



Multi-objective Optimization of Forming Parameters for Tube Hydroforming Process Based on the Taguchi Method

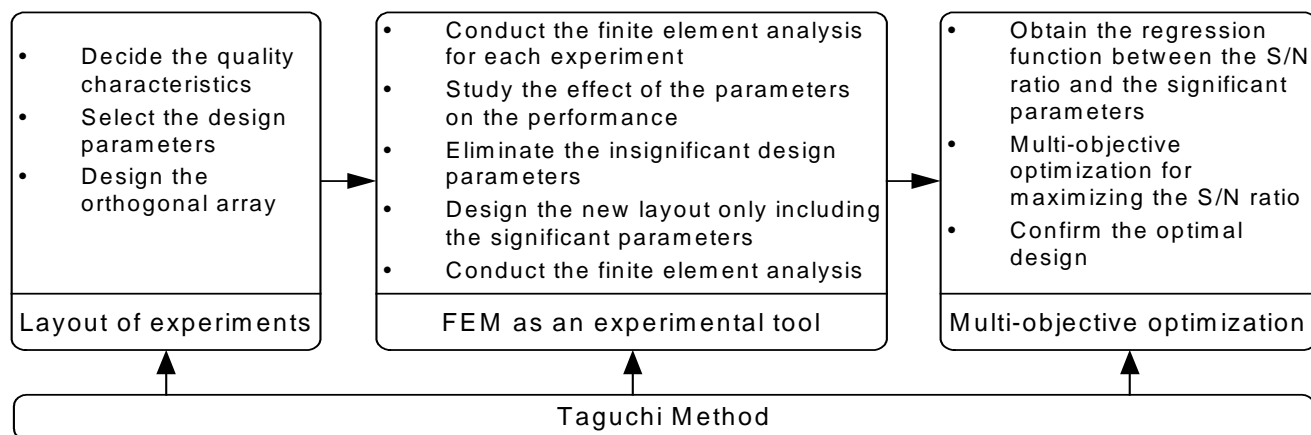
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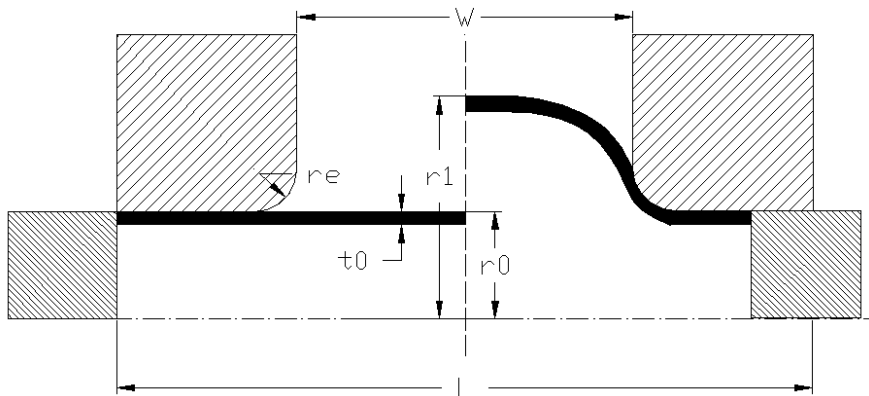
Introduction

Tube Hydroforming is a relatively new technology which has attracted the increasing attention of automotive industry around the world. In order to successfully obtain the final desired hydroformed parts, it is necessary to study the influence of the forming parameters on the hydroformability. The purpose of this study is to develop a method to analyze the effects of the forming parameters on the quality of part formability and determine the optimal combination of the forming parameters for the process.

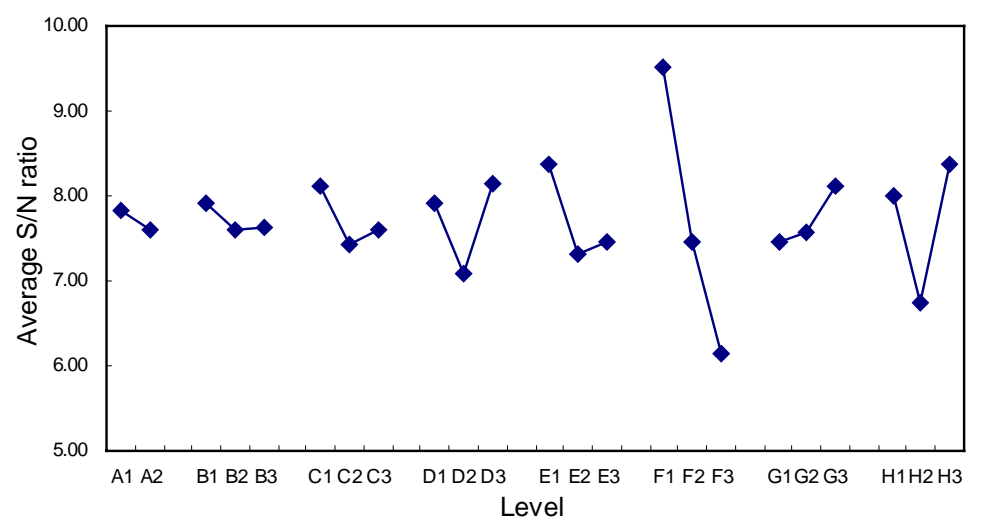
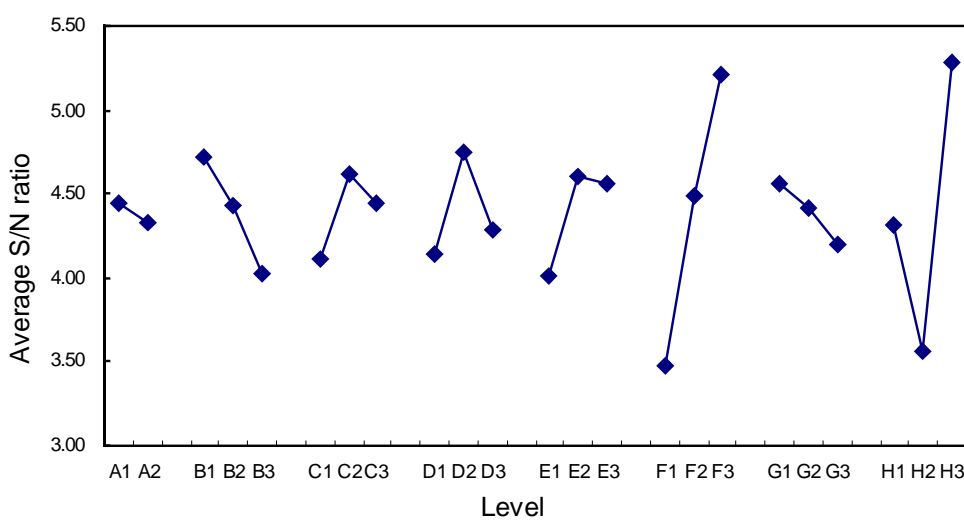
Methodology



Results and Discussion



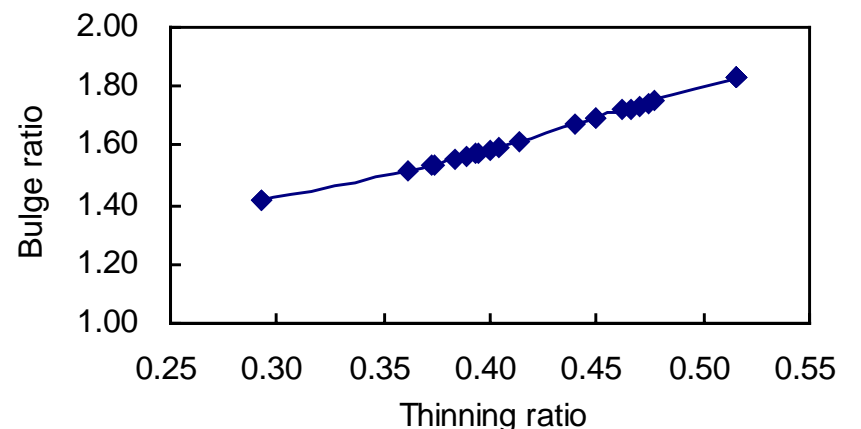
Designation	Forming parameters	Level 1	Level 2	Level 3
A	Length of the tube (mm)	180	200	220
B	Thickness of Tube (mm)	1.35	1.5	1.65
C	Die entry radius (mm)	8	10	12
D	Bulge width (mm)	90	100	110
E	Hardening Exponent	0.207	0.227	0.247
F	Internal Pressure (MPa)	36	40	44
G	Nominal Stress Ratio	0.2	0.4	0.6
H	Friction coefficient (Coulomb)	0.02	0.06	0.1



Average effect of forming parameter on the bulge ratio

Parameters	Degree of freedom	Sum of squares	Contribution (%)
Length of the tube	1	0.055	0.37
Thickness of tube	2	0.747	5.10
Die entry radius	2	0.398	2.71
Bulge width	2	0.621	4.24
Hardening exponent	2	0.658	4.49
Internal pressure	2	4.543	31.00
Nominal stress ratio	2	0.198	1.35
Friction coefficient	2	4.458	30.42
Error	2	2.978	
Total	17	14.654	

Average effect of forming parameter on the thinning ratio



Conclusions

1. Internal pressure and friction coefficient have the greatest effects on a free bulging tube hydroforming process.
2. The bulge ratio and thinning ratio for a given free bulge tube hydroforming process are improved simultaneously through our approach.
3. The corresponding optimal thinning ratio can be obtained according to the Pareto set of the optimization problem if a specific bulge ratio is required for a given free bulge hydroforming process.