Studies on Roll Forming Parameters that impact the 'Critical to Quality' Parameters of Racking Upright

Gowtham S. | 16BME0185

Godrej Storage Solutions, Chennai

Motivation/ Introduction

The manufacturing industry has always had the perennial hunger to improve productivity, quality and overall performance. Traditional operator driven processes are highly dependent on the skill and experience of the worker, and are subject to productivity and quality losses due to their reliance on the worker and the lack of explicit knowledge of the process parameters. This is the problem statement taken up for this study conducted at Godrej Storage Solutions, Chennai, a metal forming industry that specialises in creating industrial racking structures from sheet metal. The study was used to establish a robust system that could be implemented in all sectors of production for large scale improvement and innovation.

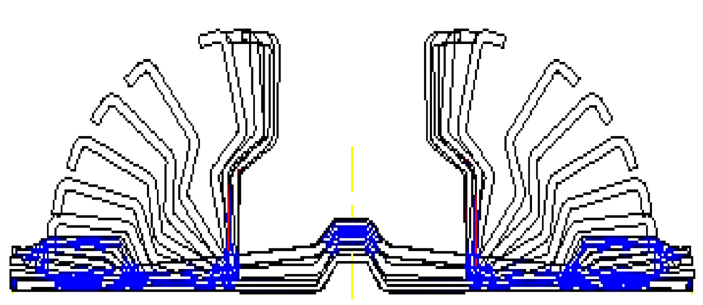
SCOPE of the Project

The components of industrial racking systems are roll formed components created by incrementally applying higher degrees of pressure in the required bending directions, thus creating required intricate cross-section. The structure of this design and accuracy of its dimensions are affected by a plethora of factors including but not limited to the pressure applied for deformation and the material properties of the inbound raw material. The goal is to theorize which input parameter showcases the greatest degree of significant impact on the dimension(s) and thus provide the industry with some tools that will help establish an experimental method that is designed to

1. Study the parameters that affect the CTQ parameter of the roll formed metal component

2. Reduce the mean time to repair (MTTR) and changeover time, thus reducing productivity losses and quality losses

3. Be a robust process that can be implemented for improvement of any process in the industry while also possessing the capacity to be a small cog in the new industrial revolution.

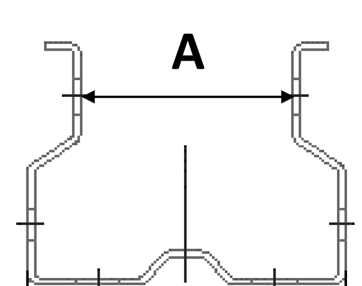


24 Station Roll Forming of the GXL Upright

Methodology

1. Product and Process Study

2. CTQ Parameter = **Inner Width A**



3. Factors Affecting CTQ Parameter

4. Factors reduced to vital few by studying their impact on process, their measurability, and ensuring varying these factors does not affect production quality excessively

5. Control Factors - **PRESSURE SETTINGS AT SIX STATIONS**, chosen due to their contribution to the formation of the Inner Width **A** (as based on the flower pattern of the roll formed product), and Noise Factors – Material Properties: **YS** and **THICKNESS**

6. MSA and measurement method and location specified

7. Experiments designed keeping Material Properties as noise factors using **L27 Orthogonal Array** as defined by Taguchi and considering **NO INTERACTIONS**

8. Initial results showcased highest contribution by Station 13; Validation Required.

9. Interaction effects studied; Showcased high contribution by S23xS24; Validation Required

10. Effect of noise factors – YS and Thickness studied

11. Analysis of product dimension by varying S13 to validate; Identified that S13 variation is caused more by measurement deviation caused by forming station effect

12. Study of CTQ Parameter variation due to combined interaction effect of S23 and S24

13. Hypothesis of S23xS24 interaction effect having highest contribution Validated

14. Validation of Experimental Hypotheses and observation of results

Note: Analysis done using Minitab 14 function to analyze Taguchi Design and ANOVA

Formulae utilized for ANOVA:

- Factor DOF = Number of levels – 1
- Sum of Squares,

$$SS = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \bar{Y})^2$$

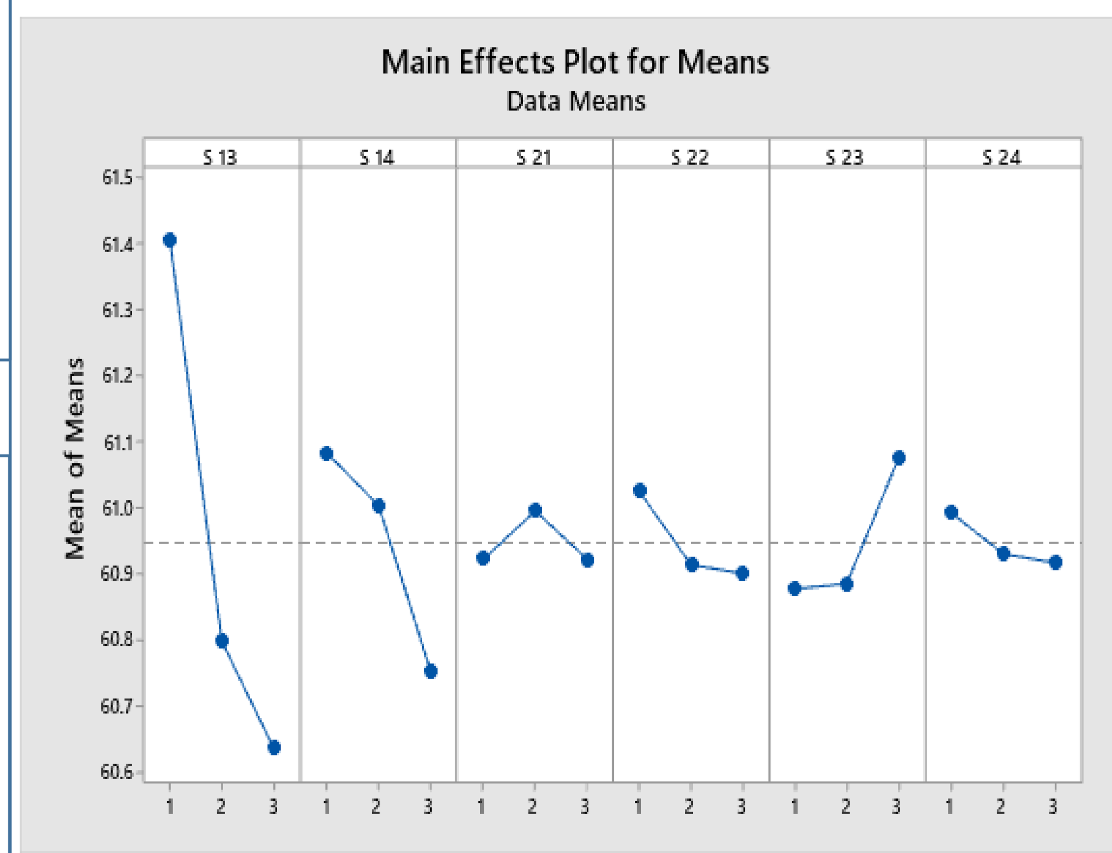
- Mean Sum of Squares,

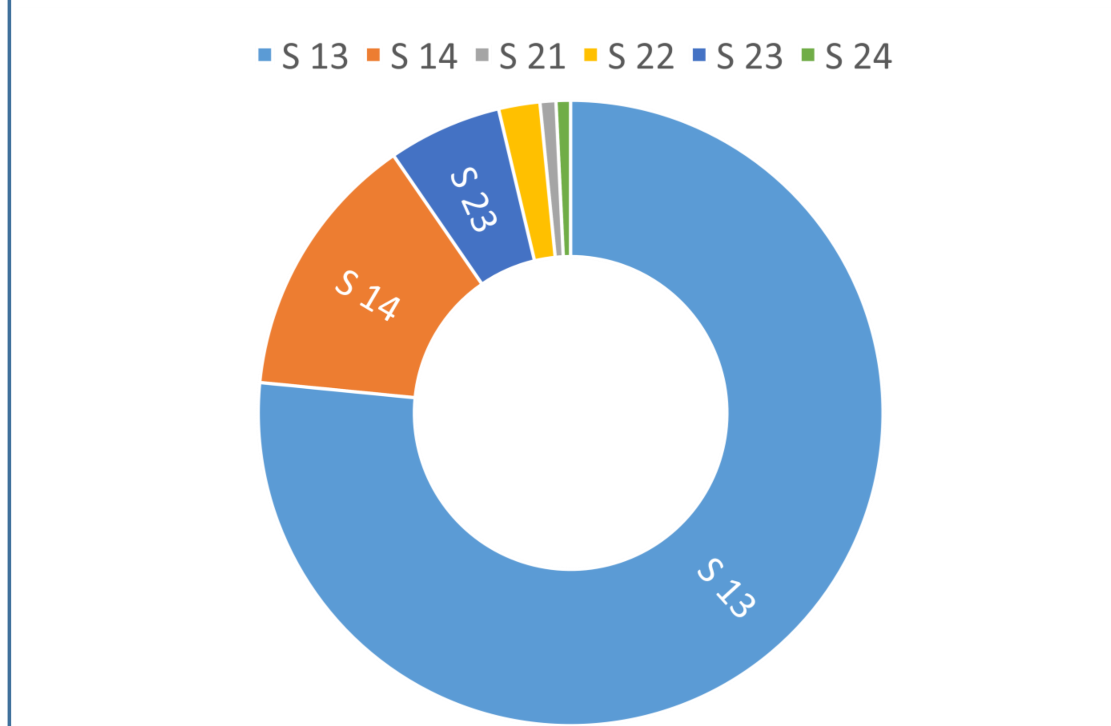
$$MS = \frac{1}{n}\sum_{i=1}^{n}(Y_i - Y_o)^2$$

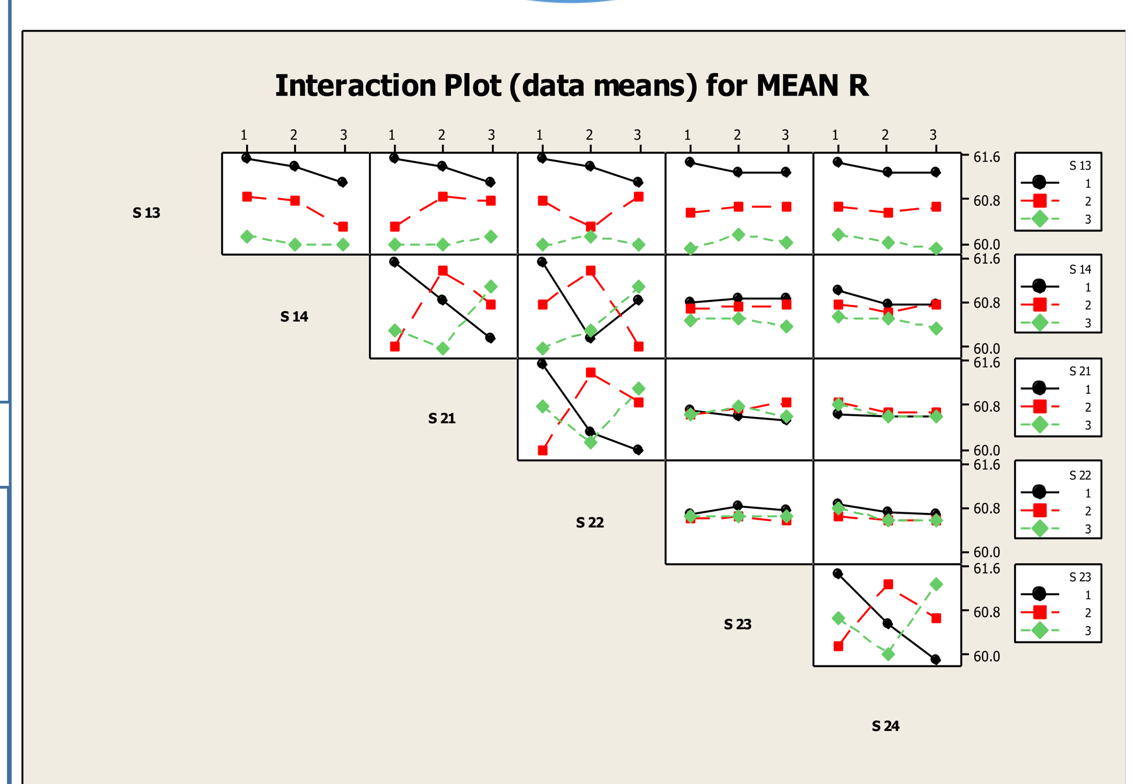
Individual Roll Station whose pressure settings are adjusted by turning the head screw

Results

Significant Factors and their influences on 'A'

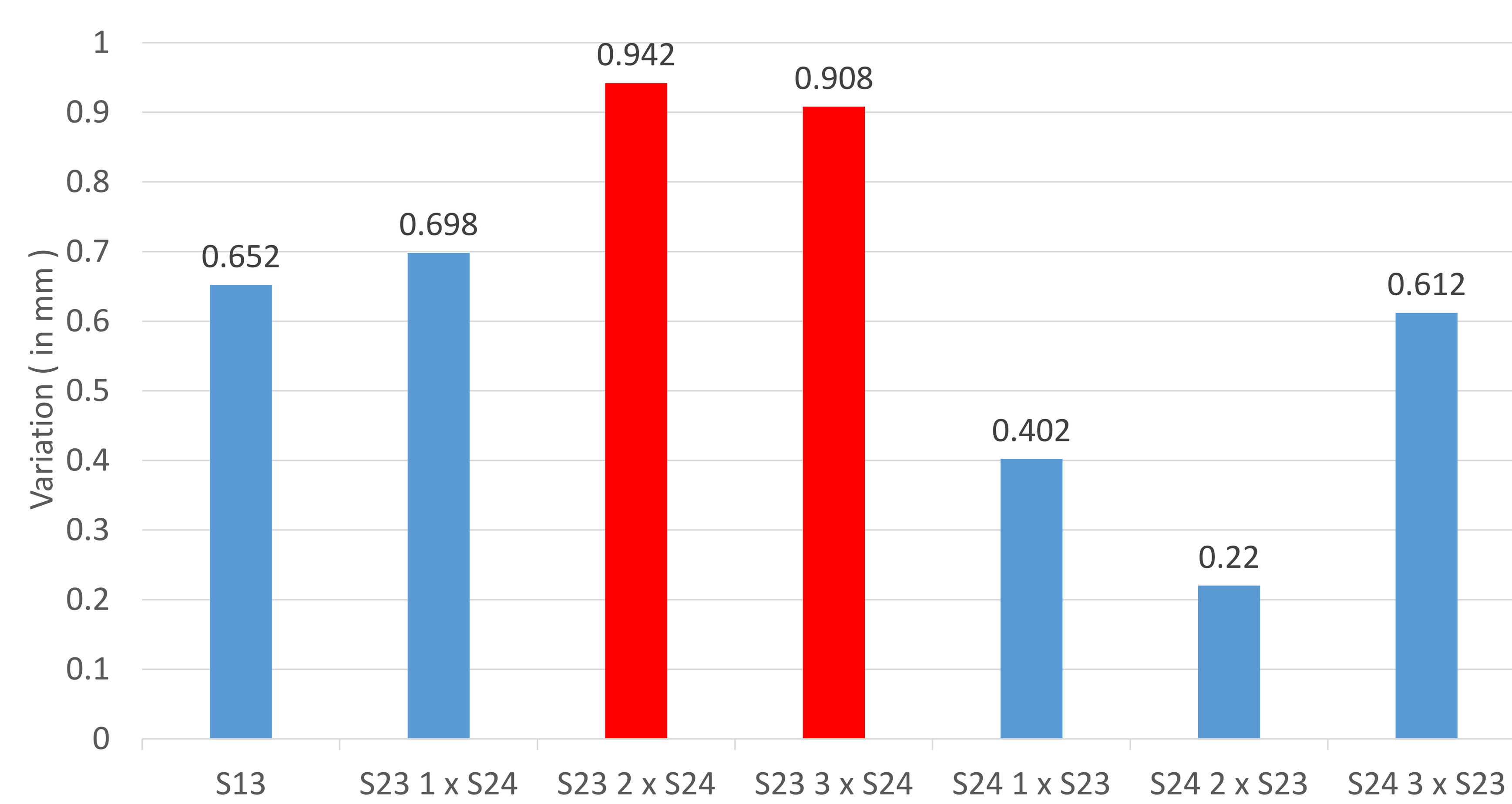






Experimental Trial	Factor/Interaction considered	Percentage Contribution of effect	P Value (alpha = 5%)	Significance
395 x 2.0	S14xS21, S14xS22, S21xS22	S21xS22 – 61%	0.099	Not Significant
	S13xS22, S14xS22, S21xS22	S13 – 56%	0.055	Not Significant
	S23xS24	S23xS24 – **56.9%**	0.009	Significant
398 x 1.8	S14xS21, S14xS22, S21xS22	S21xS22 – 85%	0.117	Not Significant
	S13xS22, S14xS22, S21xS22	S13 – 85%	0.094	Not Significant
	S23xS24	S13 – 8.06% S23xS24 – 78.36%	0.027 0.000	Both Significant
427 x 1.8	S23xS24	S13 – 8.038% S14 – 1.285% S21 – 1.55% S24 – 1.42% S23xS24 – 85.62%	0.000 0.029 0.017 0.022 0.000	All Significant

Maximum variation in output CTQ parameter was induced by the interaction effect of S23xS24



Conclusion

- The S23xS24 interaction factor was pointed out by the machine operators who have gained experience from running the machinery for years to have the greatest effect on the output of the racking upright. Thus, this study was able to scientifically verify the same and that is a mark of the robustness of the experimental design and the strength of the process.

- The emergence of Station 13's significance and the possible effect of *spring back* on this metal forming were intriguing new findings. Studies into these and how the interaction effects work is the immediate next step of this study. With the most significant contribution to the CTQ parameter, they are an important factor to be understood and researched.

- The data obtained from analysis of variance can be used to develop and train a statistical model. Knowledge can be fed about every process parameter into the model, taking the first steps to automating and optimizing the entire process.

Contact Details

gsenthilkum2@wisc.edu

References

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- Halmos, G.T.(Ed.). (2006). Roll Forming Handbook. Taylor & Francis