Engineering Specifications

Overview

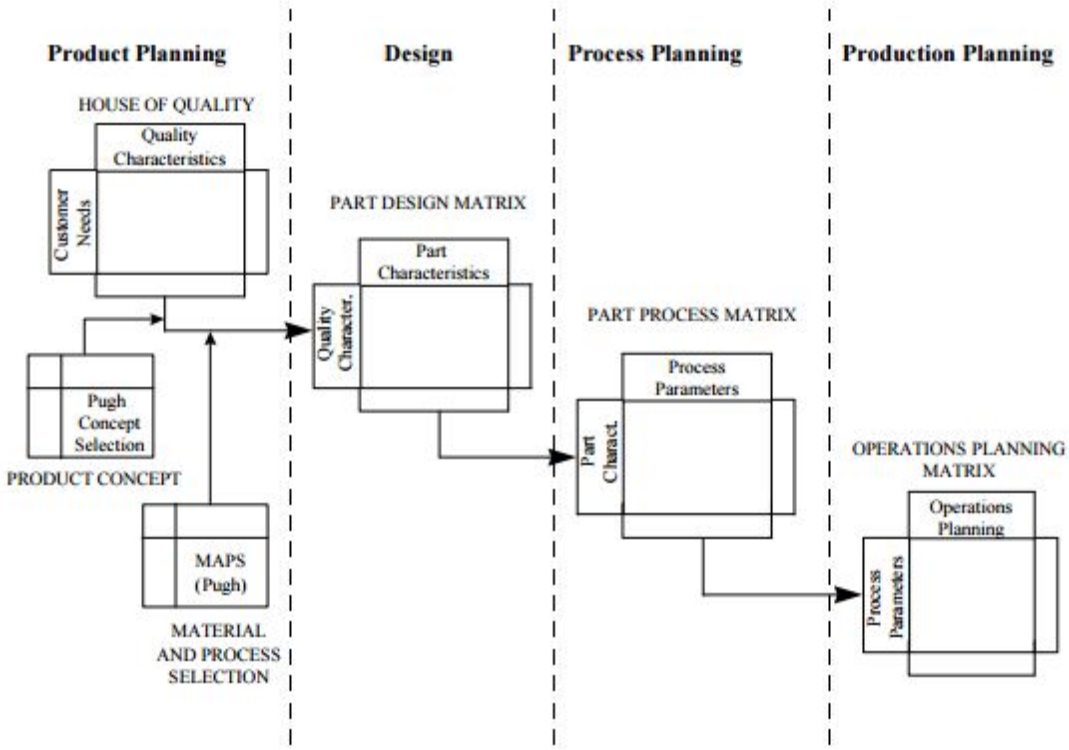


Figure : Houses of Quality incorporated for operations planning.

Quality Function Deployment (QFD) is a subsection of Quality Assurance used by engineers to connect priorities of interest between desired customer quality, quality characteristics, and process characteristics. Initially, this meant that an engineer would use a fishbone diagram with a quality as the “head” of the fish and relevant processes as the “bones”. However, a more intricate combination of multiple fishbone diagrams lead to the creation of a comprehensive matrix known as the house of quality. The house of quality interrelates multiple processes of quality characteristics and using a mathematical model. This mathematical model is formed by weighing the value of a quality based on client feedback, helping the engineer prioritize certain processes over other processes. This deciphering of client necessities, market research, and specialized benchmarking organizes data into a proper number of engineering design targets [3].

There are multiple houses of quality (figure above) used in sequence to develop the work cell production process from the end users paint requirements. The house of quality used in this report begins with the initial end user requirements and compares the target technological process to that of other leading automotive manufacturers. By properly engaging in market research the work cell design team can optimize the work cell requirements for the end user rather than the manufacturing client. This approach was selected rather the traditional paradigm due to the shift in the consumer electronics and software industry domain. Replicating the success of these other industries means creating end products that exemplify quality and are less prone to recalls, i.e. regressions.

Using the QFD process enables the work cell design to attain higher levels of client satisfaction, increasing the speed and efficiency of the work cell design process, and increasing profits are goals to achieve while improving current work cells and developing new work cells.

House of Quality

The first phase house of quality requires market research that is based by segregation of region, i.e. climate, terrain, and unique regulations per national regulatory bodies [1]. For the Canadian client, focus will be put on rust resistant applications, opacity of paint, coating layers, number of paint options, paint thickness levels, point paint thickness checks, safety of the paint work cell, etc.

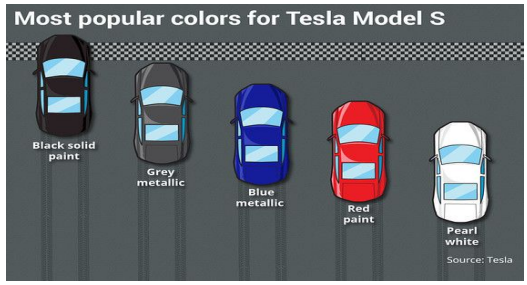


Figure : Pearlescent paints use iridescent pigments to create deeper colour and popularity chart indicating demand for paint colors is not equal.

There are three categories of paints that manufacturers use for various lines of vehicles. Solid paints have no sparkle effects except for the base color, most commonly used for industrial vehicles, ex. Heavy transportation vehicles, aircrafts, and construction equipment.

Part Design Characteristics

Please see the appendix for the relevant house of quality matrix

After the chassis is prepared by the previous work cell, the coating process is broken down by process, including a primer coat, base coat, mid coat (optional), and a clear coat [2]. The primer serves as a first coat and determines the leveling of paint as it fills in any gaps or indents in the chassis body, it is also the coat responsible for rust resistance, heat differences, deformities of the chassis, and UV lighting. The base coat is the source of color applied after the primer, this may contain a solid color with no sparkle effects or aluminum flakes for a metallic finish, or pearlescent paints, i.e. iridescent pigments. The clear coat is the final glossy finish that made to withstand UV light, abrasions, and hydrophobic for snow buildup resistance.

These segmentations of coating is the design characteristics optimized for when design the work cell, it functions to optimize what will be required and emphasized over the client targets and process requirements.

Process Operations

Please see the appendix for the chart

Timings were optimized in this tertiary level to the house of quality to establish machine parameters to optimize times for desired coat times, the calculations for these times are beyond the scope of this section and is instead incorporated in the material and paint process calculation section.

Production Planning Requirements

The production planning requirements are derived from the process operations characteristics and is provided by the manufacturing modelling specific guidelines. Based on targets acquired by the house of quality process we would recommend that the client choose appropriate suppliers from industry. As for the equipment, equipment from the major paint manufacturers need to correlate with the targets [2].

Automotive Paint Equipment Suppliers:

Taikisha
TKS Industrial (US subsidiary of Taikisha)
Durr
Eisenmann
FANUC

Works Cited

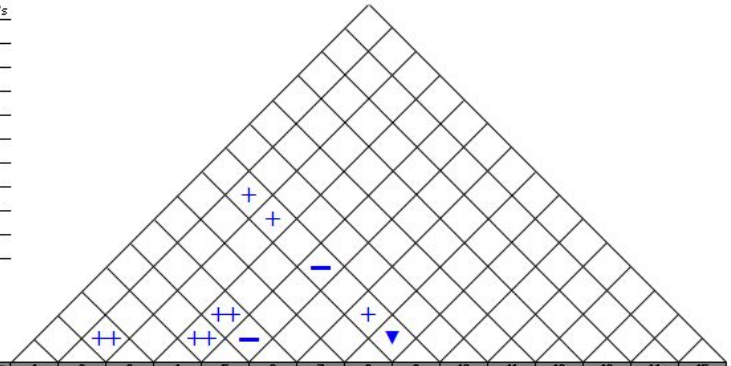
[1] “Custom Car Paint Colors - Auto Paint Colors Guide - TheCoatingStore,” *TheCoatingStore*. [Online]. Available: http://www.thecoatingstore.com/car-paint-colors/. [Accessed: 01-Dec-2016].

[2] H.-J. Streitberger and W. Kreis, *Automotive paints and coatings*. Weinheim: Wiley-VCH, 2008.

[3] M. Xie, T. N. Goh, and K. C. Tan, *Advanced QFD applications*. Chapter 2 Milwaukee, WI: ASQ Quality Press, 2003.

House of Quality - Voice of the Client

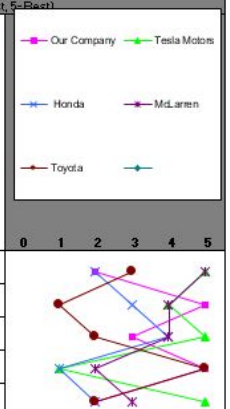
Title: Paint work cell, customer requirements vs functional req's
Author: Group 14
Date: 10/15/2016
Notes:



Legend

⊙	Strong Relationship	9
O	Moderate Relationship	3
▲	Weak Relationship	1
++	Strong Positive Correlation	
+	Positive Correlation	
−	Negative Correlation	
▼	Strong Negative Correlation	
▼	Objective Is To Minimize	
▲	Objective Is To Maximize	
X	Objective Is To Hit Target	

Rov #	Max Relationship Value in Rov	Relative Weight	Weight / Importance	Demanded Quality (a.k.a. "Customer Requirements" or "Whats") / Quality Characteristics (a.k.a. "Functional Requirements" or "Hows")	1 Multicoat (Pearlescant Coat)	2 Layer Thickness	3 Primer Strength	4 Weight	5 Volume	6 Base Color Coat	7 Consistancy	8 Hardness	9 Cost by Complete Coating Application	10 Paint coat density	11	12	13	14	15	Our Company	Tesla Motors	Honda	McLaren	Toyota	
				Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)	X	X	X	▲	▲	▲	▲	▼	▼	▲						**Competitive Analysis** (0=Worst, 5=Best)					
1	9	6.7	5.0	Clarity (no abberations or banding)		⊙	⊙				⊙									2	5	2	5	3	
2	9	13.3	10.0	Antirust Coating				▲	⊙	⊙	O									5	4	3	4	1	
3	9	33.3	25.0	Scratch Resistance (due to highway debris)								⊙								3	5	4	4	2	
4	9	26.7	20.0	Low Cost									⊙							5	1	1	2	5	
5	9	20.0	15.0	Colour Depth	⊙									O						2	5	2	3	2	
6																									
7																									
8																									
9																									
10																									
				Target or Limit Value	Pearlescent Coating	100 microns	10 microns	2 L	1 L	% aluminum composition	Point checks	4H (sample size)	$200	5 psi											
				Difficulty (0=Easy to Accomplish, 10=Extremely	5	7	5	2	3	5	8	6	3	3											
				Max Relationship Value in Column	9	9	9	1	9	9	9	9	9	3											
				Weight * Importance	180.0	60.0	60.0	13.3	120.0	120.0	100.0	300.0	240.0	60.0											
				Relative Weight	14.4	4.8	4.8	1.1	9.6	9.6	8.0	23.9	19.1	4.8											



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Part Design Characteristics

Title: Paint work cell - Functional Req's vs. Production Attributes
Author: Group 14
Date: 10/19/2016
Notes:

Legend
Strong Relationship 9
Moderate Relationship 3
Weak Relationship 1
Strong Positive Correlation
Positive Correlation
Negative Correlation
Strong Negative Correlation
Objective Is To Minimize
Objective Is To Maximize
Objective Is To Hit Target

Column # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)
Quality Characteristics (a.k.a. "Hows")
Demanded Quality (a.k.a. "Whats")
Row # | Max Relationship Value in Row | Relative Weight | Weight / Importance

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality (a.k.a. "Whats")	Total Coating Time	Heat Dry Temperature	Order of Coats	Length of Base + Mid Coat Time / Total Coating Time	Length of Primer Coat Time / Total Coating Time	Total Cure Time	Coating Shelf Life	Luminescance of Paint	Cost of Coat	Exposure to Air	Cost of Midcoat	Use of Pearlescent Coat	Separating Pearlescent Coat Mid Coat	Use of combo Base + Midcoat	Ratio of Aluminum flakes or Pearlescent Material to Base coat
1	9	14.4	180.0	Multicoat (Pearlescent Coat)															
2	3	4.8	60.0	Layer Thickness										○		◀			▼
3	1	4.8	60.0	Primer Strength										▼			▼		▼
4		1.1	13.3	Weight															
5	1	9.6	120.0	Volume	▼	◀													
6	9	9.6	120.0	Base Color Coat	⊙	⊙											○		
7	9	8.0	100.0	Consistancy	○	○	⊙	◀		○						○		⊙	
8	9	23.9	300.0	Hardness									⊙		○		▼		
9	9	19.1	240.0	Cost by Complete Coating Application															⊙
10	9	4.8	60.0	Paint coat density		⊙													
11																			
12																			
13																			
14																			
15																			
Target or Limit Value					1 hour	350 F - constant	Base coat followed by Primer	2 Minutes	30 Seconds	1 day	Manufacturer Recommended Shelf Life	Clarity and Hardness based	$150 per Chassis	4 hours	$50 per chassis			Best paint manufacturer by test	0.05
Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)					3	6	2	4	3	6	4	3	6	6	2	0	0	2	2
Max Relationship Value in Column					9	9	9	1	1	3	3	9	9	3	3	3	3	9	9
Weight / Importance					248.9	232.0	71.8	8.0	8.0	23.9	23.9	71.8	215.4	19.1	71.8	52.7	47.9	71.8	181.9
Relative Weight					17.7	20.7	5.1	0.6	0.6	1.7	1.7	5.1	15.3	1.4	5.1	3.7	3.4	5.1	12.9

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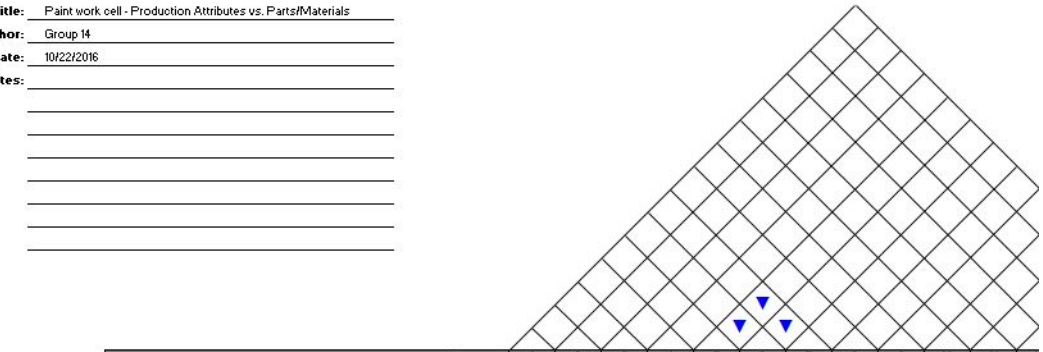
Process Operations

Title: Paint work cell - Production Attributes vs. Parts/Materials

Author: Group 14

Date: 10/22/2016

Notes:



	Column #	1	2	3	4	5	6	7	8	9	10	11	12
	Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)	x	▲	x	x	x	x	x	x	x	x	x	
Row #	**Demanded Quality** (a.k.a. "Whats") / **Quality Characteristics** (a.k.a. "Hows")	FANUC configuration	Robot Configuration Time	Base Coat Type	Primer Type	Metalic Coat Type	Pearlescant Coat Type	Mid Coat Type	Paint Quality Required	Spray Method Required	Color Type	Cure Time	
1	Total Coating Time	○	⊝										
2	Heat Dry Temperature	⊝											
3	Order of Coats		⊝										
4	Length of Base + Mid Coat TIme / Total Coating Time		⊝										
5	Length of Primer Coat TIme / Total Coating Time		⊝										
6	Total Cure Time												
7	Coating Shelf Life		○									⊝	
8	Luminecance of Paint			⊝	⊝	⊝	○	▲	○		⊝		
9	Cost of Coat							○					
10	Exposure to Air		▲							▲			
11	Cost of Midcoat												
12	Use of Pearlescant Coat						○	⊝					
13	Separating Pearlescant Coat Mid Coat					⊝						⊝	
14	Use of comobo Base + Midcoat					⊝	▲					▲	
15	Ratio of Aluminum flakes or Pealescant Material to Base coat		⊝										
	Target or Limit Value	Convection	6 months	Regular or Metallic or Pealescant	Hardness + Antirust Coating	Level of Luminance	Level of Irradiance	If selected	AAA	Electrocoating	Black and White by Demand	Based on Storage Space of Next cell	
	Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)												
	Max Relationship Value in Column	9	9	9	9	9	3	9	3	1	9	9	
	Weight / Importance	239.5	337.7	45.9	45.9	122.3	31.6	84.6	15.3	1.4	45.9	51.0	
	Relative Weight	23.5	33.1	4.5	4.5	12.0	3.1	8.3	1.5	0.1	4.5	5.0	

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality (a.k.a. "Whats")
1	9	17.7	248.9	Total Coating Time
2	9	20.7	292.0	Heat Dry Temperature
3	9	5.1	71.8	Order of Coats
4	9	0.6	8.0	Length of Base + Mid Coat TIme / Total Coating Time
5	9	0.6	8.0	Length of Primer Coat TIme / Total Coating Time
6		1.7	23.9	Total Cure Time
7	9	1.7	23.9	Coating Shelf Life
8	9	5.1	71.8	Luminecance of Paint
9	3	15.3	215.4	Cost of Coat
10	1	1.4	19.1	Exposure to Air
11		5.1	71.8	Cost of Midcoat
12	9	3.7	52.7	Use of Pearlescant Coat
13	9	3.4	47.9	Separating Pearlescant Coat Mid Coat
14	9	5.1	71.8	Use of comobo Base + Midcoat
15	9	12.9	181.9	Ratio of Aluminum flakes or Pealescant Material to Base coat