tube lengths becomes possible. Due to the fact that laser radiation is electromagnetic radiation, there is no chemical influence to the glass like condensation water, soot or any combustion residues, such as known from the burner heating.

Lamp glass



One important process step at the production of lamps is the cutting of glass tubes.
The cutting is differently realized depending on the kind of glass. While glasses with higher coefficients of thermal expansions are cut by thermal shock or scratched and cracked-off, quartz glass is typically sawed. Here, mostly a water-cooled saw blade is guided through the quartz tube. Appearing mechanical forces during sawing lead to chipping at the cutting edge. Depending on further processing the cutting edge has to be reworked which contains grinding and polishing or glazing with burners. In any case, washing and drying becomes often necessary to get rid of the chips.

In contrast, no additional process steps are required when laser cutting the glass tubes. The laser beam is focused and used to evaporate the irradiated glass material. The contamination of the tubes by appearing soot is avoided by an efficient extraction. A tool wear as arising at sawing, scratching and cracking-off process does not occur. The cutting times, depending on tube diameter and wall thickness, are only a couple of seconds. The cut tube can immediately be used and further processed after the laser cut. Post-processing steps compared to wet-cutting are not necessary. Required infrastructure for washing and drying the glass tubes including an appropriate water treatment is not needed anymore at laser cutting.

Solarthermics

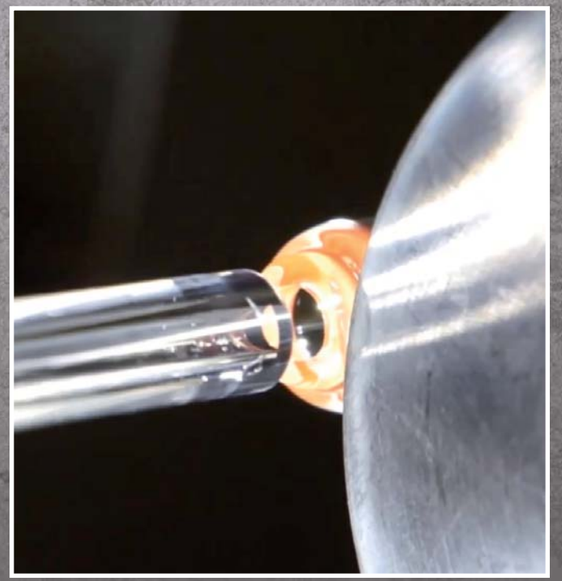
Besides laser cutting, glass tubes can also be heated with laser radiation for complex forming processes like flanges etc.. The laser heating is e.g. used for production of heat pipe evacuated-tube collectors. Here, two glass tubes with different diameters are concentrically arranged and laser-heated at the front side. By means of forming tools one of the glass tubes is flanged and then joined together with the other tube. A limited space between both tubes is created, which can be evacuated to reduce heat losses of the later solar collector. The advantage of the laser at this process is, in addition to the precise and fast heating of the tubes, the adaptable and geometric limited heating zone. Therefore, the forming tool can operate during laser-heating without being directly heated as well.

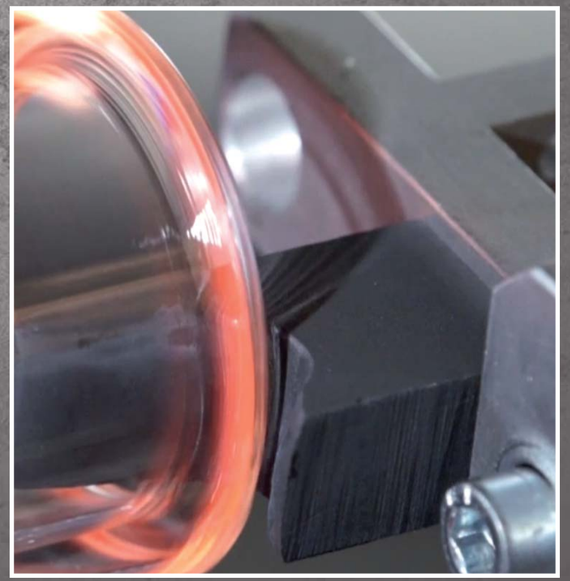
Furthermore, tubes can be joined by a laser in butt joint. A special highlight is the glass-metal-sealing, which is also used in solarthermics. Since the oxide layer of the metallic partner is essential for a vacuum-suitable glass-metal-sealing any influence to the layer has to be avoided during the joining process of glass and metal. A dispersive burner flame influences this oxide layer during the joining. In case of thin-walled metal components destruction can occur in the worst case. At this point the adjustable and geometrically limited heating zone while laser-heating helps to overcome this problem.

2 TOOLS

Arnold forming tools

Due to the geometrically defined heat input while using lasers for glass processing, forming tools can usually operate during heating which leads to shorter process times. Common materials for forming tools can be gray cast iron, graphite or stainless steel. The material is based upon the forming process and the kind of glass to be formed.

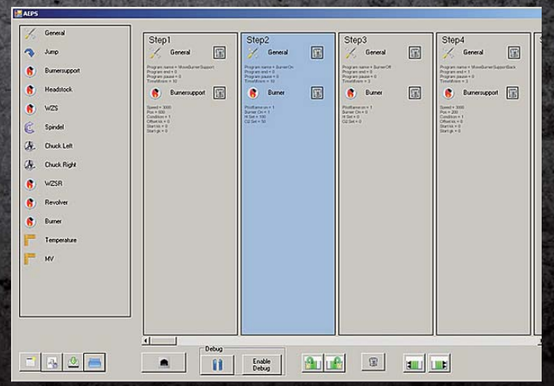




SOFTWARE

Anold AEPS+

With the launch of laser processing machines, the controls of Arnold machines have been basically redesigned. It is now possible to create freely programmable process sequences via Drag & Drop by means of a graphics-based programming platform. Pre-programmed sequencers, with limited allowance to the individual working process of the machine are a thing of the past. The new software AEPS+ can be installed at any commercially available computer. The communication with the machine control system (PLC) is realized via Ethernet interface. The creation of the fully-automatic program sequence is then effected via Drag & Drop. Here, from a defined tool box (picture, left hand column) the symbol for the individually to be accessed hardware is selected and moved to the desired program step (picture, right hand column) and then parameterized.
As shown at the sample program in the graphic, the axis for the burner support is moved with 3000 mm/min to position 600mm at the first step (Step1). In the next step, the burner is switched-on, ramped up to the defined flow rates and operated for 10 seconds with these flow rates. The third step involves the switch-off of the burner. At the fourth step, the burner support is moved to position 200mm and the sequence ends. After creating this program it is now passed on to the machine control by pressing just one button. After this transfer, the computer is not longer necessary and can be unplugged, since the process sequence is now performed by the machine control.



Advantages for the use of AEPS+

1. **Creation or modification of program sequences without external software engineer**
   - No disclosure of internal process Know-how to external software engineers
   - High flexibility and independency
   - Short reaction times at urgently required adjustments of process parameters
   - High cost savings
   - Permission management

2. **Intuitive graphical machine programming per Drag&Drop**
   - No programming skills of the system operator / process specialist are needed
   - Creating of new / adjustment of existing program operations in the shortest time possible without training
   - Sequence programming is carried out on commercially available Notebook / PC
   - Theoretically infinite numbers of program sequences can be created / stored
   - Creating redundant backups to external media is possible

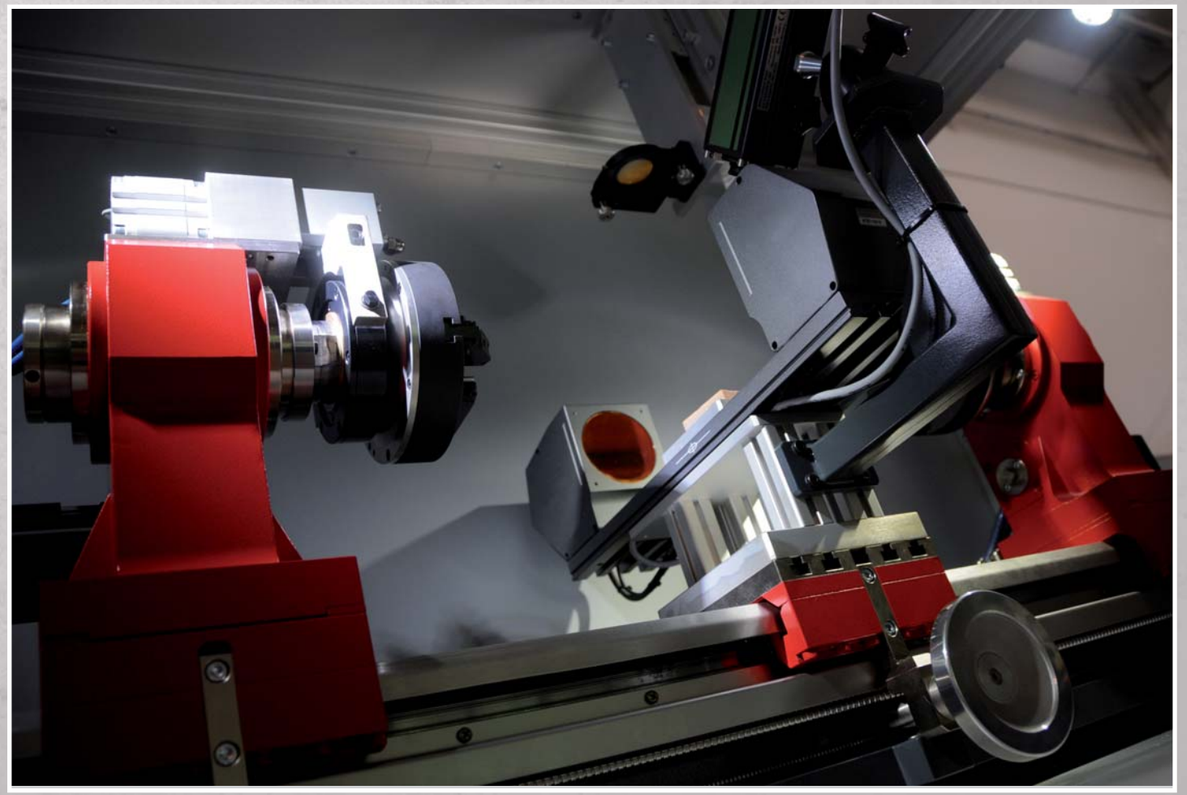
Conclusion:
By using AEPS+, new working processes can efficiently be developed and implemented. Furthermore, existing process sequences can quickly and easily be changed, resulting in a more efficient use of the existing production machines. In addition, the entire machine hardware is made freely available for the system operator respectively the process specialist. Thus, the machine potential can be fully used. Due to the intuitive operation, the production process has now first priority and not the proper machine programming.

MACHINE

Arnold lathes

Arnold glass working lathes are used in the laboratory glass production and electronics industry for joining, forming and fusing operations. They are also used in quartz glass industry for calibrating the diameter and/or the wall thickness of large, long tubes as well as for joining and forming operations with special tools and machine equipment. Another range of applications is the fiber industry with special machine concepts for individual process steps.

Depending on the application and customer requirements with regard to the cycle time, the glass working lathes can be equipped with ball screw spindles or linear motors.
This drive concept is characterized by high acceleration and top speeds. Due to the non-contact transfer of driving forces between the working head and the machine bed, these drives work almost wear-free.



Arnold P1040 Laser

The machine type P1040 is based on the Arnold Standard Glass working lathe P1040. This all-purpose precision glass working lathe is especially suitable for laser applications, e.g. in the laboratory and lamp glass industry; possible processes include joining, forming, cutting, flange / thread production, calibrating and drilling. The system is designed with a stable and torsion-free machine bed as well as a separate drive technique for each working head. A continuous adjustment of the laser beam diameter becomes possible by using a motorized axis for traveling the focusing lens.

The machine is designed as a compact system including the laser unit and machine control and can be operated either manually or fully automated, for instance by loading and unloading of work pieces via industrial robot.

Machine design

- Machine design on a stable frame for the acceptance of the glass working lathe, laser system including beam guidance as well as control unit, media supply and the required safety equipment - as a compact unit.
- Glass working lathe with a robust, torsion-free machine bed with mounted precision linear guides, mounted on an aluminum plate.
- Closed stainless steel cover above bed guidance for protection against contamination and heat.
- Moveable machine parts – left and right working head – are mounted on prestressed guiding wagons. Working heads are equipped with quick clamping devices for automated opening and closing of chucks.
- With all required laser protection devices with 2 manual sliding doors, feeding sector, where operator is working for a generous access into process area. Protection equipment is designed for a safe operation of laser and according to safety regulations.
- Applications like automatic focal plane adjustment on different tube diameters or alternating operations – cutting – joining – forming - are possible.

Drive technology

- Each spindle head is equipped with an own AC servo motor running the spindle directly via toothed belt
- The spindle heads are equipped with the following operating modes:
- Synchronous drive of both spindle heads (standard operation) or
- Individual operation of each spindle head
- Drives of working spindles guarantee an exact control even at low rotational speeds
- Working heads equipped with separate, one each AC servo motor and integrated transducer system. Positioning of working heads is freely programmable via machine control

Laser and beam guidance

- Rofin Sinar CO2-Laser
- The laser is chosen according to customer's application
- Chiller for controlled laser cooling in recirculation operation.
- Beam guidance via mirror system starting at beam exit via focusing optics to the work piece.

Industrial process and control

- Machine is controlled by a Siemens Simatics S7-PLC control unit, integrated in the control cabinet.
- Process programming and –visualization with Lenze OPC Touch Panel.
- Programming with Arnold AEPS+, process parameter and process sequence can be programmed by e.g. process specialists, without any basic knowledge of PLC programming languages.
- Option: pyrometer for closed loop temperature control during heating resp. joining and forming steps, for reproducible process characteristics during automatic mode

Technical data:	**1040P**
Diameter of spindle bore	42 mm
Centre height above support	200 mm
Workpiece length between chucks	750 mm
Rev. of spindle	up to 300 1/min.
Laserpower	variable

Arnold NC56 Laser

The machine NC56 Laser is based on the Arnold standard glass working lathe NC56. This numerically controlled precision glass working lathe is especially suitable for laser applications, like for instance joining or forming of larger tubes, e.g. in the solar industry or in the chemical apparatus industry. The machine consists of an extremely sturdy and torsion-free machine bed as well as a separate drive technology for each working head. The laser with the required chiller is adapted as separately positioned unit. Via mirrors an economic operation of several machines with only one laser system becomes possible. The machine can be operated either in manual or in automatic mode – for instance with an automatic loading and unloading system of work pieces.

Technical data:	**NC 56**	**Options**
Diameter of spindle bore	162 mm	102 / 122 / 202 mm
Centre height above support	450 mm	
Workpiece length between chucks	1.100 mm	customized version
Rev. of spindle	up to 500 1/min.	
Laserpower	variable	

Arnold 75/01 Laser cutting plant

The Arnold 75/01 is consequently designed for the application of high-performance glass tube cutting. After being manually loaded with tubes to be cut, the glasses are automatically separated and transported to the laser cutting unit by means of a gripper system. Here, different tube diameters and tube lengths can be automatically cut on up to 4 simultaneously working stations. The laser-cut tube segments will be taken-off by means of a second gripper system and loaded into an optional glazing line where the cut front edges can be glazed with conventional burners. Beside the manual loading and unloading (robot systems as an option) the whole system works fully-automatic. Due to the used cutting method evaporated glass material occurs in and closed to the laser cut. This sublimate is effectively vacuumed in the cutting area from the inside as well as from the outside of the tubes. In order to achieve high cutting outputs the working heads, handling the glasses, are equipped with linear motors that combine high top-speeds with high accelerations' and excellent positioning accuracies.

In case the laser production technique is of interest to you, it will be a pleasure for us to support you with our know-how. In our company in Weilburg/Lahn we have installed a laser production cell which can be demonstrated by our process-laser specialists for the validation of laser processes with your parts. Upon request this cell is also available for job-shop purposes to support your own production capacities.

ARNOLD GRUPPE

SINCE 1950

HERBERT ARNOLD GMBH & CO. KG
Weilstr. 6, 35781 Weilburg

Telefon: + 49 (0) 64 71 / 93 94 0
Telefax: + 49 (0) 6471 / 20 65
Internet: www.arnold-gruppe.de