Using Multiple Regression to Improve Front Line Worker Morale

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INTRODUCTION

Productivity and costing metrics like *units per hour* are commonly used in industry for planning and management purposes. However, these metrics are fair to front line workers only if the units under production have comparable cycle times. For custom ankle-foot orthotic braces, dramatic differences between braces and the amount of work needed to produce them are the norm. For example, there are many different designs of braces available to treat a wide variety of walking dysfunctions. Some designs are relatively simple while others are complex with hinges, support structures, inner liners and the like. And of course, there is wide variation in the geometry of people's lower leg, so braces range from tiny, short & narrow to large, tall & wide. Therefore, for ankle-foot orthotics, common factory metrics such as *units per hour* don't fairly measure front line worker productivity, particularly for the edge finishing processes. The result is disputes and out-of-sequence selection of small braces through no fault of the front line worker. An equitable metric like *weighted units per hour* was badly needed.

This paper details a series of regression models that were developed to estimate the edge length of ankle-foot orthotics and thus predict, within limits deemed acceptable, a target cycle time that is proportional to the actual amount of work needed.

METHODS

DEFINE

This project was managed with a simplified version of the Six Sigma DMAIC method. The first order of business was to write a project plan with a team consisting of front line production, financial, planning, IT and supervisory personnel. A charter document stated the project objectives and included the needs of all end users into the project structure. A useful ObDOE method, *Checklist for Asking the Right Question*[1] provided guidance and clarity. A lean tool, the *Product Quantity/Product Routing Matrix* was used to categorize 33 different brace designs into 5 brace families that would each be modeled separately.

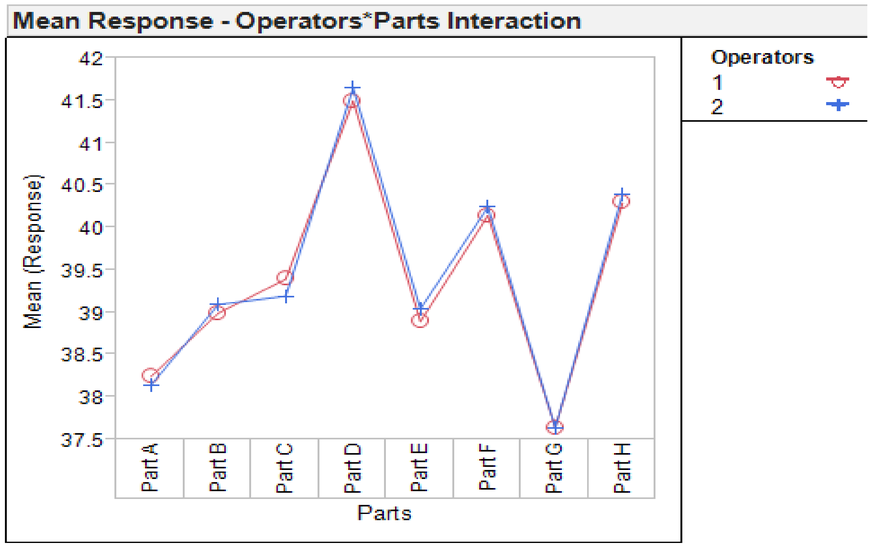
MEASURE

The main project response variable was edge length and it was measured with a length of low-elongation string, a steady hand and a measuring tape. A measurement system analysis was performed with 8 similar parts, 2 operators and 3 replicates. The 1.5% EMP Gage R&R and 1.93% AIAG Gage R&R (Variance method) were judged by all team members as acceptable for the purpose.

EMP Gauge R&R Results

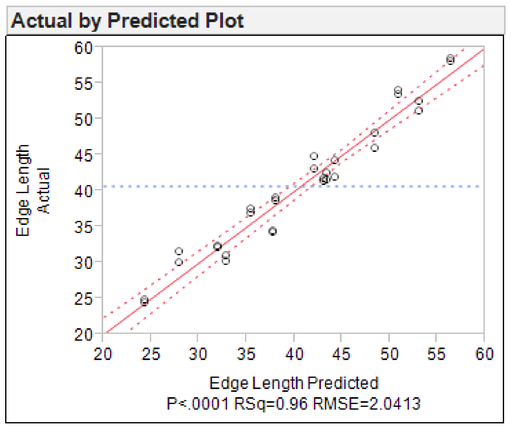
Component	Std Dev	Variance Component	% of Total	20 40 60 80
Gauge R&R	0.1534329	0.0235417	1.5	
Repeatability	0.1534329	0.0235417	1.5	
Reproducibility	0.0000000	0.0000000	0.0	
Product Variation	1.2562019	1.5780432	98.5	
Interaction Variation	0.0000000	0.0000000	0.0	
Total Variation	1.2655374	1.6015848	100.0	

Mean Response - Operators*Parts Interaction



ANALYZE

The study included the brace length, width and height as predictor variables. All 3 predictor variables were readily available on production documentation, so data collection was simple and non-intrusive to production operations and personnel. The response variable was the edge length of the brace.



Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	3.9057762	1.600451	2.44	0.0215*
Length	3.9103473	0.754596	5.18	<.0001*
Height	1.069794	0.518505	2.06	0.0488*

IMPROVE

The team chose regression models using only length and height as predictor variables because of the marginal gain provided by including brace width. The regression models were then evaluated against carefully measured cycle times to provide the vital link between edge length and the actual amount of edge finishing work, *i.e. the useful and equitable productivity metric we needed.*

A number of iterations and thorough discussions meant that our new *weighted units per hour* metrics were both useful for management and accounting purposes and, perhaps most importantly, acceptable to front line workers.

CONTROL

Because the predictor variables were easy to gather, a weekly check of the model was performed for 2 months and the results were judged as satisfactory. Final details were ironed out and the models were made available for production management and IT systems.

DISCUSSION

Without question, a key to project success was the involvement of front line workers and a consensus approach to decision-making. Another key was the ability for the project leader to present results to the project team in JMP10's concise graphical form as demonstrated above.

Here is one of the 5 models. Similar equations were developed for the other 4 product families.

EDGE LENGTH IN INCHES = 3.9 + 3.9L + 1.1H

where,
L = brace foot length in inches.
H = brace height in inches.

From this simple equation, we could quickly calculate the edge length of a wide range of brace sizes using readily available information. Benefits include an opportunity for better manufacturing and financial decision-making, better labor allocation and dramatically improved employee morale.

REFERENCES

[1] *Performing Objective Experiments Using JMP, an Exercise Manual*, William D. Kappele, ObDOE, August 2011

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