

# How to improve your profitability with the latest glass processing machinery and software solutions

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## Keywords

1=Low-E                    2=Productivity                    3=Optimizing  
4=Glass tempering      5=Safety glass

## Abstract

Rising costs in expensive, coated Low-E glasses and the demand for shorter delivery times require new logistics concepts in safety glass processing. In predicting the efficiency and quality of glass processing, the glass processor has to rely on factors set by the glass as well as the available processing technology and software. This paper is an overview of different processing factors for architectural safety glass processing, focusing on high productivity and glass quality in pre-processing and glass tempering. The paper also covers different theoretical and practical approaches to the prevention of quality costs, mainly due to machinery being used far below its design capacity and the total manufacturing process not being under control. The objective of this study is to find an optimum glass processing technology with better production sequence, and an optimum glass yield with minimum space requirement for multi-stepped architectural safety glass production. High productivity is the sum of several components: machine capacity, factory layout, production flow, available service functions, buffers, availability and skill of personnel, and the level of quality to be obtained. Experiences of the use of advanced glass processing machinery combined with new optimizing algorithms and planning methods have demonstrated that the optical quality of glass has improved and stayed on a high level while the productivity and yield of the process have also improved.

## 1. Introduction

The constantly rising pressure on costs in the manufacturing of architectural glass requires new solutions in plant and software concepts. The goal of the glass processing industry worldwide is to attain the highest possible productivity. This is achieved only when the maximum quantity is produced at an acceptable quality and the lowest costs. Modern production machinery makes ever-increasing demands on organizational concepts and control software. These machines – highly



Figure 1.  
Today's glass architecture requires advanced processing and logistic concept; Zeil Gallery, Frankfurt am Main

complex, sensitive high-tech systems – allow fast clock rates and thus a high throughput, but only if the overall concept fits and the production process is optimally scheduled (see Figure 1). In dynamic and flexible production in a state-of-the-art production environment, the use of a machine cannot be considered an isolated factor; it depends on other factors like the previous and following machines, individual requirements and, most of all, the software that controls all these elements and optimizes their interaction to produce the maximum output. Let's take a few good examples to prove our point.

A good capacity for an Insulating Glass Unit (IGU) is 800 units per shift, while the reality is only 400-600 units. And when it comes to furnaces, a good usage is 60-70%, but the reality is often less than 30%. In each of the above examples, the flow of the process is malfunctioning. When the process is not properly managed, errors accumulate and the whole process is as weak as its weakest link. Optimizing individual

machines can easily create the need for large buffers, which in turn may result in a large number of search and locate activities, with the risk of damaging products already partially processed or of creating low flexibility within the organization. There is a solution. Just follow the flow by reviewing the complete process, identifying bottlenecks and reducing buffers.

## 2. Optimized production flow increases productivity

The timing of on-site deliveries and the phasing of glass installations with other key stages of the construction project are crucial for overall cost efficiency, smooth installation and avoidance of the risks typical of a construction site environment. Today's safety glass manufacturing factory layouts result in structured line flows and/or cells dedicated to specific product groups in organized value streams which appear as cells or lines in the factory.

Steering and control for modern machinery landscapes newest

production control software systems (as an example PANORAMA with Tool TV) deliver detailed visualization of the machine and the current operational situation. Status and error reports are generated not only via barcode readings or other manual input, but are now taken directly from the machine's electronic "heart" – via the interim control (see Figure 2).

### 2.1 Factory layout

It is critical that the process be organized in a way that matches the physical arrangement of the factory. Laying out the factory in cells or line-flow arrangements drastically reduces the distance glass must travel through the production process. Machines, people and workstations are located much closer together, which enables fast communication often through visual methods (Tool TV). Productivity and quality improve because of the more efficient workplace, and employee morale improves due to improved quality of life. One common layout approach is to locate cutting and pre-processing lines adjacent to heat treatment and IGU production lines (see Figure 3). By reducing travel distance, throughput time is normally reduced, sometimes as much as 90%. This has a direct impact on planning lead-times in order entry and production control systems. As these lead-times are reduced, the planning horizon can be shortened, which makes it more accurate.

### 2.2 State-of-the-art glass cutting and sorting optimization system

The rack organization in the cutting area sets the pace for a safety glass company's entire production control – this is where the optimization of output and processes begins. A state-of-the-art cutting line with automatic x, y and z breakout together with a manual or automatic dynamic sorting system requires a completely new optimization method and algorithm [1]. Optimization will no longer take place the batch way, as distinct optimization lots, but in a continuous, ongoing process, which will be restarted and re-optimized in a continuous way (see Figure 4). On a planning level, a new, dynamic method is thereby implemented. It endeavors to generate a continuous glass flow in the cutting and sorting area. As soon as new production orders from the fine planning task are released for manufacturing, these are attached immediately to the current manufacturing orders. The optimization run is again activated with the new starting situation. The orders are linked one into the other in a toothed flow. At the end of a shift, the manufacturing and sorting process is only interrupted. The next morning, the manufacturing will continue sorting exactly at the checkpoint of the preceding shift. The

Figure 2.  
PANORAMA- detailed visualization of the machine and the current operational situation

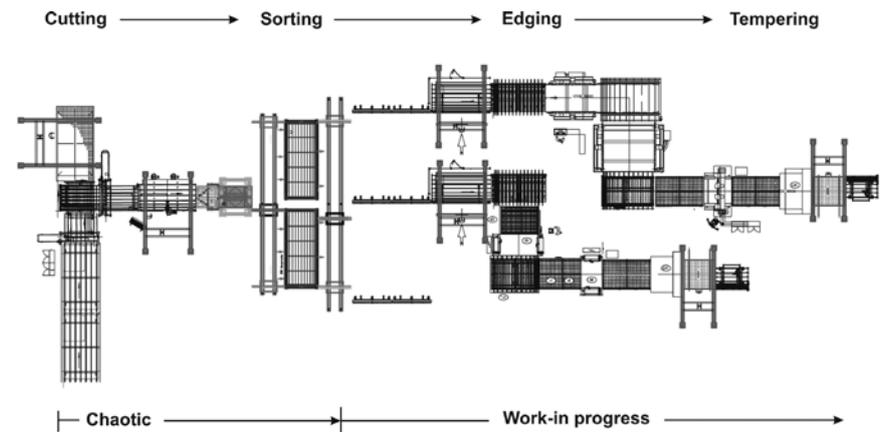
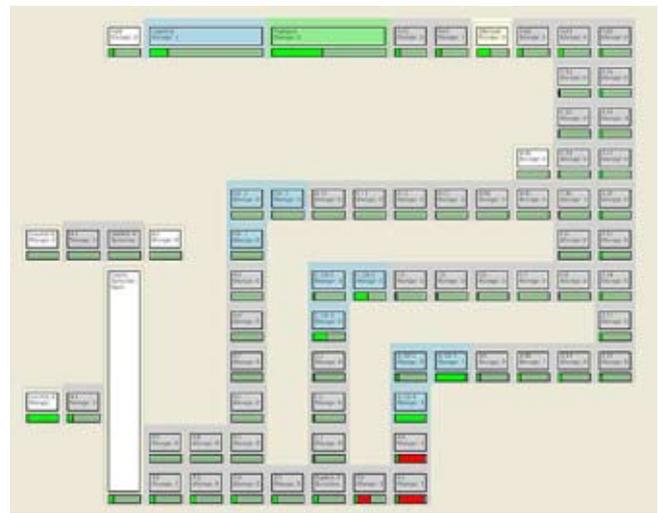


Figure 3.  
Factory layout with combined cell and line-flow arrangement



Figure 4.  
Dynamic optimization guarantees constant flow of production

dynamic buffer is therefore not driven empty.

### 2.3. Traditional optimization vs. dynamic optimization

Traditional optimization systems are based on production jobs and, for reasons of yield, the glass used to be processed type by type. For the user, this usually meant one residue plate per job and glass type. The production

jobs were tied up which meant: once optimized, they were cut this way. Remakes and rush jobs were extremely difficult to fit in. Residue plates could hardly be used, and were more often than not thrown away.

Dynamic optimization production jobs are completely different. The production of a day, or of half a day, is optimized at once. An alternate stock plate can be cut without affecting the yield. This means that cutting sequences

such as 'Stock plate glass type 1 – stock plate glass type 1 – stock plate glass type 2 – stock plate glass type 1 – stock plate glass type 3' etc. can be achieved. Stock plate alternate cutting is a prerequisite of creating correct cutting sequences by means of the dynamic buffer. At the same time, breakage can be cut automatically, and one of the next stock plates of the same glass type can frequently be used at the time it is needed. For traditional, 'tied-up' jobs, breakage can be cut only from a residue plate or manually. The result is the well-known but undesirable situation of having jobs 'waiting' in the cutting area until the last sheet has been cut and consequently a stop-and-go production rhythm that wastes precious machinery time.

A dynamic optimization system on the other hand, produces a constant flow of glass (see Figure 4). There are fewer enforced breaks; the biggest transport unit waiting to be completed at cutting is a standard harp rack of 50 sheets. Rush jobs can be easily and smoothly integrated online into this constant flow of production

#### 2.4. Production and packing sequence

Consequently, dynamic sorting is part of an integrated concept that covers all production and logistic parameters, from the loading of stock plates up to packing onto transport racks. This solution allows the user to get the sheets into the correct production and packing sequence. This results in excellent yield and helps to increase the use of cutting line capacity (see Figure 5). There is no need for expensive interim buffers and residue plate stock, and repacking in the despatch area is reduced.

#### 3. Factors affecting productivity and quality in pre-processing and tempering

Glass size and coating materials in themselves require advanced processing to ensure flawless quality and productivity on the processing line. The high costs associated with advanced glass products leave little room for lost production as a result of careless handling or quality defects. Glass quality requirements vary considerably, depending on the market. Regulatory and local standards, customer specifications and product development are factors that define quality in each individual market. The cost of poor quality is visible in the cost of measures necessary to prevent and inspect for defects, the internal cost of fixing or scrapping defects, and the cost of failing to meet customers' expectations, thus losing market share. In summary, it is easy to see that poor quality cuts into your margins and your ability to compete.

### XOPT-ON Plus with buffer, 6 harp racks no of sheets: 9.544, no of glass types: 20

	Results Alcim				Results XOPT-ON Plus			
	no of plates	overall yield	yield XOPT	no of res. plates	no of plates	overall yield	yield XOPT	no of res. plates
all glasses	580	80,62%	90,42%	49	526	88,90%	91,54%	10
glass1	182	85,48%	93,08%	10	168	92,60%	93,79%	1
glass2	225	85,84%	92,64%	14	207	93,30%	93,67%	1
glass3	62	70,70%	80,85%	7	53	82,71%	83,14%	2
glass4	43	70,74%	88,32%	6	35	86,91%	89,88%	1

Figure 5.

Dynamic optimization and sorting reduces interim buffers

Figure 6.

Good edge quality may result 5-10% shorter processing time in tempering



#### 3.1. Good edge quality results in better yield and minimizes roller wave distortion

In the tempering process it is well known that, during the heating period and the early stage of air quench, both the surface and edges experience temporary tension whose magnitude depends on glass temperature, glass viscosity and the cooling rate [2]. In view of the good quality of float glass, temporary tensile stresses can be sustained by the surfaces but not necessarily by the edges. In the case of low grade edge quality, large flaws weaken the ability to sustain tempering stresses [3]. When the combination of temporary tension and flaw severity becomes unbearable, the result is glass breakage. For example, such breakage occurs when the glass exit temperature is not high enough or uneven and the quenching rate is too high.

Good glass edge quality depends on the pre-processing machinery used, the diamond grit of the finishing tool, the type of coolant, the process speed and the edge support design of the glass template. For example, when diamond wheel seaming and grinding are performed in the grinding groove direction, the grinding result is smoother (fewer microcracks) and the glass edge strength is a lot higher than in traditional X-belt seaming. In cross-direction sand belt seaming, more flaws (microcracks) are created.

Consequently, edge quality plays an important role during the heat treatment process. A lower breakage rate and reduced processing time together with minimized glass

deformation increase productivity and optical glass quality (see Figure 6).

#### 3.2 Over-processing

In optimizing glass pre-processing, the issue of over-processing should not be underestimated. Firstly investing more in pre-processing than the customer is willing to pay for will decrease your profitability (see Figure 7). Glass cutting that is not done properly, i.e. cutting tolerances are not within a range of  $\pm 0.20$  mm, results a higher material removal in grinding, leading to longer processing times and significant increased wear on tools. In average architectural and IG safety glass, the required edge quality in the manufacturing of up to 8 mm glass thickness is seamed; for thicker glass of 10-12(15) mm, a matt ground edge is required.

#### 3.3. Improved cycle time reduces energy costs in tempering

The result of the tempering process is based on the combination of perfected heating and cooling technology. The Low-E tempering process must be controlled precisely to maintain symmetrical heat transfer through the cross-section of the glass pane. The conditions inside the furnace must be the same – cycle after the cycle. A combination of forced convection and radiation heating performs the heating of the glass in today's oscillating tempering furnaces. For example, in

the Sonic furnace the glass heating performance of sputtered Low-E glass (0,02-0,04) is between 29-35 s/mm and clear float 25-30 s/mm depending on glass size, edge quality and loading. The advantage of convection heating is about being able to accelerate the heat transfer into cold glass. Supported by profiled radiation, this allows more speed and flexibility in the case of architectural glass size tempering. Glass breakage is avoided by heating glass slowly at the initial stages, which is something that radiant heating automatically ensures. The heating of glass always takes an equal amount of energy, which is set by the heat capacity of the glass. On the other hand, quench consumes a given amount of energy regardless of whether the glass is being tempered. During the heating cycle, quenching blowers are idling. Due to a faster heating cycle the idling time of the blowers is reduced and savings in kWh/m<sup>2</sup> of produced glass are achieved.

### 3.4 Furnace bed optimization results in higher production capacity

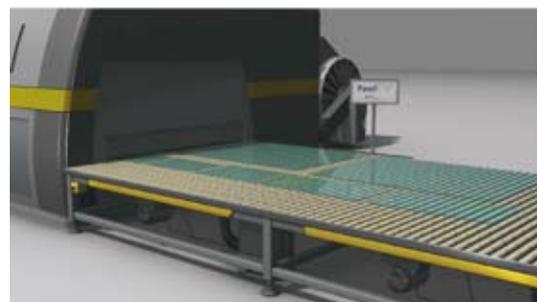
Today's tempering furnaces are bigger and faster. This means that there is more glass to be loaded into the furnace with less time to do it. The furnaces also have a multitude of capabilities and have, as a result, also become more complex and demanding in operation. The increasingly dynamic and flexible processing environment is strongly influenced by changing glass specifications, varying processing batches, bigger and more complicated glass shapes, and special products that are needed for i.e. solar control, Low-E and silk printed solutions. In a situation like this, it is not surprising that operators sometimes cannot perform the loading and define the recipe fast enough to run the furnace at 100% capacity. This may lead to waste, the missing of top quality, loss of capacity and increased processing costs. Automatic, advanced process control solutions with bed optimization software and automatic furnace loading systems have therefore proved to be really helpful in a complex process. Glass sheets are filled in harp racks with the right input sequence for the furnace bed, manually or automatically. The system visualises an operator furnace bed in front and at the end of furnace. Higher loading efficiency results better production capacity with reduced energy cost (see Figure 8). Where the furnace bed optimization system is combined with an automatic loading system, fewer defects due to manual glass handling and lower labor costs are additional benefits.

### 4. Conclusions

Real-time optimized production in a factory environment consisting of structured line flows and/or cells combined with harp rack organization

Edge Type	Funktion (reduced risk of injury)	Design	Costs
<b>Cut edges:</b> Glass is scribed with a diamond or hard metal wheel and then broken on the scribe	—		■
<b>Seamed edges:</b> Reduced risk of injury	+		■
<b>Ground edge W' seam:</b> The broken area is matt ground. Additionally may be seamed	+		■
<b>C-edge:</b> The broken area is ground to form a C. It has a matt finish	+		■
<b>Bevelled edges:</b> The edge is ground to form a bevel. In general a bevel is larger than a seam and may have any desired angle between 20° and 70°	+		■
<b>Polished edges:</b> Polished for transparency and design	+		■

Figure 7. Requirements for edge work



Loading efficiency (%)	kWh/m <sup>2</sup>
90	3,81
80	3,94
70	4,11
60	4,32
50	4,62
40	5,08
30	5,83

ProE 2448-CS20, 6mm float glass  
Tempering EN 12150-1

Figure 8. Higher loading efficiency results better production capacity with reduced energy cost.

brings glass into the correct production sequence for the pre-processing line and other workstations after the breakout station. Rush orders and urgent remakes can be inserted in time with a remarkably small amount of waste. With this arrangement, flexibility is increased enormously without any negative influence on process organization in the production plant. Optimized use of existing processing capacity through steady glass flow with less down time will reduce energy and labor costs due to shorter running time. The correct production and packing sequence results in improved quality with fewer defects, less reworking, fewer customer returns, lower reprocessing costs and reduced time spent handling customer

complaints. Maximum benefits in terms of reducing costs, increasing speed and flexibility, lowering inventories, and improving on-time shipment performance may finally be within your reach.

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