Process Assessment in AMAN Windshield Factory

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Abstract

- The objective of this project is to assess the manufacturing processes in AMAN & SAFETY INTERNATIONAL, the leading windshield manufacturer in Egypt.
- The major problem is the big percentage of defects in the final products, which negatively affects the reputation, and the competitiveness of the factory in the Egyptian and global market. This project also studies the conformity of the manufacturing processes with the quality and workplace standards.
Content

- Abstract
- Methodology
- Problem Definition & Objective
- Windshield Industry
- Aman & Safety Group
- Process Sequence
- Data Gathering
- Quality System
- Defects Types
- Analysis
- Areas of Improvement
- Conclusion
DMAIC Methodology

Define

Control

Measure

Improve

Analyze
The DMAIC (Define-Measure-Analyze-Improve-Control) is the classic Six Sigma problem-solving process. Traditionally, the approach is to be applied to a problem with an existing, steady-state process or product and/or service offering.

Variation from customer specifications in either a product or process is the primary problem.
The problem we are facing in this project according to the feedback we had from the plant administrative & the customers can be all summarized in one main problem, which is “The different Defects in the final product”.

This problem can be divided into the following categories:

- Different Types of Defects.
- Large percentage of defected items.
- Inventory Problems.
- Workplace Conditions.
- Quality Control System.

Our goals are making an assessment to the whole process made in AMAN, identifying the key problems, finding their causes & suggesting improvements can be made to eliminate them.
Glass Manufacturing

Materials

- Silica: 71%
- Lime: 10%
- Soda: 14%
- Oxide/Aluminia/Manganese: 5%

Silica
Lime
Soda
Oxide/Aluminia/Manganese
Laminated glass is a kind of safety glass used mainly for windshields. As it consists of two layers of glass laminated together by a film, in the event of breakage the glass pieces tend to adhere to the interlayer.

Tempered glass is mainly side windows of vehicles. It is very strong and has the unique fracture characteristic of shattering instantly in the event of breakage.
AMAN & SAFETY Group

- Factories
- Products
- Market
Factories

1. Aman Auto Glass
2. Aman For Glass Products
3. Safety Glass
4. Safety International
Products

1. Windshields
2. Backlights
3. Front Doors
4. Back Doors
5. Sidelights

Also, it covers all types of vehicles:

- Passenger Cars
- Trucks
- Buses (In All Sizes)
Market

- Products
- Local Market
- Companies
- Export
- General Motors
- Chevrolet
- Hyundai
- Suzuki
- Others
Safety International Factory

- Location: 6 October City 3rd Industrial zone, plot no. 66
- Total number of labors: 200
- Total space: 20,000 sqm
- Annual production capacity: 500,000 pieces of windshields
- Main Products: Laminated safety windshields for all types of vehicles. It is also equipped with a furnace for producing safety auto glass for trucks at a very high capacity. There are also 2 processing lines for cutting, washing, grinding & printing in addition to 3 furnaces.
A

Cleaning and Inspecting

PVB Sheets

Vacuum Hosing

Vacuuming

Autoclave

Quality Check

Transport to Inventory

Quality Check

Reworkable?

Reworkable?

Rework

Store in Inventory

End
Common Manufacturing Defect Types
Defect Types

- Scratch
- Powder
- Silk-Screen
- Dirt
- Lint
- Hair
- Bubble

- Helix
- PVB Shrinkage
- Optical Distortion
- Shift
- Curvature
- Chips
Scratches

- Windshields have scratches on the surface
- Scratch length tolerances differ from one specification to another
- One auto-manufacturer allow up to 2 mm scratch length, while another only permits 0.5 mm scratch length
Powder

- White, foggy-like spots appear between the layers of the glass sheets
Silk-Screen

- Distortion in the dark surrounding frame on the windshield
- Stencil marks are tolerated up to 6 mm from the outer edge of the glass
- A single drop of diameter 1 mm is tolerated on the whole windshield
- Reworking or defect treatment using black band is tolerated on some conditions

A windshield with nonhomogeneous silk-screening fill
Dirt

- Colored spots appear between the layers of the glass
- They may take a dark, white or red color
- Its tolerance limits range from 0.2 mm to 5 mm diameter according to different auto manufacturers’ special specifications
- Some specifications from some auto-makers only require that the dirt spot does not affect the driving experience or the general look of the windshield no matter how large the spot can be
Chips

- It can be chips from the float glass sheets, or produced during the manufacturing process.
- Tiny chips produced from either the cutting or grinding processes build up on the sheet inside the furnace, which in turn cause either a scratch or pitting defect.
PVB Shrinkage

- The PVB sheet is not cut properly and it shrinks during the vacuum stage, leaving the outer perimeter of the windshield improperly laminated.
- Tolerance up to 1.5mm from the edge of the windshield.
Optical Distortion

- Light fringes appear on the windshield distorting the vision
Helix

- A pitting or a surface crack appears on the windshield
- Up to 2 spots of 1mm diameter are tolerated within a perimeter of 200mm
Quality System
Windshield Quality Standards

- There are several standards and regulations that specify requirements for glazing safety. They have several purposes:
  - Reduce injuries resulting from impact
  - Ensure the proper transparency for driver visibility
  - Minimize the possibility of occupants ejection in accidents

- Common windshield quality standards:
  - ECE R43 – United Nations Economic Commission for Europe
  - Safety Regulations for Road Vehicles, Article 29 – Japan Automobile Standards Internationalization Center (JASIC)
  - FMVSS No. 205, 212 and 219 – Federal Motor Vehicle Safety Standards
Windshield Quality Standards (cont.)

- There are also standards and regulations set by individual auto-manufacturers to meet their quality assurance needs.
- Most of these standards require windshields to pass the following tests:
  - Mechanical strength test
  - Resistance to the environment
  - Optical test
- In Aman, sample finished products go under mechanical and optical tests.
Quality Inspection Stations

- Silk-Screen
- Furnace
- Plastic
- Autoclave
- Final Product
After the Silk-Screening

- Silk-screened sheets are inspected visually using a system of lighting to find printing defects or scratches.
- Powdered sheets are inspected visually against powdering sufficiency.
After the Furnace

- Pairs of bent glass sheets are inspected visually against shifting or misalignment defects.
- Curvature dimensions are inspected either visually or using a guide according the regulation or standard set by the auto-maker.
Before Plastic

- In-process inspection is performed during the cleaning and wiping process against a system of lighting.
Sheets get inspected after releasing from the autoclave to check against bubble defects or optical distortion.

Windshields racked on pallets for inspection
Final Product Inspection

- Finished products are inspected visually before packing and warehousing.
- Some silk-screen and scratch defects are reworked here.
Final Product Inspection (Video)
Quality Inspection Report

A bar chart showing the percentage of defective parts against the total inspected lots.
Frequency of Defect Types

- Scratch: 37%
- Powder: 21%
- Silk-Screen: 11%
- Dirt: 11%
- Chips: 4%
- Shifting: 4%
- Optical Distortion: 3%
- Curvature: 1%
- Helix: 1%
- Hair: 1%
- Air Bubble: 1%
- PVB Shrinkage: 0%
- Raw Material: 0%
Pareto Analysis

Significant Defect Types

<table>
<thead>
<tr>
<th>Defect Types</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scratch</td>
<td>1717</td>
<td>37%</td>
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<tr>
<td>Powder</td>
<td>1007</td>
<td>58%</td>
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<tr>
<td>Silk Screen</td>
<td>504</td>
<td>69%</td>
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<tr>
<td>Dirt</td>
<td>501</td>
<td>80%</td>
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<tr>
<td>Chips</td>
<td>214</td>
<td>84%</td>
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<tr>
<td>Raw Material</td>
<td>199</td>
<td>88%</td>
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<tr>
<td>Optical Distortion</td>
<td>189</td>
<td>92%</td>
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<tr>
<td>Helix</td>
<td>137</td>
<td>95%</td>
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<tr>
<td>Shifting</td>
<td>75</td>
<td>97%</td>
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<tr>
<td>Hair</td>
<td>61</td>
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<tr>
<td>Curvature</td>
<td>46</td>
<td>99%</td>
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<tr>
<td>Air Bubble</td>
<td>30</td>
<td>100%</td>
</tr>
<tr>
<td>PVB Shrinkage</td>
<td>5</td>
<td>100%</td>
</tr>
<tr>
<td>Lint</td>
<td>1</td>
<td>100%</td>
</tr>
</tbody>
</table>
Most Significant Defect Types

- Scratch: 37%
- Powder: 21%
- Silk-Screen: 11%
- Dirt: 11%
- Other Defect Types: 20%
Cause & Effect Analysis of the Most Significant Defects
Scratches Potential Causes

- Machines
  - Unclean machines
  - Unclean MHE
- Man
  - Unexperienced workers
  - Workers not wearing gloves
- Materials
  - Metallic binder clips
  - Powder impurities
  - Sheets scratched by supplier
- Methods
  - Unclean floor
- Scratches
  - Contamination not avoided
  - Workers wearing rings & metal belts
Powder

- Powder has impurities
- Improper cleaning in the plastic stage
- Excessive powder is used in the powdering stage
- Improper method of cleaning
- Wiping fabrics are inefficient

Powder Defect

Man

Materials

Machines

Methods
Silk-Screen

Man

Material

Machines

Unclean machine

Insufficient ink

Improper loading

Methods

Improper machine setup

Bad anti contamination

Materials

Bad inspection

Bad ink material

Silk-Screen Defect

Bad ink material

Unclean machine

Improper loading
Dirt

- Machines
  - Unclean machines
  - Unclean tools
  - Unclean MHE

- Man
  - Workers not wearing gloves
  - Workers not wearing head covers

- Methods
  - Insufficient clean stages

- Materials
  - PVB sheets are dirty

- Contamination
  - PVB has impurities

- Improper cleaning

Dirt Defect
Process Capability

Calculations Results

- \( n \) (average) = 6813.556
- \( p \) (average) = 0.074981
- UCL = 0.084553
- LCL = 0.06541
- CL = 0.074981
Results

- The process capability analysis shows that the process in AMAN is uncontrolled.
- There are lots of variations with different causes.
- The 2 key causes for the defects are the Man & Method.
Areas of Improvement
Quality Control Improvement
Quality Control Improvement

- Apparatus to be purchased

  1) Dropping tower

To assure credibility and ensure safety of finished products, we recommend purchasing the dropping tower for mechanical tests.
Quality Control Improvement

- Apparatus to be purchased

2) PVB Humidity Meter

The PVB Humidity meter measures the water contained in the PVB before and after lamination.
Material-Handling Equipment Improvements
Material-Handling Equipment Improvements

- Free Standing Windshield Racks

Features:

1. Capacities from 15 to 90 windshields
2. Welded steel construction
3. Light gray enamel finish
4. Half inch thick neoprene glass stop strips
5. Polyethylene peg covers are slotted for easy installation
6. Plastic peg caps included
7. Partial KD for shipping
8. A virtual lifetime of service
9. Maximum use of floor space
Material-Handling Equipment Improvements

- Windshield Carriers
  Features:
  1. Capacities from 5 to 44 windshields
  2. Easy access top-loading
  3. Polyethylene sleeves cover pegs between bumpers
  4. No moving parts to repair or replace
  5. Durable powder coat finish (steel models)
  6. Windshields fit snugly between molded rubber bumpers
  7. Lower bumper flanges interlock to form a continuous setting area
Material-Handling
Equipment Improvements

- Windshield Carts

Features:

1. Capacities from 15 to 30 windshields
2. Elevated windshield setting area
3. Pegs pivot downward for easier loading and unloading
4. Walk-in base
5. Polyethylene peg sleeves & caps
6. 1/2” thick rubber setting strips
7. Rugged 6 x 2 ball-bearing casters with the brakes on swivel casters
5S Study Suggested Improvements
5S is a method of creating a clean and orderly workplace that exposes waste and makes abnormalities immediately visible. As such it’s important to realize that 5S is far more than a housekeeping initiative like so many confuse it to be.

When someone refers to 5S they’re generally referring to 5 Japanese words that start with S.

They are:
- **Seiri** which is commonly translated as sort
- **Seiton** which means to straighten
- **Seisou** which means to sweep or shine
- **Seiketsu** which actually means to sanitize but is most commonly referred to as standardize today
- **Shitsuke** which means self discipline or sustain
5S Study Suggested Improvements

➢ Sort

I. Removing the racks of broken & defected windshields from the plant.

II. Moving the old un-used quality inspection jigs to the inventory.

Broken glass
5S Study Suggested Improvements

- **Set in order**
  
  I. Making certain places for the broken & defected windshields.
  
  II. Labels to be put on the material handling equipment showing the processes done, next processes & the quality inspection tests made.

*One of the material handling equipment left in a wrong place*
5S Study Suggested Improvements

- **Shine**
  I. Removing the ashes of the glass while cutting & polishing.
  II. Sweeping the floors regularly.
  III. Moving the broken glass out of the plant area.
Conclusion

- This thesis is about the assessment of a leading automotive glass manufacturers in Egypt and the Middle East. Upon the end of the analysis and evaluation of working conditions, the quality systems, the level of quality of the final product and the work system in the facility we could conclude the following:
  - There is a high level of defects in the final products.
  - The reasons behind vary widely to include almost all the 4M’s (Man, Machine, Method and Material).
  - The main reasons could be summarized to include the handling, storage tools and techniques.
  - The quality system in the factory is not conforming to the global standards and regulations.
  - The work environment lacks many of the standard work conditions.
Conclusion

- A plan is made to suggested solutions. These solutions are studied thoroughly and evaluated for feasibility in order to increase the plant’s productivity and to decrease the percentage of defects.

- This plan can be summarized:
  - Investigating the similar global factories and imitating their operational and managerial systems.
  - Assuring the application of the standard global tests to achieve full conformity with the regulations.
  - Applying 5S techniques to improve the workplace productivity.
  - Investigating the available material handling equipment used in auto glass industry and suggesting better alternatives.
  - These suggested solutions need to be implemented to see the actual impact on productivity and product quality. However, due to the shortage on time and the factory’s managerial policies, it was not possible to make a full implementation of the study.
Thank you