To Reduce the Rejection Of H4 Halogen Lamp At Sealing Stage By Proper Pinch Seal

***Sharad Shrivastava **D.S.Kumani**
Poornima College of Engineering, Jaipur

Abstract

This report gives the quality improvements that are needed to reduce the defects at the "Sealing stage" of manufacturing Halogen Lamps at M/S Autolite (India) Ltd, Sitapura, Jaipur. The Sealing process of manufacturing Halogen Lamps was studied and the problem areas that contribute more significantly to defects were identified using fish bone diagram. The major contribution in defectives is due to process inconsistency in pinch seal formation due to improper alignment process, tilting of mount, press hammer pressure and annealing temperature. By removing the above process inconsistency after detailed study and observations, significant quality improvements were observed and the defects at sealing stage were reduced from 3.8 % to 1.82 %

1. Introduction

Autolite (India) Limited is serving the Automotive Lighting Industry since last four decades. A large part of products manufactured by the lighting division are made of glass. 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 bulb industry is important. Autolite Group has always been pioneer in manufacturing Head Lamps and Halogen Bulbs in India. Health, Safety & Environment has always been prime focus for the Company.

2. Scope

Automotive Halogen lamp manufacturing involves mainly nine vital steps. These are Coil making, Stemming, Lamp forming, Mount making, Sealing, Evacuating and gas filling, Annealing, Base attachment and Packaging. Defects are observed more at two stages mainly lamp forming and Sealing .The defects occurring at "Sealing" stage were studied in details, main reasons were identified with fishbone diagram, suggestions were made and implemented to reduce these defects. At "Sealing" stage mainly, cracks due to improper annealing, improper pinch seal formation, tilting of mount, incorrect alignment of mount, and invariable pressure of press hammer produce these defects.

A machine called a press seal is used to hermetically seal the mount inside the bulb. The mount is inserted into the bulb and both parts are held securely. The bottom portion of the bulb is then heated to around 3,272°F (1,800°C) using gas/oxygen burners to soften the hard glass Stainless steel press pads, operating at pressures of 20 to 60 psi(1.40Kg/cm^2 to 4.22Kg/cm^2), press the glass to the molybdenum foils forming the hermetic seal**.**

3. Operation performed on sealing Machine

In Autolite (India) Limited, Jaipur 36 head Turret machine is used for sealing the mount with bulb glass tube. In this process tabulated bulbs are loaded into the upper Fixture and mounts are loaded into the lower Fixture of the turret head at respective Insertion station of machine feeding system. The Bulb shell is dropped down over the mount by Bell crank lever arrangement operated with the help of Special Cam mechanism and mount is hold by mount holding jaw for correct positioning before the first burner for heating.

Fig 1; Bulb Shell Tube Feeding

The heating of Bulb shell is done by Burners in increasing order of temperature from room temperature to 1800 ^{0}C at Burner station No.1 to Burner Station No.11 for sealing .From burner station no.2 to Burner Station no.11 air and LPG are used for producing the flame for heating the bulb, Between Burner station No.3 and Burner station No.4 Stainless steel press pads (hammer) are used to change the circular shape of bulb into rectangular shape and producing first pinch, then from Burner station No.4 to Burner station No.11

temperature is continuously increased by burners .Between burner station No.11 and burner station No.12 when final temperature gains is 1800 ^{0}C final leak proof seal develops between glass bulb shell and mount be produce by pressing them with second Stainless steel press pads.

Fig.2: Stainless Steel Pressure pads

From Burner station No.12 to burner station No.23 slow cooling occurs or gradually the temperature reduces down (using the mixture of Oxygen+LPG) .This slow cooling perform the annealing operation of the bulb ,which is necessary for stress removal of bulb shell producing the different types of defects like surface cracks(inside or outside),marks ,scratches etc. During this operation, the bulb is being flushed with an inert gas (nitrogen or argon) to remove the air and prevent the filament Bulb from oxidizing. After the Burner station no.23 air cooling begins and at last the cooled annealing bulb exits for next evacuation machine. The burners from station No.1 to station No23 is cooled by continuous supplying of cooled water through rubber tubes fitted for each burner, so burners body were not overheated.

4. Layout of Sealing Machine

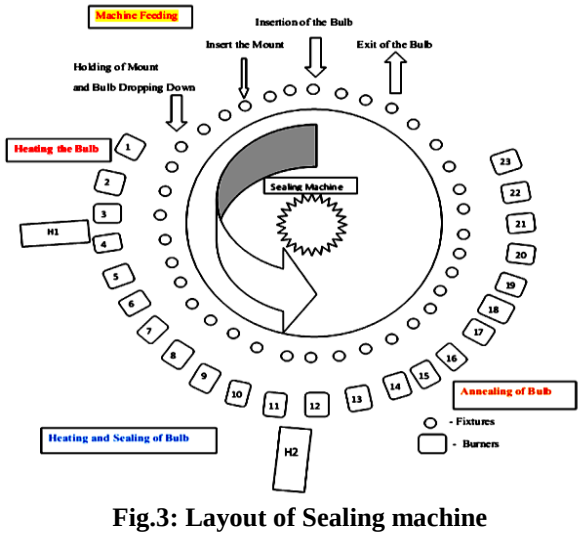


Fig.3: Layout of Sealing machine

5. Stages of Pinch seal

The width of this zone is about 6 to 8 mm. It is heated not to melting temperature however, but only to a working temperature of about 1100 ^{o}C that is until the glass will have the viscosity of about 10 ^{4} poise.It is plastic however and is then pinch-sealed to the wire**.** This is the **first pinching step**.

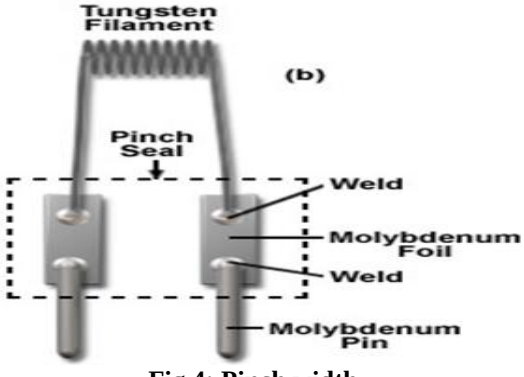


Fig.4: Pinch width

The pinch will surround mechanically the lead wires without however at this stage wetting the lead wires that is being fused. When the pinch tool or pinch hammer has been withdrawn from the pinch zone where the pinch was preliminarily formed only localized heating is carried out. In a preferred form, the heating is so localized that only those portions of the glass which are immediately adjacent the wires are heated to fusion temperature, that is to liquefaction. When those portions of the glass are heated to liquefaction temperature the glass will fuse with the wire. Upon reaching wetting temperature, an intimate merging of the glass with the oxide layer will result so that the desired vacuum-tight fusion will be obtained.

The **second pinching step** is then carried out. The second pinching step is not used to improve the tightness of the seal. The seal has already been formed when the glass was melted and fused with the wire. The glass, rather, is pinch-moulded so that the pinch seal will have the desired external shape which it is to retain after the lamp has been made, but which was lost due to the reheating after the initial pinching operation upon subsequent heating of the glass to fusion temperature.

6. Parameters which influence the Sealing Process

1. Temperature
2. Preheating & Cooling Effect
3. Remaining Stresses
4. Sealing of bulb shell
5. Carburising of bulb shell

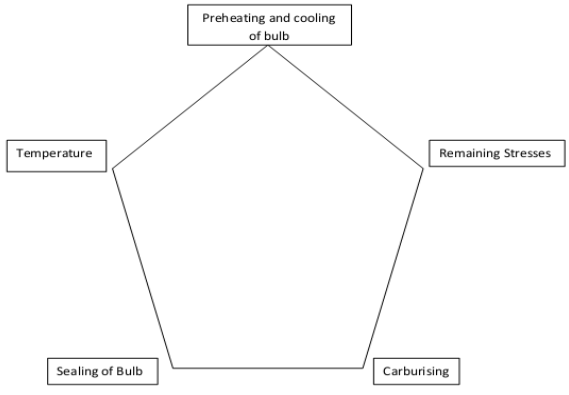


Fig.5: Parameters

7. Fishbone Diagram

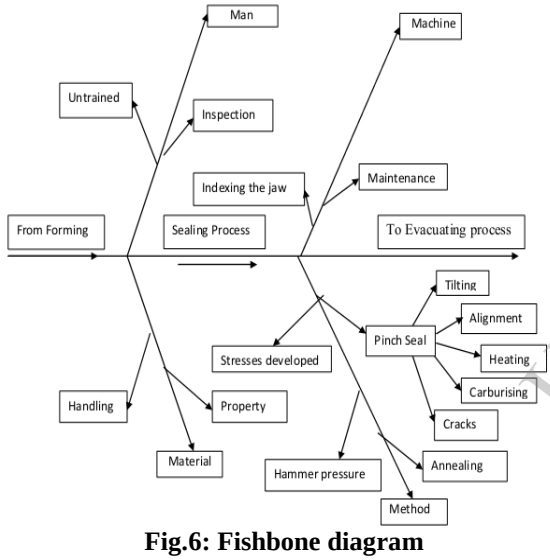


Fig.6: Fishbone diagram

8. Findings and suggestions

Observing the above data, the Rejection of automotive halogen bulb at sealing stage of manufacturing in the form of cracks, incorrect alignment, Tilting the mount, carburizing, invariable pressure, different sealing temperature etc which are inside the glass or on the surface. Generally the shell cracks developed on the tube shell of bulb. By the following ways defects developed are:-

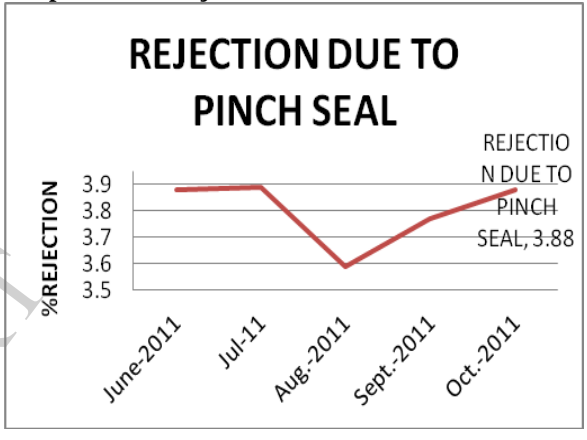
(1) Rejection due to improper Pinch Seal.
(2) Rejection due to improper Annealing.
(3) Rejection due to variable Pressure of sealing hammer.

These all defects are observed and examined on the sealing machine, after that the rejection of each defects recorded from June 2011 to Oct 2011 .These are following:-

Table 1: Past Rejection data

Month	Pinch Seal	Annealing	Hammer pressure	Total Rejection
June-2011	3.88	0.462	0.778	5.12%
July-2011	3.89	0.459	0.811	5.16%
August-2011	3.59	0.45	0.82	4.86%
September-2011	3.77	0.42	0.75	4.94%
October-2011	3.88	0.39	0.75	5.02%
Mean	3.80%	0.44%	0.78%	5.02 %

Graph 1: Past Rejection data



9. Optimization of process parameters *i.e.* Reduction of Rejection in making proper Pinch Seal

In pinch seal process the defect due to following ways are observed :-

(1) The mount and Glass bulb shell not in correct alignment.
(2) The tilting of mount with bulb shell.
(3) Improper heating of pinch area of bulb.
(4) Carburization of inner side bulb.

9.1 The mount and Glass bulb shell not in correct alignment

The Mount at lower fixture is properly hold vertically & mount holding jaw grips the mount horizontally from sides .The mount holding jaw is reciprocated at correct place using air pressure. At same stage, the bulb holding sliding rod (plunger) of upper fixture reciprocates down to align itself at proper vertical and horizontal If in this process any mismatch of position of bulb shell occurs, it can result in severe defects. Similarly if Turret indexing head of sealing machine is unable to position itself correctly, defects may also arise.

Remedial measures-

(1) The Cam profile (lobe) should be maintained in such a way that it always gets vertically aligned over the mount.
(2) There should be no clearance in the gear drives operating the Turret Indexing head.
(3) Proper air pressure (1.2 kg/cm^2) for moving the mount holding jaw.

9.2 The tilting of mount with bulb shell

As the sliding rod along with bulb shell comes down over the upper fixture, there are possibilities of it getting slightly tilted due to any small clearance between rod and fixture. This can happen if the mount holding jaw gets a bit shifted (tilted) from its original place or via sliding rod tilting. If there occurs, a play in rotating Turret head, the fixtures will get tilted by all the above ways the tilting produce can consequently develop the tilting defects.

Remedial Measures-

(1) The fixtures should be made of good metal like Stainless steel or Chrome steel.
(2) The clearance between fixture and sliding rod should be regularly checked using gauge.
(3) As soon as play develops in Turret head, the bearing should be replaced.
(4) The screws holding tightly the lower fixtures should be checked so that they do not get loose.

9.3 Improper heating of pinch area of bulb

If bulb shell temperature does not reaches up to 1800 ^{0}C i.e. at its softening temperature, the sealing of Press hammer will be incomplete and leak proof seal between Mount and Glass Bulb shell won't develop

Remedial Measures-Softening temperature should lie between 1700 ^{0}C – 1800 ^{0}C for proper sealing of Glass

9.4 Carburization of inner side bulb

While Press Hammer seals the Glass bulb shell and Mount, the oxygen inside the shell comes in contact with tungsten metal in Filament, its oxidation starts and a black layer of carbon gets visible inside the glass bulb shell which is called as Carburization.

Remedial Measures-The supply of Nitrogen (inert) gas at ~1.8 kg/cm^2 during sealing process should be accurate which will prevent Bulb shell being Carburized (Deposition of carbon layer).

10. Implementation & Comparison of Results

The rejection data of Sealing machine in the month of Nov.2011showing

Table 2: Rejection data

S. No.	Dates	Bulb Rejection in % Defects	Mean-X	Sample No.
1	1-Nov-11	2.75	X1	$\bar{x}_1$
2	2-Nov-11	2.73	X2	
3	3-Nov-11	2.74	X3	
4	4-Nov-11	2.69	X4	
5	5-Nov-11	2.23	X5	
6	6-Nov-11	2.54	X6	$\bar{x}_2$
7	7-Nov-11	2.69	X7	
8	8-Nov-11	2.29	X8	
9	9-Nov-11	2.15	X9	
10	10-Nov-11	2.67	X10	
11	11-Nov-11	2.19	X11	$\bar{x}_3$
12	12-Nov-11	2.47	X12	
13	13-Nov-11	2.47	X13	
14	14-Nov-11	2.56	X14	
15	15-Nov-11	2.63	X15	
16	16-Nov-11	2.01	X16	$\bar{x}_4$
17	17-Nov-11	2.44	X17	
18	18-Nov-11	2.53	X18	
19	19-Nov-11	2.66	X19	
20	20-Nov-11	2.42	X20	
21	21-Nov-11	2.71	X21	$\bar{x}_5$
22	22-Nov-11	2.32	X22	
23	23-Nov-11	2.49	X23	
24	24-Nov-11	2.69	X24	
25	25-Nov-11	2.71	X25	
26	26-Nov-11	2.23	X26	$\bar{x}_6$
27	27-Nov-11	2.49	X27	
28	28-Nov-11	2.35	X28	
29	29-Nov-11	2.61	X29	
30	30-Nov-11	2.53	X30	

Table 3:X-Bar chart with their limits

S.No.	SAMPLE SIZE (5)	MEAN VALUE ($\bar{x}$)	UCL	LCL	$=\bar{x}$ MEAN OF REJECTED BULB
1	$\bar{x}_1$	2.628	2.772	2.239	$=\bar{x}=\frac{\bar{x}_1+\bar{x}_2+\bar{x}_3+\bar{x}_4+\bar{x}_5+\bar{x}_6}{5}$ =2.506
2	$\bar{x}_2$	2.468	2.772	2.239	
3	$\bar{x}_3$	2.372	2.772	2.239	
4	$\bar{x}_4$	2.552	2.772	2.239	
5	$\bar{x}_5$	2.488	2.772	2.239	
6	$\bar{x}_6$	2.53	2.772	2.239	

Graph 2:X-Bar chart with their limits

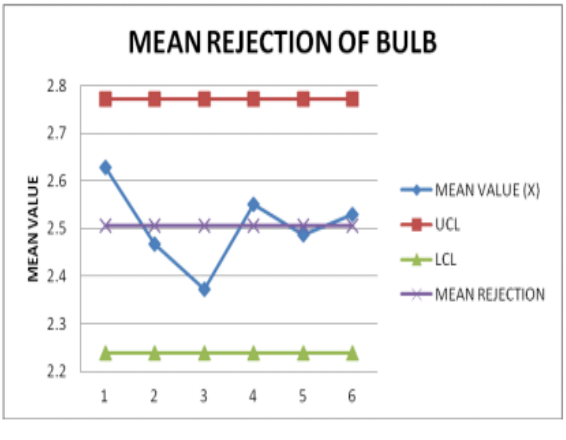


Table 4: R-Bar chart with their limits

SAMPLE No.	RANGE (R)	UCL	LCL	MEAN RANGE $\bar{R}$ OF BULB REJECTED
1	0.461	0.975	0.0	$\bar{R}=\frac{R1+R2+R3+R4+R5+R6}{6}$ =0.461
2	0.54	0.975	0.0	
3	0.62	0.975	0.0	
4	0.29	0.975	0.0	
5	0.48	0.975	0.0	
6	0.32	0.975	0.0	

Graph 3: R-Bar chart with their limits

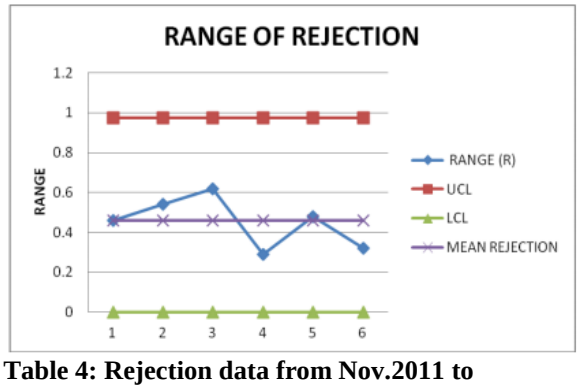
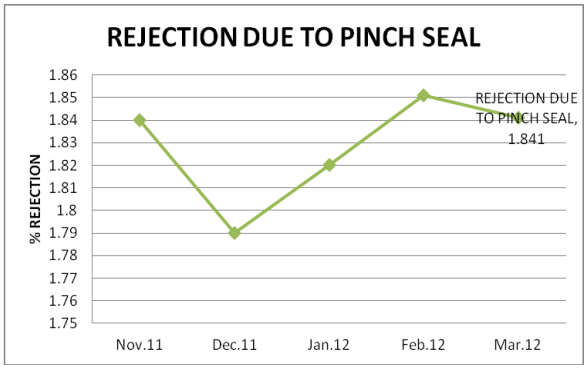


Table 4: Rejection data from Nov.2011 to March2012 after implementation the remedial measures

Month	Pinch Seal	Annealing	Hammer pressure	Total Rejection
Nov.2011	1.84	0.257	0.418	2.515
Dec.2011	1.79	0.259	0.451	2.50
Jan.2012	1.82	0.257	0.423	2.50
Feb.2012	1.851	0.246	0.418	2.515
Mar.2012	1.841	0.238	0.42	2.50
Mean (%)	1.82%	0.251%	0.426%	2.506 %

Graph 4: Rejection data from Nov.2011 to March2012 after implementation the remedial measures:



11. Conclusion

The rejection of automotive halogen bulb at sealing stage is in the form of defects appeared inside or outside the bulb surface in the form of cracks, incorrect alignment, Tilting the mount, carburizing, invariable hammer pressure, invariable annealing which cannot be completely removed, but these can be reduced to certain extent by preventive & controlled measures in the form of Proper sealing of mount with the bulb glass tube and Proper annealing.

After the constant observation and analysis of the statistical data of total bulbs produced and rejected in every month from June 2011 to March 2012, the percentage of rejected bulbs with individual defects (before and after measures implementation) was obtained, after plotting the graph found that the mean rejection on sealing machine decreases from 3.8 % to 1.82 %.On the basis of rejection data on sealing stage of Nov.2011, calculating and observing the Mean ,Upper control limit and lower control limit ,it was found that the process is within the control condition under significant manner.

Acknowledgement:

The authors are thankful to **Shri. D.D. Kalla G.M.** and **Shri. R.K.Mathur works Manager** M/s Autolite (India) Pvt. Ltd., Sitapura, Jaipur) for providing their full guidance and allowing to use the facilities available in the company.

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Author:-
Sharad Shrivastava
Poornima college of Engineering
Jaipur (Rajasthan)
M.No.09414931879
Sharad_bsf@rediff.com