

Virtual DOE

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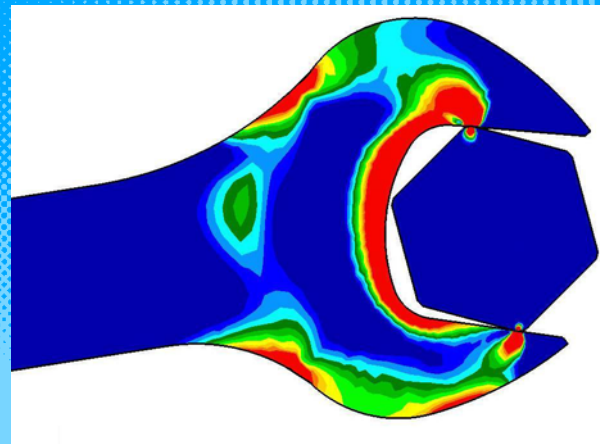
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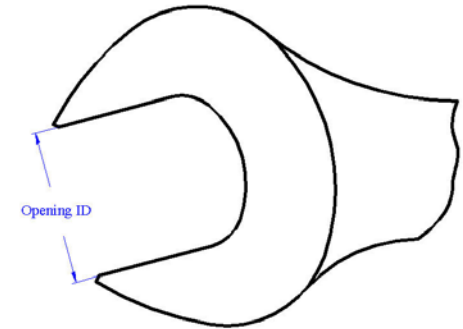


Introduction

Danaher Tool Group is a leading manufacturing company for Sears Craftsman ® Brand.

Craftsman's tool specification require Danaher to meet 150% of the ASME loading standard, while matching the ASME standard for geometry.

Failure is described as loading and unloading an open-ended wrench and not exceeding a permanent deformation of 0.002" (2 mils) above the maximum allowable for the open-end id.

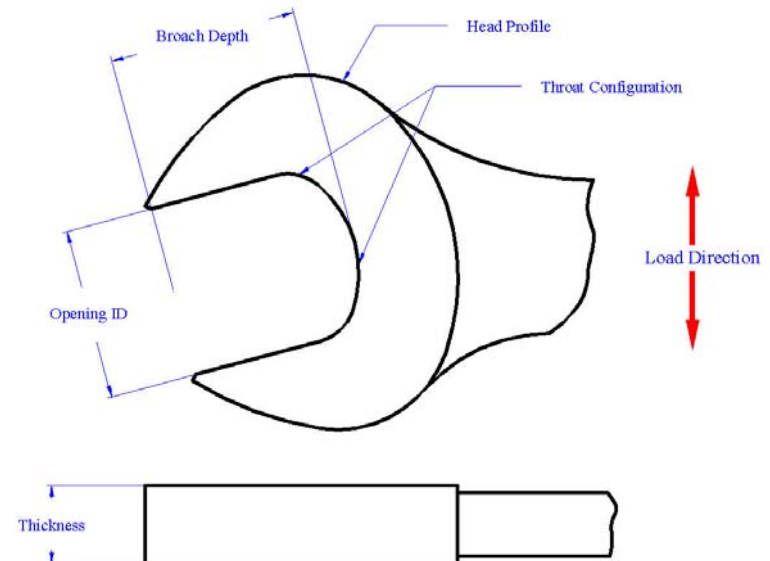




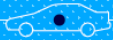
Method & Approach



		Forge Coining	Test Direction	Throat Configuration	Head Profile	Hardness	Thickness*	Opening ID*	Broach Depth*	# Levels
ID	Factors	H	G	F	E	D	C	B	A	
A	Broach Depth*				I		I	I	M	2
B	Opening ID*						I	M		2
C	Thickness*			I			M			2
D	Hardness			I		M				3
E	Head Profile			I	M					2
F	Throat Configuration			M						3
G	Test Direction		M							2
H	Forge Coining	M								2

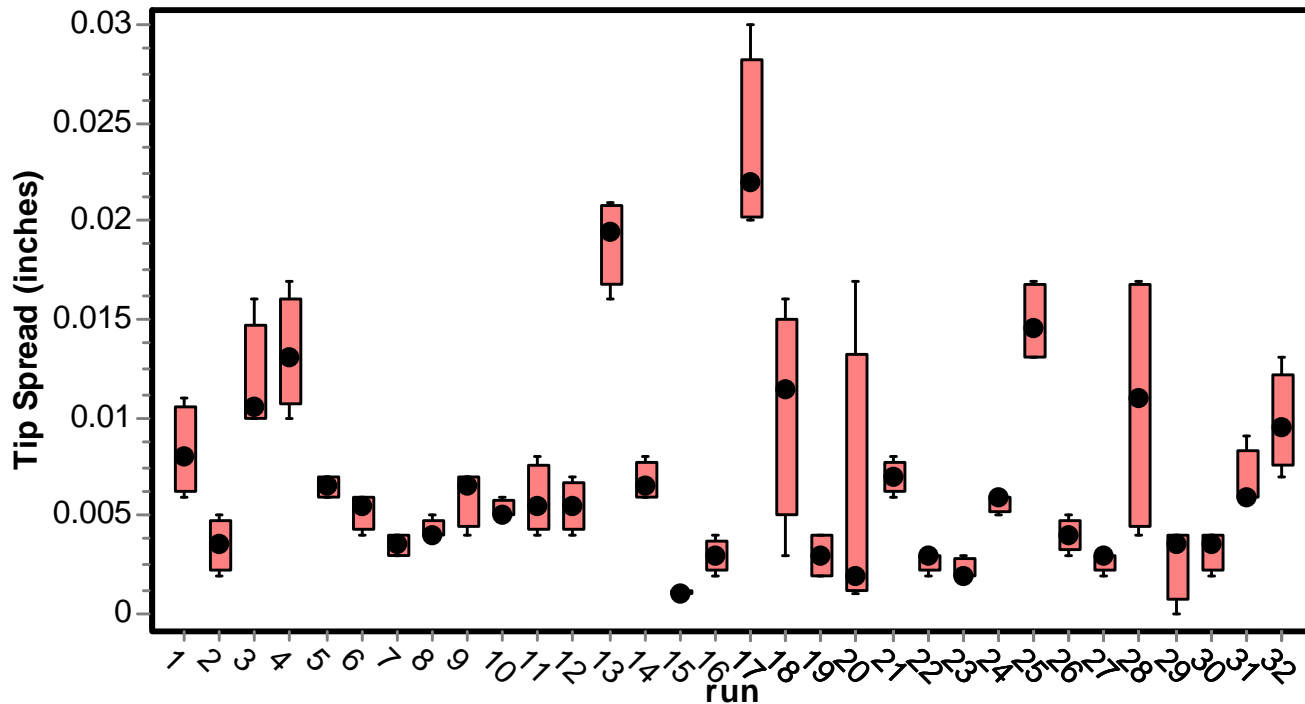


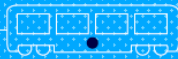
Correlating Testing & Virtual Design of Experiment Using MSC.Patran & MSC.Marc



Testing Results

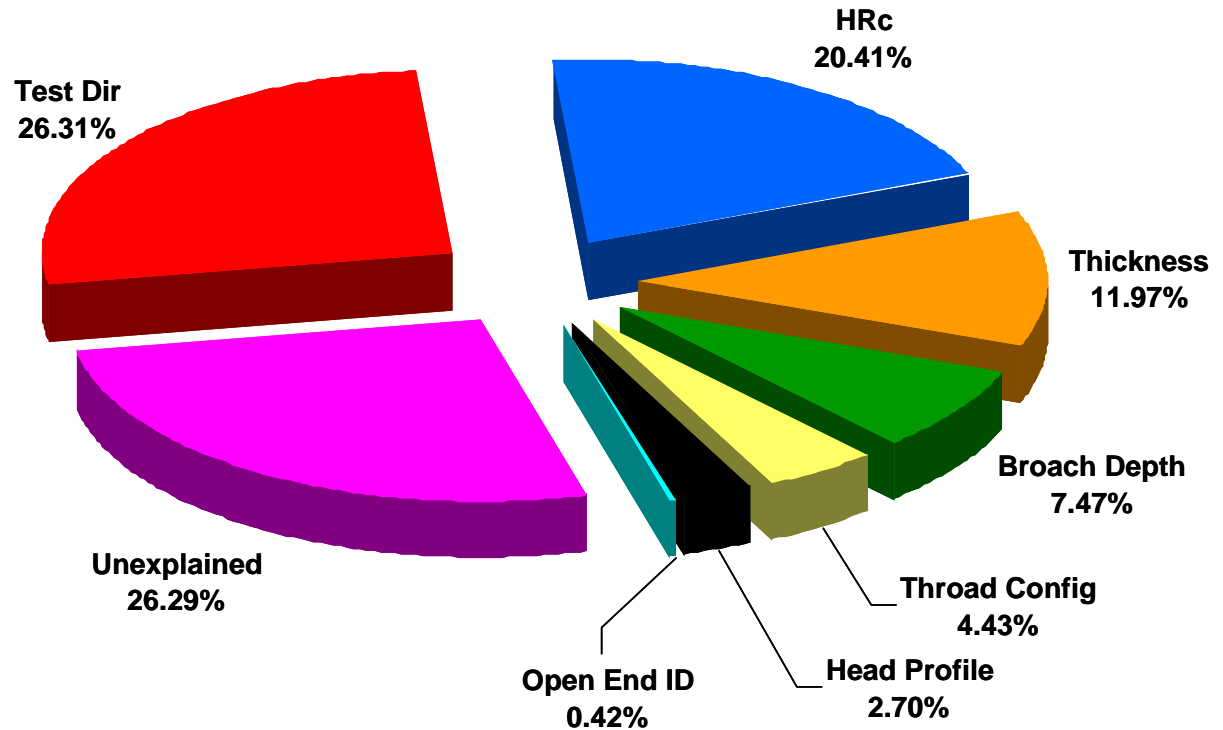
Permanent Tip Spread After Loading to 150% ASME





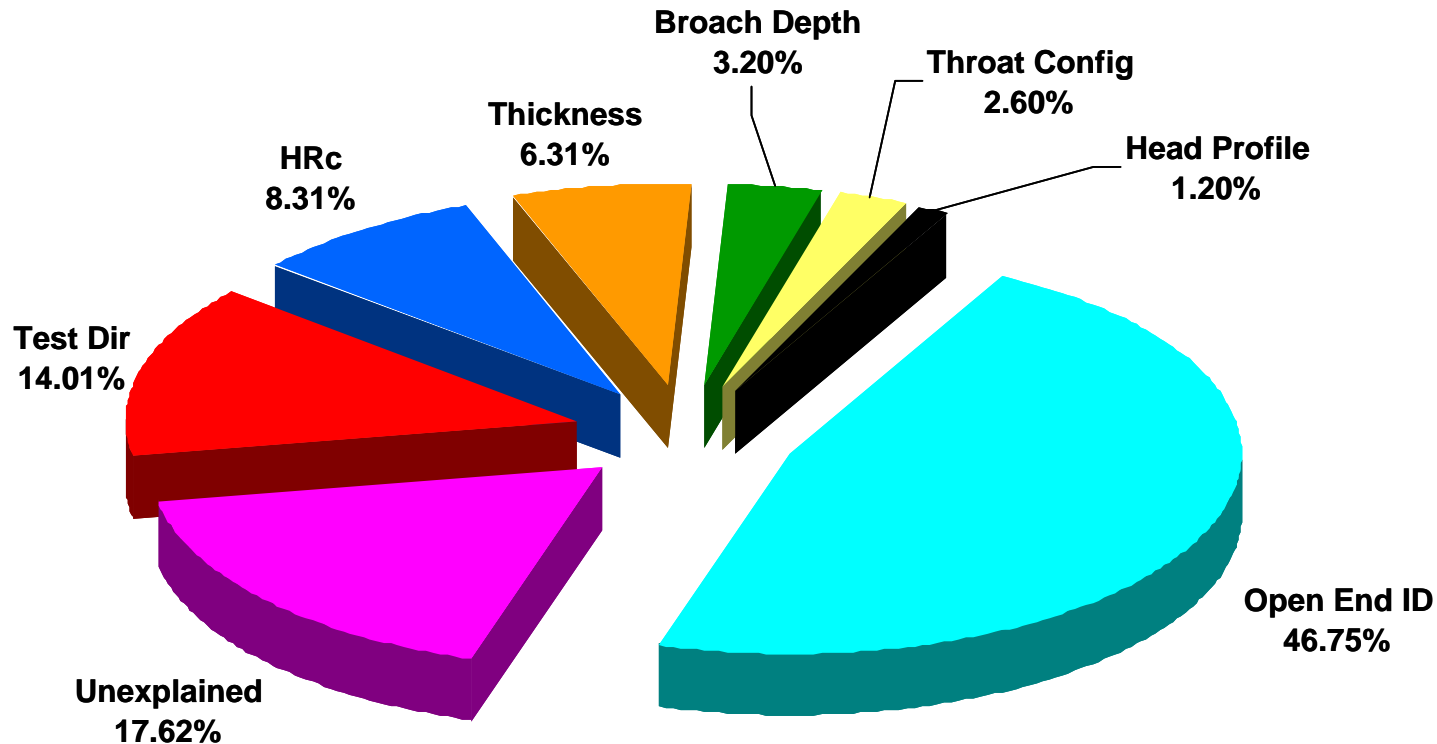
Analysis of Test Data

ANOVA test one relative importance related to permanent deformation.

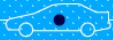




ANOVA Test Two Relative Importance Related to Failure Criteria

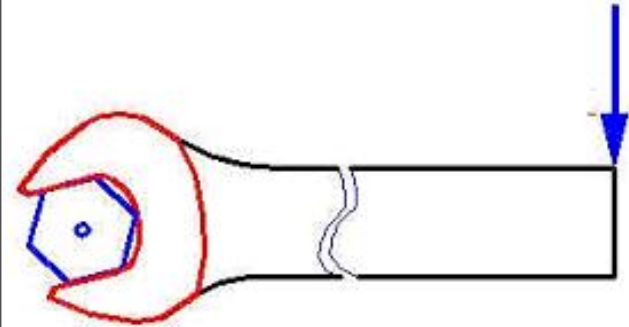
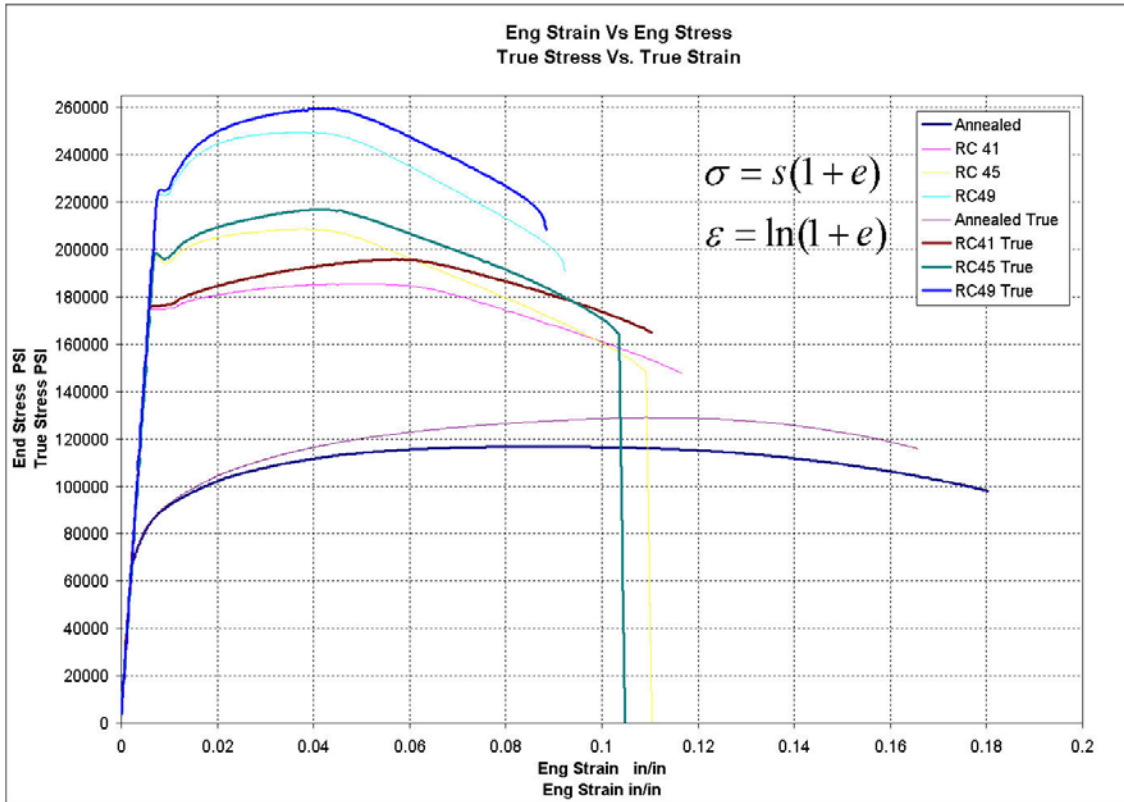


PRODUCT DEVELOPMENT CONFERENCE



Virtual Design of Experiment

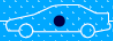
Material Properties/Initial Model



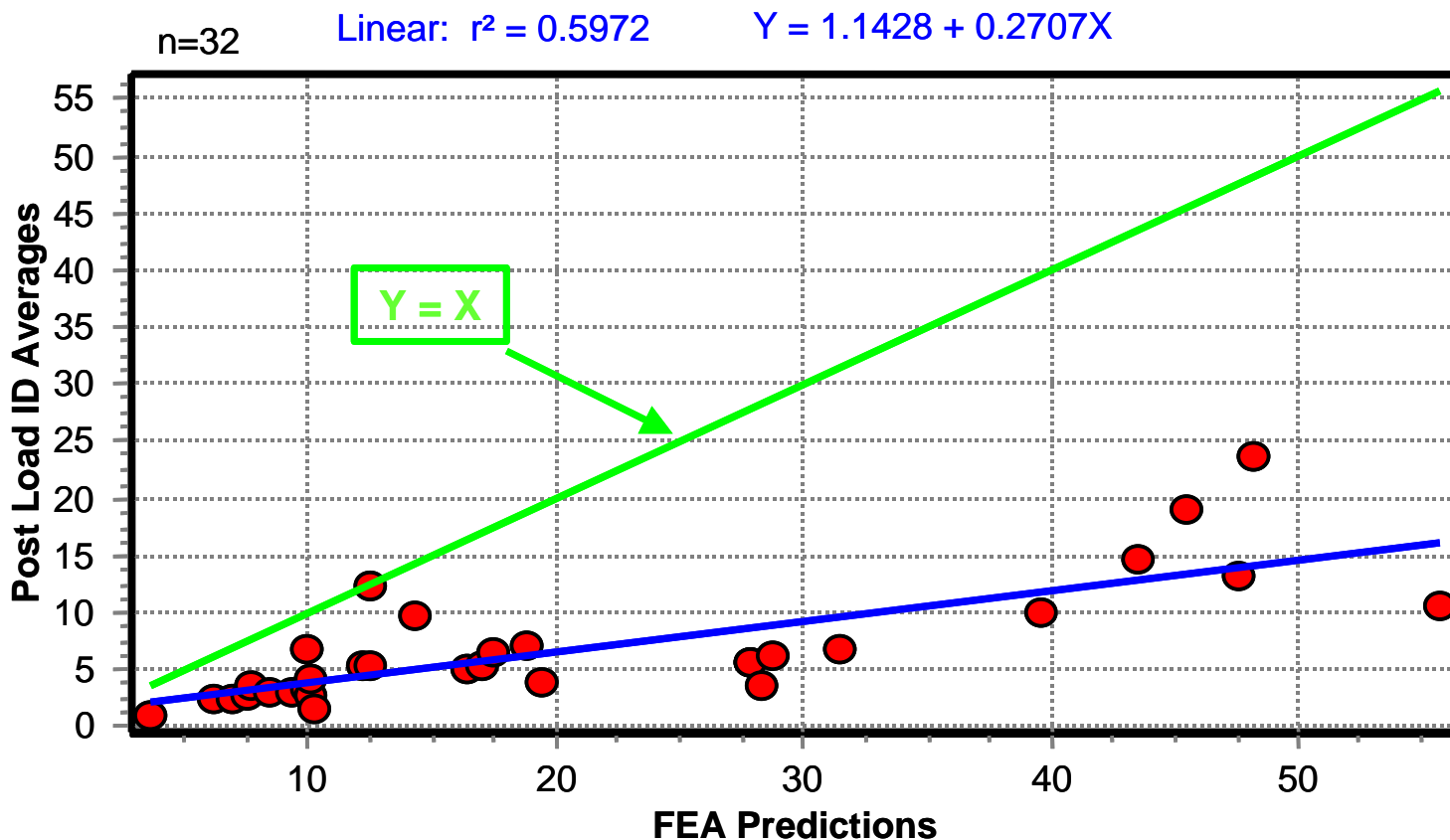
B.C.

Material

PRODUCT DEVELOPMENT CONFERENCE

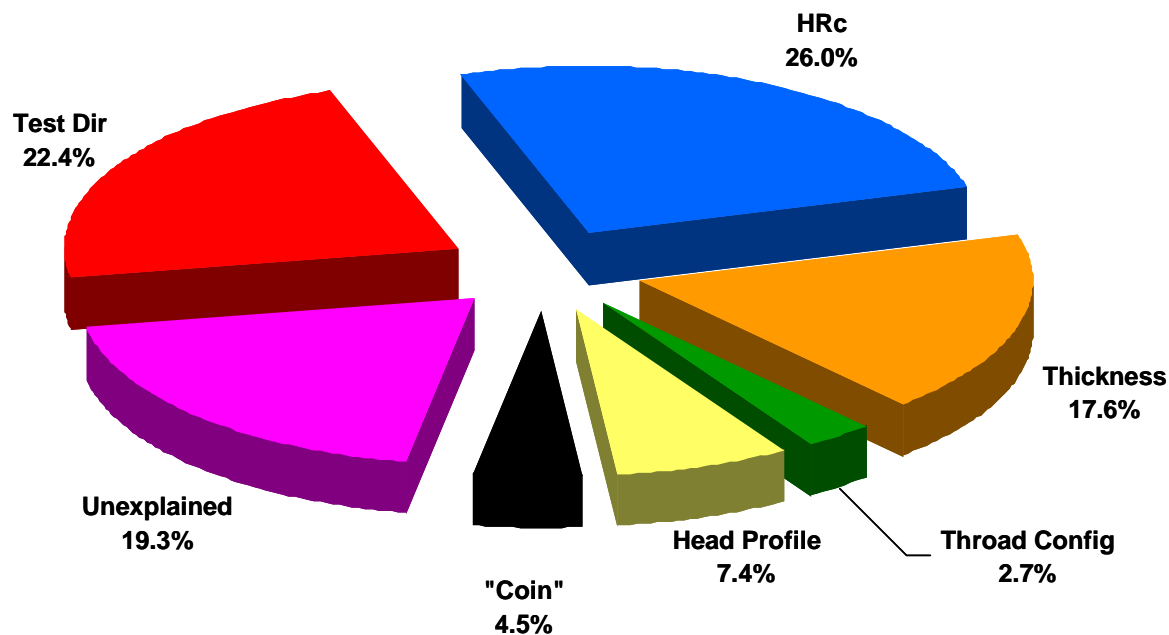


Correlation of Initial Results from Virtual DOE and Physical DOE





Ranking of Importance Factors

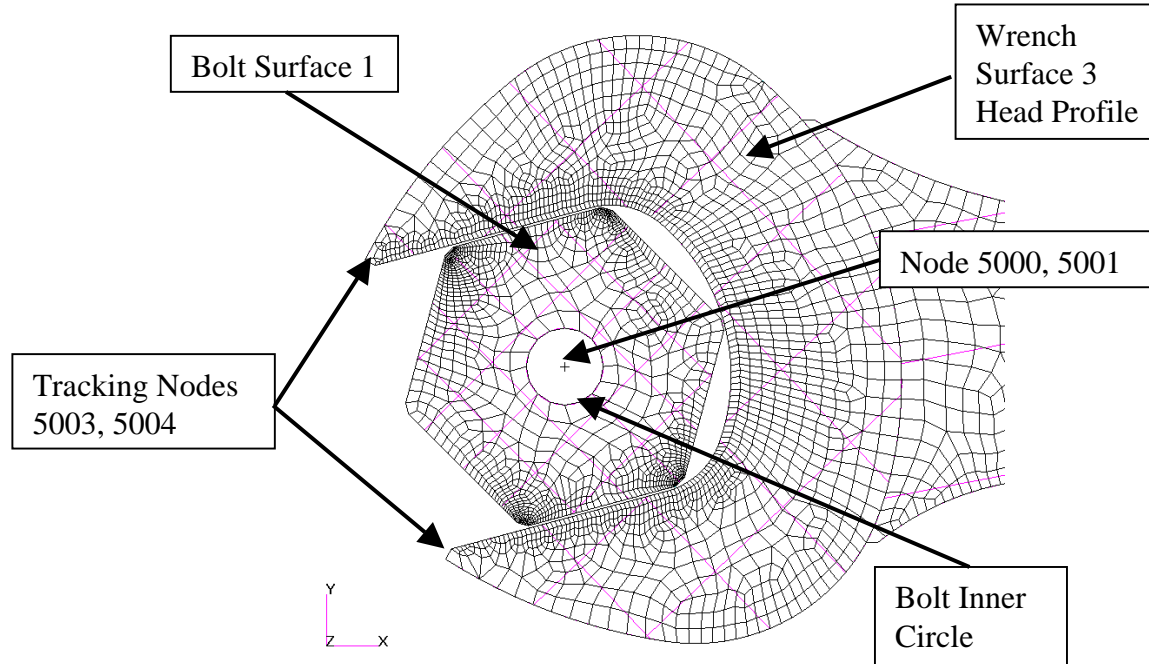


	Importance Rank	
	FEA	Physical DOE
Head Profile	4	6
Throat Config.	5	5
Hardness	1	2
Thickness	3	3
Test Direction	2	1



Virtual Design Of Experiment – Model Changes in MSC.Patran

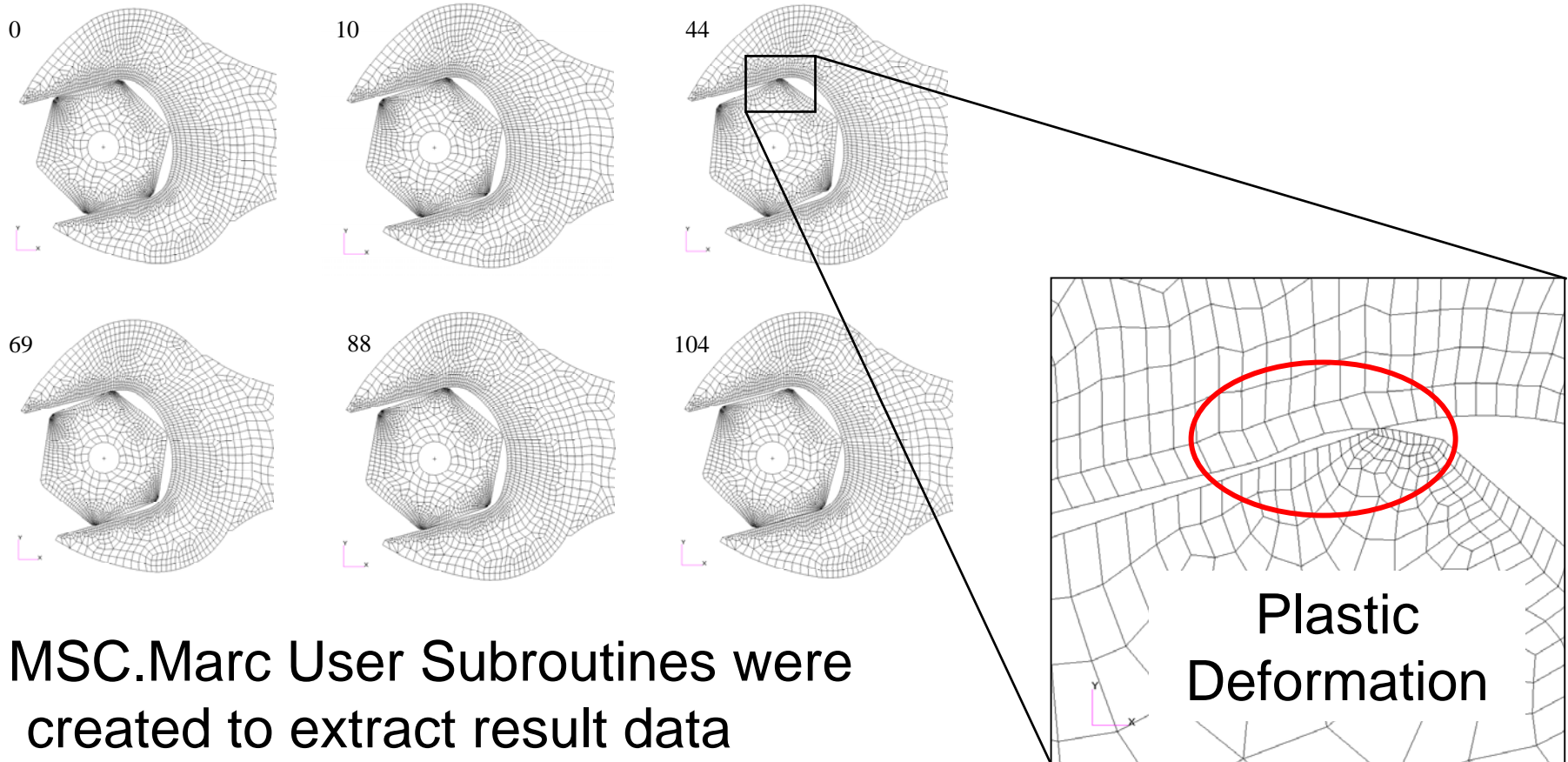
Fix End of Wrench and Applied Torque to Bolt



Addition of Friction to the Models



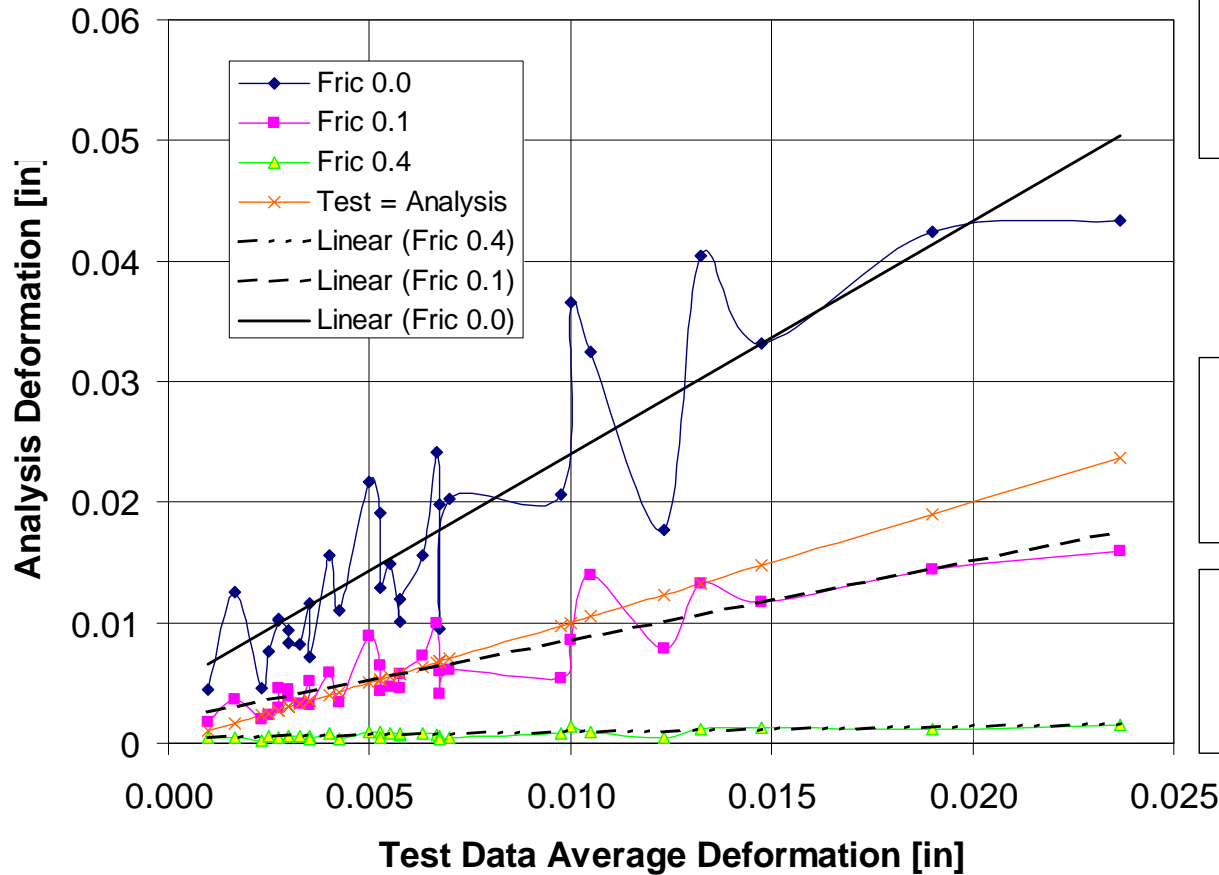
Results of Models



MSC.Marc User Subroutines were created to extract result data



Deformation Correlation Summary



Friction 0.0

$$y = 1.9319x + 0.0047$$

$$R^2 = 0.7868$$

Friction 0.1

$$y = 0.6578x + 0.002$$

$$R^2 = 0.7816$$

Friction 0.4

$$y = 0.0464x + 0.0004$$

$$R^2 = 0.5792$$



Conclusion

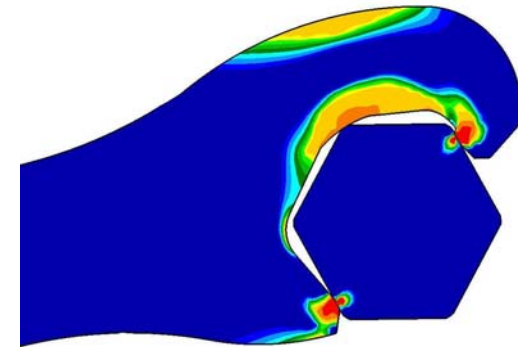
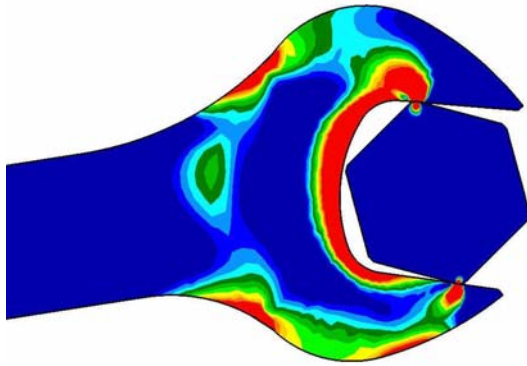
From the correlation of both the Physical and Virtual Design of Experiment, it was found that ranking each factor became important.

From this study, Danaher Tool Group was able to improve the product performance from 100% to 130% ASME standard.

Using MSC.Patran and MSC.Marc helped us develop a process to reduce future testing and the costs associated to testing, while still having confidence in our design.



The Virtual Design of Experiment Study using MSC products has Lead to a New Design in Open-End Wrenches – “The Claw”.



Offers higher torque applied to the fastener with little to no chance of stripping the corners of the bolt.

In other words, you will rip the bolt head off before the bolt head will strip!



Thank You