A Study on Reducing the Sink mark in Plastic Injection Moulding - Taguchi Technique

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Abstract:- It is much difficult to set optimal process parameter levels which may cause defect in articles, such as sink mark. In this study Taguchi optimization technique is used to produce the good quality of plastic injection molded part. The optimum process parameters are melt temperature is 200 ◦C, injection pressure is 70 bar, injection speed is 3 mm/sec. ,screw speed is 20% and cooling time is 25 sec. In this the study found that melt temperature is the more sensitive parameter.

Keywords:- Sink mark, Plastic injection moulding , Taguchi Technique etc.

I.   INTRODUCTION

Sink marks or depressions usually form over the thicker sections of a part. This is due largely to the difference in cooling rates between the thick and thin sections. As thicker sections cool, the molten polymer contracts or shrinks, pulling the surface skin toward the center. The result is usually the formation of a depression or sink mark on the surface.The quality of an injection molded part is affected by material properties, mold geometry, process conditions and etc. Obtaining optimum parameters is the key problem to improve the part quality. Sink marks is one of several important flaws of injection molded parts.The injection moulding process was first designed in the 1930s and was originally based on metal die casting designs (Douglas, 1996). This process is most typically used for thermoplastic materials which may be successively melted, reshaped and cooled. Sink marks are depressions on the surface of injection moulded plastic parts caused during the plastic cooling process. Thicker sections of plastic will cool at a slower rate than others, and will yield a higher percentage of shrink in that local area. The extra shrinkage in that local area is what causes the depressions. After the on the outside has cooled and solidified the core material start to cool. Its shrinkage pulls the surface of the main wall inward, causing a sink mark (Michael et.al, 1997).

II.   PROBLEM STATEMENT

A sink mark is a local surface depression that typically occurs in moldings with thicker sections, or at locations above ribs, bosses, and internal fillets. Sink marks and voids are caused by localized shrinkage of the material at the thick sections without sufficient compensation when the part is cooling.

III.   OBJECTIVE OF THE PROJECT

Study the process parameters, which will affect quality of plastic injection moulded part.
A study on reducing the sink mark in plastic injection moulding

EXPERIMENTAL STUDIES
▪   **Selection of the quality characteristic**
Signal to Noise analysis is designed to measure quality characteristic.
$S/N = -10 \log_{10} (MSD)$
Where MSD = Mean Square Deviation
For the larger the better characteristic,
$MSD = (1 / Y_1^2 + 1 / Y_2^2 + 1 / Y_3^2 + \ldots\ldots.) \times 1/ n$
Where Y1, Y2, Y3 are the responses and n is the number of tests in a trial

- **Selection of control and noise factors**

SI.NO	Table 1: selected Factors and Levels	Level 1	Level 2	Level 3	Level 4
	Factors	Level 1	Level 2	Level 3	Level 4
1	Melt Temperature,A (˚C)	180	190	200	210
2	Injection pressure , B (bar)	40	50	60	70
3	Injection speed , C (mm/sec.)	2	3	4	5
4	screw speed , D (%)	20	30	40	50
5	Cooling time , E (sec.)	15	20	25	30

Table 2: Combination of parameters in (L16) Orthogonal Array Variance

Trial No.	A	B	C	D	E	
1	180	40	2	20	15	
2	180	50	3	30	20	
3	180	60	4	40	25	
4	180	70	5	50	30	
5	190	40	3	40	30	
6	190	50	2	50	25	
7	190	60	5	20	20	
8	190	70	4	30	15	
9	200	40	4	50	20	
10	200	50	5	40	15	
11	200	60	2	30	30	
12	200	70	3	20	25	
13	210	40	5	30	25	
14	210	50	4	20	30	
15	210	60	3	50	15	
16	210	70	2	40	20	

IV.   RESULTS AND DISCUSSION
Table 3: Combination of parameters in (L16) Orthogonal Array Variance

Trial No.	A	B	C	D	E	(weight in grams)	S/N
1	180	40	2	20	15	2.4	7.6
2	180	50	3	30	20	2.42	7.67
3	180	60	4	40	25	2.44	7.74
4	180	70	5	50	30	2.48	7.88
5	190	40	3	40	30	2.54	7.95
6	190	50	2	50	25	2.51	7.99
7	190	60	5	20	20	2.53	8.06
8	190	70	4	30	15	2.54	8.09
9	200	40	4	50	20	2.55	8.13
10	200	50	5	40	15	2.56	8.16
11	200	60	2	30	30	2.6	8.29
12	200	70	3	20	25	2.65	8.46
13	210	40	5	30	25	2.61	8.33
14	210	50	4	20	30	2.59	8.26
15	210	60	3	50	15	2.6	8.29
16	210	70	2	40	20	2.61	8.33

Table 4: Control factors

| LEVEL	A	B	C	D	E
1	7.7225	8.0025	8.0525	8.095	8.035
2	8.0225	8.02	8.0925	8.095	8.0475
3	8.26	8.095	8.055	8.045	8.13
4	8.3025	8.19	8.1075	8.0725	8.095
DIFFERENCE	0.58	0.1875	0.055	0.05	0.095
RANK	1	2	4	5	3

Above reading shows (from table 4) melt temperature (A) is more effective parameters as compared to injection pressure (B) , injection speed (C) , screw speed (D) , and cooling time (E).
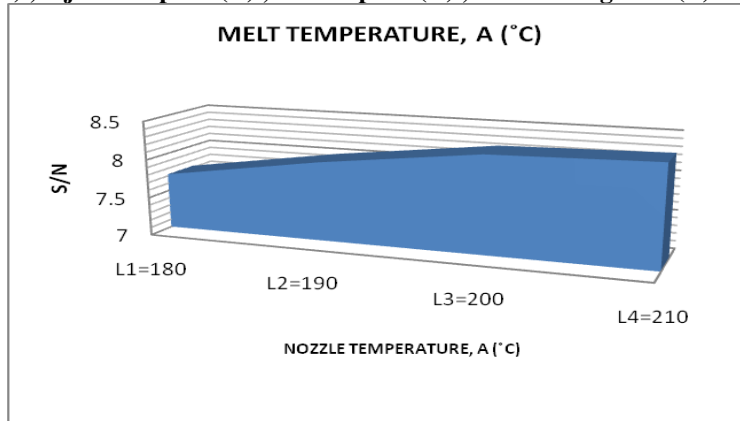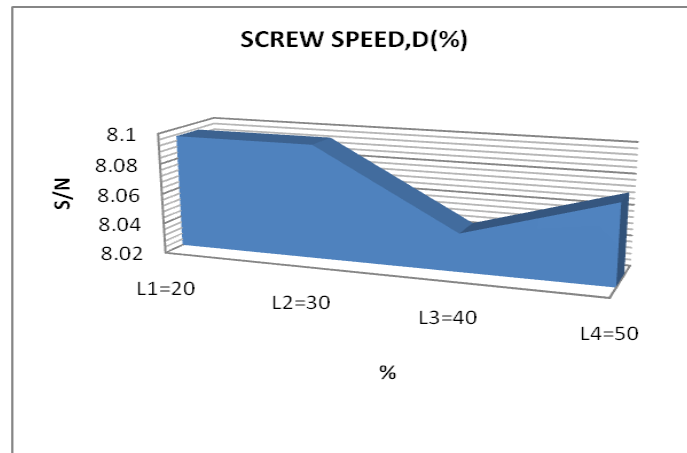

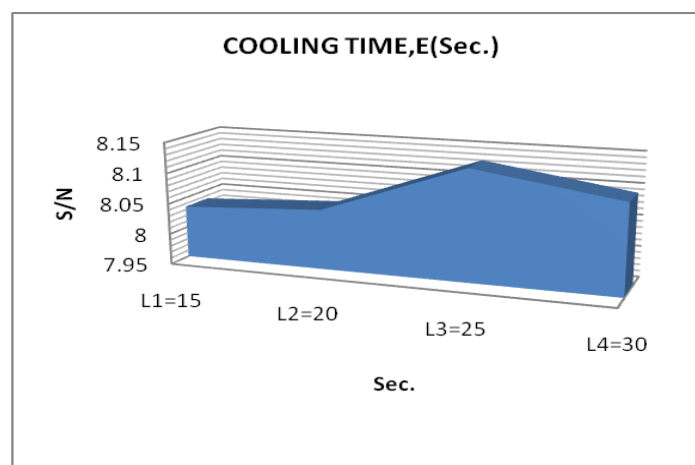**Graph 1: S/N Response for melt temperature**
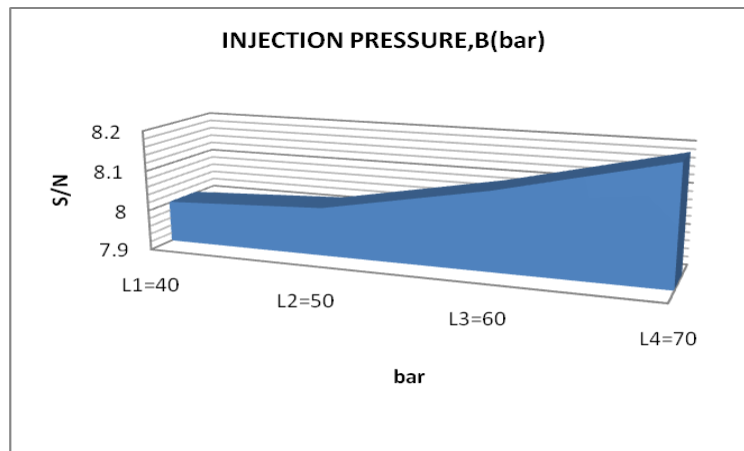
Graph 2: S/N Response for injection pressure
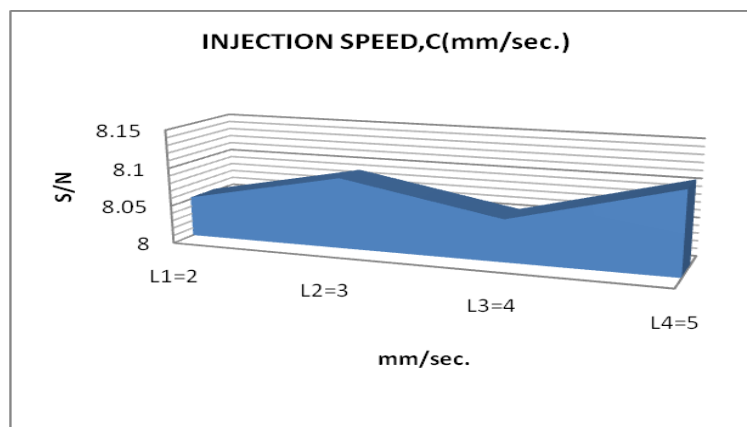
Graph 3: S/N Response for injection speed

Graph 4: S/N Response for screw speed

Graph 5: S/N Response for cooling time

V. CONCLUSION

Sink mark is one of the main defect in plastic injection molding process which appears due to Insufficient polymer in the mold to allow for shrinkage. In this study Taguchi method is used to found out the optimum process parameters for reducing the sink mark defect during injection process. The optimum process parameters are melt temperature is 200 ◦C, injection pressure is 70 bar, injection speed is 3 mm/sec. ,screw speed is 20% and cooling time is 25 sec. by setting these parameters ,we produced defect free molded part.

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