Research Paper Engineering

To reduce the rejection at H4 cutting and forming machine in halogen lamp making process

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ABSTRACT

This report gives the quality improvement that are needed to reduce the defectives at the "Cuttings and Forming Stage" of manufacturing H4 Halogen Lamps at M/s Autolite (India) Pvt. Ltd., Sitapura, Jaipur.
The "Cutting and Forming Process" of manufacturing H4 Halogen Lamp was studied in details and the problem areas that contribute more significantly to defectives were identified by fishbone diagram. The major contribution in defectives is due to process and machine inconsistency in flow of gases cleaning and grinding of cutting tool and rotor, positioning of glass tubes and nonuniform cooling during annealing. After detailed study /observation/experiments, some of the inconsistencies in above process and machine maintenance were removed that resulted in quality improvements and the defects at cutting and forming stage were reduced from 3.81 to 1.48 % (significant improvement).

INTRODUCTION

Autolite (India) Limited is the current global market leader in the automotive lighting (halogen lamp, fog lamp, etc.) industry. A large part of products manufactured by the lighting division are made of glass. The knowleadge of the manufacturing process is mostly based on years of experience rather than scientific research. The lighting division is globally moving and expanding its production sites. In these the quality of the gas used to fire the burners in the heating process can be completely different. To optimize production and easily adapt to different fuel resources, knowledge of the burning and heating processes used in the glass industry is very important.

SCOPE:

This paper states that it is necessary to measure the velocity of gas during heating of glass tube. One of the processes in the factory in which glass is heated is the shell making process. The glass forming machine transforms glass tubes into little pieces with a dome-shaped with hole end, the so-called dome. These are used to make halogen lamp. In the steps of the forming process the glass tube is heated with a LPG flame and then cut off.

In heating process the flow rate of gas during glass tubing can be measured at the forming machine in the factory. Most settings are easily adjusted. Therefore we can change the settings and can measure the effect of parameters that can be analyzed. The motion and timings of the glass tube will be studied. A specification of the glass flow rate profile along the length of the glass tubing velocity measurements need to be performed. In these gas flow rate measurements correspond, different settings various conditions can be used to study and effect on the glass tube velocity. In the factory for shell making at cutting and forming machine, hydrogen is used as fuel at the cutting process.

Operation Performed on Forming Machine

Cutting machine is the first machine in the halogen lamp capsule making line. The machine is used to cut the glass tube to the desired length as per the lamp model. Provision is made in the machine to adjust the length of tube for different models. Readily available tube 16mm diameters and 1000 mm length will be stored in the tray. These tubes will be fed through a gate manually one by one on to the rolling discs mounted on ground shafts and bearings driven from motor through gears & chain. There are 12 rows of discs rotating continuously. Pre heating will be carried out by cutting burners[1] at the required positions and the glass will be cut by cold touch process by a glass cutter. The cut tube edges will be subjected for glazing for smooth edges to prevent cracks in further rows. 1 to 4 positions cutting and glazing will be arranged to get required out put. These tubes will be collected manually at the end of the machine.

Layout of Machine as given below H4 Cutting and Forming Machine

Station	Operation to be perform
No. 1.	Glass Cutting by Hydrogen Flame
No. 2	Glazing operation by LPG + O2 (heating)
No. 3	Glazing operation by LPG + O2 (heating)
No. 4	Annealing by Air + LPG(Dome is made)
No. 5	Annealing by Air + LPG(Dome is made)
No. 6	Pre-heating, softening ,tempered (heating by LPG)
No. 7	Dome is formed by tungsten carbide tool
No. 8	Gradually cool down and has uniform temperature(By LPG)
No. 9	Gradually cool down and has uniform temperature(By LPG)
No. 10	Gradually cool down and has uniform temperature(By LPG)
No. 11	Annealing by air + H2 flame
No. 12	Tube is scratched by a cutting wheel
Exit of tube shell	

Fig-1: H4 Cutting and Glass Forming Machine

Finding past Rejection Data- Due to hit and trial method the past rejection data at forming stage were:

Table 1- Rejection Data(%)

Month (July10-April11)	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April
Rejection Data(%)	3.82	3.65	4.10	3.65	3.75	3.63	4.0	4.0	3.80	3.72

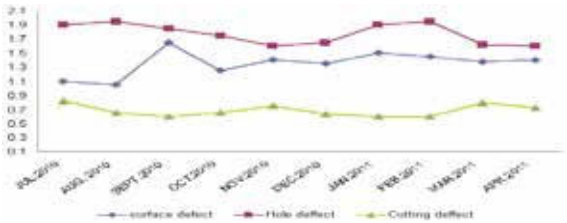


Fig-3: Month v/s Types of Defects in Percentage before Implementation of suggestions Analyze the Rejection at H4 Cutting and Glass Forming Machine

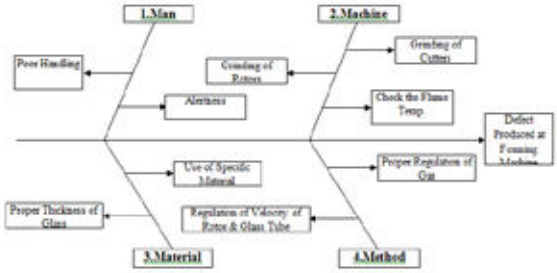


Fig-4: Fish Bone Diagram [2]

In this method, generally there are two types of cracks developed on shell which are –

1. Shell crack – The crack which seen on the surface tube. It occur during the heating process of glass tube.
2. Hole crack – This type of crack is seen near the hole. This happens during the cutting of glass tube.

These types of defects can be reduced by controlled the process parameters and thus reduction can be minimized.

Parameters which Influence the Process

1. Pressure of gases: - For this process control of pressure is very important. Gases regulate the flame generation process.

2. Flame temperature:-There is no such type of instruments are available to measure the temperature at different burner stages, so pressure regulation of gases and air the flame temperature can be controlled.

3. Motion of rotor:-The rotation of rotor affects the process. It is adjusted by the hit and trial method. Its motion is dependent on the glass properties.

4. Motion of glass tube: - The motion of the glass tube is linear and its position is horizontal on machine.

5. Size of the rotor and glass tube: - This affect the working process and time of forming process so we should design the rotor and tube size according the specification of lamp.

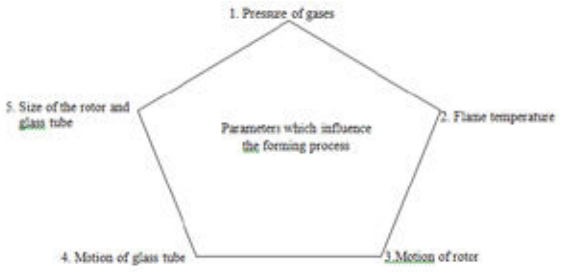


Fig.-5: Showing the parameters

Fig-6 : MODEL FT2

IMPLEMENTATION OF FINDINGS AND SUGGESTIONS
USE OF FLOW METERS

Fox Model FT2	
MEASURES	Mass Flow Rate and Temperatures
NO. OF 4 TO 20 mA OUTPUTS	Two
PULSE OUTPUT	One
DISPLAY	Optional, LCD 2 line, 16 character, flow rate, total, temperature, elapsed time, alarms
COMMUNICATIONS	RS232 standard; Optional RS422/RS485 Modbus, Profibus-DP, DeviceNet & Ethernet Modbus TCP.
APPROVALS	FM and FMc approved for Class I, II, III, Division 2, Groups A, B, C, D, E, F, G, T4 hazardous locations; NEMA 4X approved; CE approved; Remote NEMA 4X electronics enclosure with explosion proof sensor j-box.
CONTACT OR DISCRETE I/O	One discrete output for alarms & one discrete input to reset total. Discrete output unavailable if pulse output used.
POWER INPUT	24VDC or optional 85-250VAC in local or remote enclosures.

Fox Thermal Gas Mass Flow Meter[3] Features

Accurate low velocity gas flow measurement and wide turndown

• Fox meters are excellent choices, even at very low flow velocities

Direct Mass Measurements

Measure the flow of gases directly in Standard Cubic Feet per Minute (SCFM) and other mass units without temperature or pressure compensation[4].

Low Pressure Drop and No Moving Parts

A no moving parts design increases reliability and reduces maintenance costs.

MAINTENANCE SCHEDULE

In Autolite (India) Pvt. Ltd. at H4 Cutting & Forming Machine, the Standard Maintenance Schedule[5] is not properly fol-

lowed as recommended by the manufacturer in their manuals. I have discussed this matter with the maintenance manager in depth and reach the conclusion to adopt the under mentioned maintenance instructions. So that rejection can be minimized. The main maintenance instructions are summarized as under:-

Proper Cleaning of Rotor before Starting of Production
Periodically Cutter and Forming Tool should be Grinded
Oiling in Chain and Sprocket on Regular Basis
Burr should be Removed from the Rotor Head
Vent Tube should be Clean
Proper Control of Gas Flow
Distance between Rotor Head should be Equal
Fire Length should be Proper at Each Station according to their Work

Instead of above instructions I also made a maintenance schedule table as given below:

S. No.	Event	Maintenance Schedule
1.	Cleaning of Rotor	Daily
2.	Grinding of Cutter	Periodically according to use
3.	Cleaning of Vent Tube	Periodically
4.	Remove of Burr from Rotor Head	Daily and when necessary
5.	Oiling of Chain & Sprocket	Periodically
6.	Control of Gas Flow Rate	At initial starting

USE OF SQUARE RING INSTEAD OF O-RING

The Square Ring is a good alternative to the O-Ring as an axial static seal in cases where particular demands are made. The application and handling of Square Rings is comparable with those of O-Rings. The Square Ring is used as a static seal so that the square form remains practically constant even under high pressures.

O-Ring

X-Ring & Square Ring

Fig-8

Advantages of Square Rings:

• high resistance to extrusion, not sensitive to gap extrusion;
• minimum mechanical deformation of the cross-section;
• outstanding sealing behaviour over long periods;
• good compression set[6,7];
• no twisting in the groove;
• no relative movements during pressure cycles;
• dimensionally stable under pressure;
• no additional Back-Up Ring required;
• no parting line or flash on the seal;
• long service life;
• high leak tightness.

These are the advantages of use of square rings in place of O-rings.

USE OF GEAR WHEELS (SPROCKETS) AND CHAINS

Everyone has seen a bicycle or used one and noticed that it is driven by a large driver gear wheel with pedals attached. Smaller gears at the back are driven round, in turn driving round the back wheel. As the back wheel turns the bicycle moves forwards. Gears driven by chains are used in machinery, motorcycles, in car engines and have many more applications.

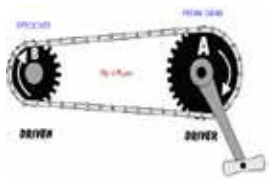


Fig-9: Transfer of Motion

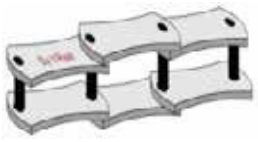


Fig-10: A Chain

A chain is made up of a series of links with the links held together with steel pins. This arrange makes a chain a strong, long lasting way of transmitting rotary motion from one gear wheel to another.

Chain drive has one main advantage over a traditional gear train. Only two gear wheels and a chain are needed to transmit rotary motion over a distance. With a traditional gear train, many gears must be arranged meshing with each other in order to transmit motion.

Working Out Gear Ratio and RPM

When working out gear/velocity ratio and the rpm of chain driven gears it must be remembered that the chain is ignored. This means that we simply find out the teeth per gear wheel and the rpm and use the same method of calculating as we should with a normal, meshing gear system[8,9].

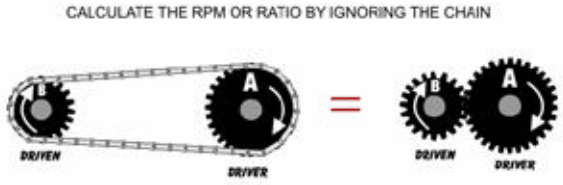


Fig-11: Power Transmission

APPLICATION OF GLASS BLOWER AT THE EXIT

Working of Glass Blower

Glassblowing is the art of forming a hollow glass object out of a ball of molten glass using a hollow tube and by gently blowing air down it. This 'bubble' is then formed and shaped using tools and molds before it cools. That sounds simple enough, but now let's examine the process more thoroughly.

Glass Blowers At Work

Glassblowers sit or stand at their workstations stations, often constructed with two parallel, flat topped and horizontal metal beams. These bars support the blow tube while it is turned or spun to control the shaping of the heated[4,10], viscous glass to the required form. A specially designed chair is commonly used, which also stores the hand tools required by the blower as well as his molds and the maver. The maver is a flat steel plated work area used for working, rolling and squeezing the cooling glass. Traditionally this maver was made of marble, from which its name is derived, however its requirement is that the molten glass does not stick to the surface. During the actual process, one continually alternates between heating the glass in a furnace and working on the shape of the heated glass using molds and by pinching, bending, flattening or stretching parts until you have achieved your required shape.

A traditional glassblowing workshop will have a vast array of equipment. Some of the essentials include one or more furnaces for melting the glass, the crucibles which the molten glass is contained within, and two types of steel rods. These steel rods are referred to as blow tubes or punts and are either hollow or solid. It is with these that one 'gathers' the required amount of molten glass, depending on the size of the object one wants to create, from a crucible. For the actual glassblowing stage one would select the hollow tube or blowpipe, as it is also referred to. If one is merely creating a solid form of glass one may use as the solid rod normally called

the punt[11], (though these names are interchangeable). At this stage one initially pre-heats the end of the blowpipe, dips it into the molten glass in the crucible[12], and then gathers a ball of molten glass on its end by rotating the tube. This is done somewhat In the manner of gathering honey or syrup from a jar using a stick. This blob of glass is actually called a 'gather'.

Glass Gathering Shape

For further manipulation and creation or sculpting of more delicate shapes, a variety of tools may be used including tweezers (referred to as jacks) and specialized glass scissors or shears. These are used specifically for cutting the glass as if cutting paper card, or sometimes for creating indents and notches within a glass design[13]. Another type of glass cutter, usually called hawk-bills or diamond shears[14], are for chopping off circular sections of hot glass. Again they can be used for grasping parts of the creation and slowly stretching and bending the forms into specific shapes, such as the neck of a swan. A high degree of coordination between tool manipulation and wrist movement is required for this[15]; the dexterity, skill and experience of the glass blower is clearly reflected in the precision[16,17] and beauty within the lines of his creation.

FINDINGS OF RESULT

Rejection data's are collected after using gas flow meter, implementing the new maintenance schedule, applying the square ring, blower at exit and power transmission by chain and gear box, in below given table:

Table-3: Rejection Data in Aug.2011 and Sept.2011 Weeks

S. No.	Week	Rejection Percentage(%)
1.	August 1st Week	1.65
2.	August 2nd Week	1.62
3.	August 3rd Week	1.45
4.	August 4th Week	1.50
5.	September 1st Week	1.55
6.	September 2nd Week	1.40
7.	September 3rd Week	1.35
8.	September 4th Week	1.35

Fig-12: After Implementing the Suggestions: No. of Weeks v/s Rejection Data(%)

On the basis of above findings achieved through practical and a face to face discussion with shop floor staff and executives for the study of ANALYZED THE REJECTION OF DATA AT HALOGEN LAMP FORMING MACHINE. In our opinion the existing layout and system available in the plant and our findings for future technical advancement we give below the comparison of both results are as under:

Comparison of rejection data	Past Rejection Data: 3.812(%)	Current Study Shows the Rejection data(%): 1.4837

Fig-13: Comparison between Rejection data Before and After Implementing the Suggestions

Fig-14: Types of Defects in Percentage after Implementation of suggestions

Rejection in October 2011 Month X-Bar & R-Chart Indicating the Limits

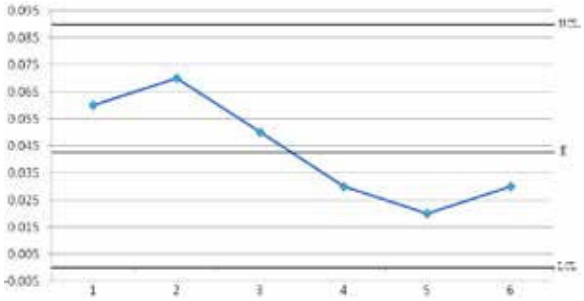
We collect the October month rejection data (%) and make the 06 groups as shown in Table.

S. No.	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
1	1.35	1.41	1.35	1.39	1.41	1.37
2	1.38	1.39	1.40	1.38	1.42	1.37
3	1.34	1.39	1.38	1.38	1.42	1.38
4	1.36	1.34	1.37	1.40	1.40	1.39
5	1.40	1.40	1.37	1.41	1.42	1.40
X-Bar	1.366	1.386	1.374	1.392	1.414	1.382
R	0.06	0.07	0.05	0.03	0.02	0.03

We make 06 groups which are shown on X-axis and the average rejection is shown on Y-axis in X-Bar Chart. In R-Chart number of 06 groups is shown on X-axis and the variation limit of group are shown on Y-axis.

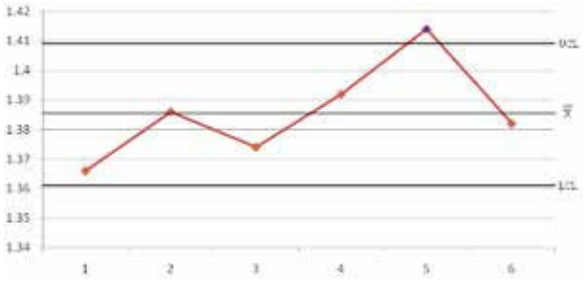
R chart

Upper Control Limit (UCL) = D(4) R-Bar
Lower Control Limit (LCL) = D(3) R-Bar
for n = 5, D(3) = 0, D(4) = 2.114 as per standard table



X-Bar Chart

Upper Control Limit (UCL) = X-Double BAR + A(2) R-BAR
Lower Control Limit (LCL) = X-Double BAR - A(2) R-BAR
for n = 5, A(2) = 0.577 as per standard table

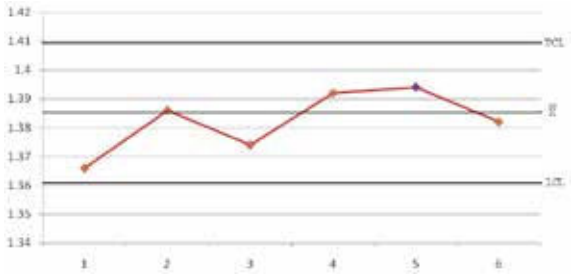


As we see that in above graph the point 5 is out of the UCL because during this period the gas cylinders (N, LPG, O2, H2) are changed. So due to adjusting of gas flow the rejection is increased.

We again draw the X-Bar chart in November month (as given below group) rejection data which shows the good result as shown in below X-Bar chart.

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
1.36	1.39	1.40	1.40	1.39	1.37
1.40	1.41	1.38	1.38	1.40	1.37
1.34	1.40	1.37	1.41	1.38	1.38
1.35	1.34	1.35	1.38	1.40	1.39
1.38	1.39	1.37	1.41	1.40	1.40

X-Bar Chart



The R-Chart is same as previously shown.

CONCLUSION

Analysis of rejection data revealed three type of defects i.e. surface defect, hole defect, and cutting defect. These defects are produced due to uneven gas flow rate, improper annealing and inconsistency / non-observance of maintenance schedules.

Gas flow meter and blower were used to monitor and main-

tain proper gas flow rate, control cooling during annealing. Further the production was asked to adopt new maintenance schedule having some minor variations to control rotor alignment.

After implementation the above suggestions the rejection data were collected at cutting and forming stage,X-bar and R-chart were drawn for the process to set UCL and LCL for the process. Production was asked to monitor to process on daily basis using these control charts so as to reduce the rejections by finding assignable cause as and when the rejection go beyond the UCL and rectifying the same.

The quality improvement suggestions as discussed above helped in reducing the stage rejection from 3.81% to 1.4% which are mainly due to random errors that are unavoidable in the existing non-automatic machine setup system.

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