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Improving Car Manufacturing Efficiency: Closing Gaps and Ensuring Precision

Chirag Vinalbhai Shah[1] and Srinivas Naveen Dolu Surabhi[2]*

[1]Sr Vehicle Integration Engineer, USA

[2]Sr Software Engineer, USA

ABSTRACT

Manufacturing of an automobile consists of production and assembly of various individual components related to both on the interior and exterior of a vehicle. All these components are spatially related to each other hence making it a very complex procedure. Sometimes a variance in this spatial relationship can have a direct effect on both the appearance as well as the performance of the vehicle. As industry produces several thousands of units a day, minor defects like gaps and flushness between parts are generally neglected as it is very costly and time consuming to rectify them. This paper demonstrates the variance in each of the unit that is produced by taking five samples of same car built by the same manufacturer. This spatial variance maybe avoided by employing procedures like PPAP and other tools.

***Corresponding author**

Srinivas Naveen Dolu Surabhi, Sr Software Engineer, USA.

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Introduction

In all major markets and nations, the automotive industry's importance to economic growth and its effects on employment are evident. There are numerous components that make up an automobile are produced at multiple sites, either by the manufacturing facility itself or by other suppliers who provide the business with a variety of parts. The car is assembled at various stations within the plant or assembled at vendor location who are the official supply partners of the company. These many components are put together on the plant's assembly line. During the car assembly process, specific hardware teams/managers supervise the advancement of the vehicle by tracking its progress through the Vehicle Identification Number (VIN) assigned to each vehicle.

A car may appear to be fully functional after assembly, although this is not the case. The freshly constructed car is nevertheless unfit for use in this condition. For instance, virtually always when fixing tires on the assembly line, the tires are not precisely aligned and are simply adjusted by tightening the nuts. So, modifications are done to withstand certain situations and harsh environments. Aligning the tire is a crucial process to prevent incorrect and off-track vehicle movement, ensuring the car travels in the correct direction once the steering is properly calibrated. Following assembly, these types of fittings are expected to be needed in practically all vehicle components, simple and complicated alike. A defective car may not only result in repeated failures which sometimes prove fatal to drivers.

Car bodywork is under more demands than ever before, both technically and in terms of design. Therefore, a prospective buyer's eye can quickly spot physical faults such uneven gaps and flushness. Typically, hand feeler gauges are used for gap and flushness assessment, which is time-consuming, incorrect, and expensive. A bigger inaccuracy in Gap and Flushness affects the vehicle's aerodynamic performance in addition to being an aesthetic fault because of the irregularity achieved, deteriorating the fuel efficiency. Following assembly, quality control is needed to make a vehicle usable and to correct flaws. Manufacturing flaws are easily detectable with a well implemented quality checking method (both physical and technical). The plant managers ensure the vehicles at the end of the line meet all quality checks and standards and ensure they are not having any dents or damages to the exterior or interior, ensure the car works as expected.

Objective

Our aim is to collect the data samples of gaps present between bumper and fender of a car and analyse the data. We collected a sample of data from five similar cars at three different points as show in Figure 1&2. The figures show the gaps present between bumper and fender at three different locations where measurements are taken from.

Figure 1: Gap Present between Bumper and Fender on Left-Hand Side

Figure 2: Gap Present between Bumper and Fender on Right-Hand Side

Manufacturing Inspections and Defects

The following are a few of the checks that are performed as part of the vehicle quality control process to look for problems in a constructed vehicle, and they are shown in Table 1.

Table 1: Various Defects in an Automobile

S.NO	Inspection	Defects
1	Interior	Parts fitting/gaps, mismatch of parts
2	Exterior	Parts gaps, flushness, mismatch Alignment Scratches looseness
3	Paint	Dents Lints Air bubbles Dust Tool marks Missing paint Colour mismatch
4	functions	Lights Door function Locking system
5	Engine room	Fitting of engine parts Oil leakage
6	Physical functions	Steering wheel angle Indicators Speedometer readings
7	Car wash test	Color degradation

Data Collection and Analysis

A sample of data is collected from five similar cars (Kia Forte GT) from LaFontaina Kia at Dearborn dealership. We measured the gaps with the help of Vernier calipers at three different locations on either side of the car. These values were collected by three different people at three different locations.

Table 2: Acceptable Limits

Place	Defect Type	Acceptable Limit
Body Panel Gaps	GAP	upto 1 mm

Experimental Data Samples on Left-Hand Side

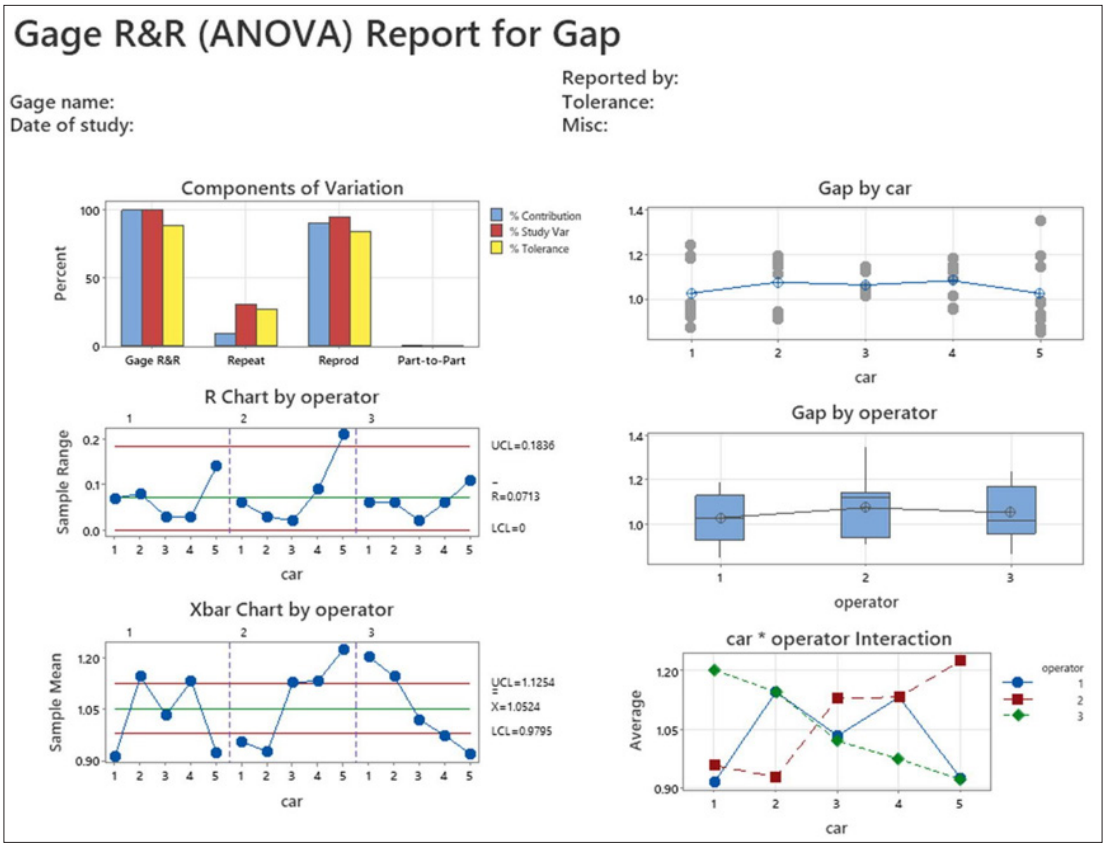
The values of the gaps between the bumper and the fender at left-hand side are displayed in table 3. This information is a sample of data obtained from measurements made of five cars at three separate sites by three different operators.

Table 3: Data Samples of Gaps on LHS

S.No	Car	Operator	Gap	S.No	Car	Opera tor	Gap	S.no	Car	Operator	Gap
1	5	3	0.91	16	4	1	1.12	31	2	2	0.93
2	5	3	0.87	17	4	1	1.13	32	2	2	0.94
3	5	3	0.98	18	4	1	1.15	33	2	2	0.91
4	5	2	1.19	19	3	3	1.01	34	2	1	1.11
5	5	2	1.14	20	3	3	1.02	35	2	1	1.19
6	5	2	1.35	21	3	3	1.03	36	2	1	1.14
7	5	1	0.93	22	3	2	1.12	37	1	3	1.18
8	5	1	0.99	23	3	2	1.13	38	1	3	1.24
9	5	1	0.85	24	3	2	1.14	39	1	3	1.19
10	4	3	0.96	25	3	1	1.03	40	1	2	0.92
11	4	3	0.95	26	3	1	1.02	41	1	2	0.98
12	4	3	1.01	27	3	1	1.05	42	1	2	0.97
13	4	2	1.18	28	2	3	1.11	43	1	1	0.87
14	4	2	1.13	29	2	3	1.17	44	1	1	0.93
15	4	2	1.09	30	2	3	1.16	45	1	1	0.94

Gauge Reproducibility and Repeatability Test

Below is the Gauge Repeatability and Reproducibility (GR&R) test for a car used to assess the consistency and reliability of measurement instruments or gauges used in the automotive industry. This test involves measuring the same parts multiple times with the same gauge (repeatability) and with different operators using the same gauge (reproducibility).

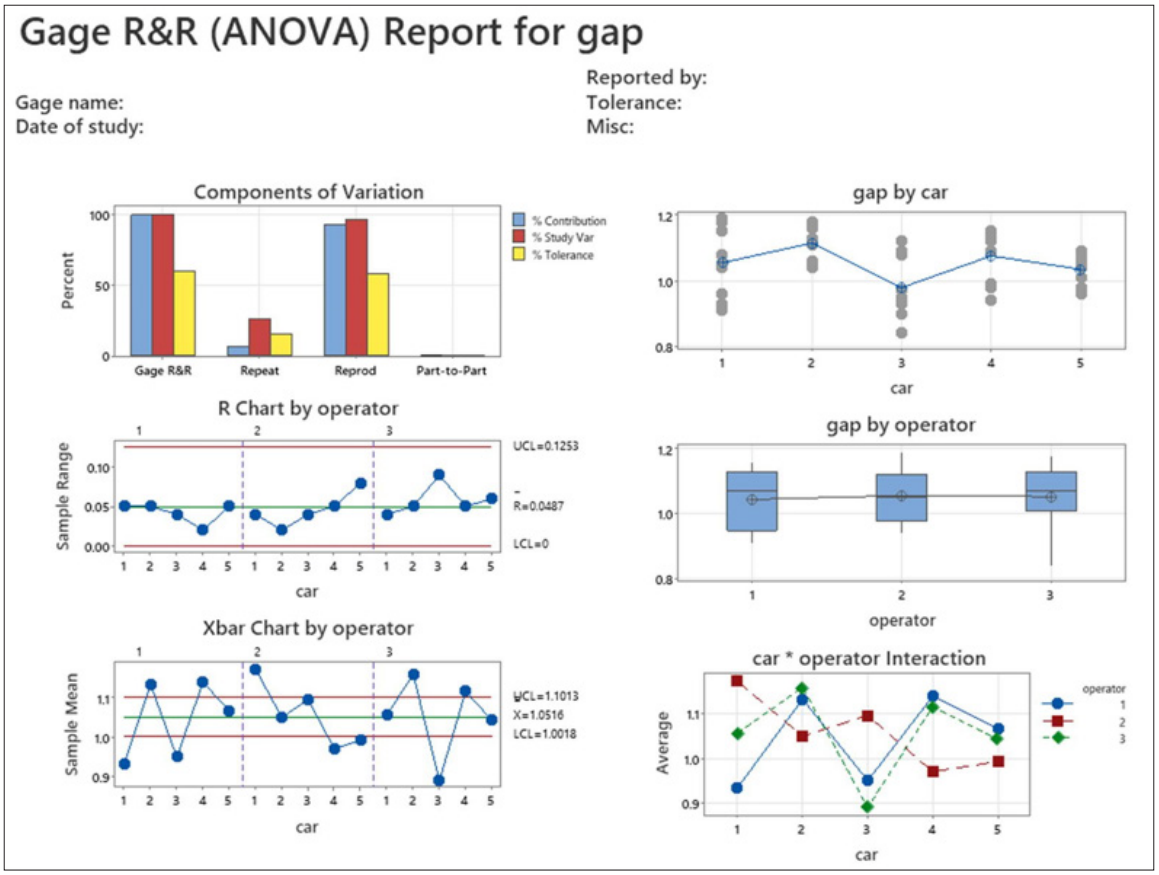


Experimental Data Samples on Right-Hand Side

The values of the gaps between the bumper and the fender at right-hand side are displayed in table 3. This information is a sample of data obtained from measurements made of five cars at three separate sites by three different operators [1-17].

Table 4: Data Samples of Gaps on RHS

S.No	Car	Operator	Gap	S.No	Car	Opera tor	Gap	S.No	Car	Operator	Gap
1	5	3	1.01	16	4	1	1.14	31	2	2	1.04
2	5	3	1.05	17	4	1	1.15	32	2	2	1.06
3	5	3	1.07	18	4	1	1.13	33	2	2	1.05
4	5	2	0.98	19	3	3	0.84	34	2	1	1.11
5	5	2	1.04	20	3	3	0.90	35	2	1	1.13
6	5	2	0.96	21	3	3	0.93	36	2	1	1.16
7	5	1	1.04	22	3	2	1.12	37	1	3	1.08
8	5	1	1.09	23	3	2	1.08	38	1	3	1.05
9	5	1	1.07	24	3	2	1.09	39	1	3	1.04
10	4	3	1.12	25	3	1	0.97	40	1	2	1.15
11	4	3	1.09	26	3	1	0.93	41	1	2	1.18
12	4	3	1.14	27	3	1	0.95	42	1	2	1.19
13	4	2	0.98	28	2	3	1.13	43	1	1	0.91
14	4	2	0.94	29	2	3	1.17	44	1	1	0.93
15	4	2	0.99	30	2	3	1.18	45	1	1	0.96



Results and Discussion

The data was physically collected from five cars made by the same manufacturer. The graphs and hypothesis tests created in Minitab using tools like Gage R&R clearly show a deviation from the accepted norms.

In hypothesis testing, null hypothesis is taken as $\mu=1$ and alternative hypothesis $\mu > 1$, and we can clearly see at 95% confidence interval, values fall between (1.0177, 1.0872) for left-hand side and (1.0249, 1.0782) on right hand side.

However, it is typical for this type of problem to be present in most automobiles manufactured in the sector. This issue can be avoided by employing procedures like PPAP and other tools.

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