

INDIAN STATISTICAL INSTITUTE
SQC & OR Unit, Hyderabad

MS in Quality Management Science: 2015 -17

III SEMESTER: FINAL EXAMINATION

**Subject: SIX SIGMA-BUSINESS EXCELLENCE STRATEGY
& PROBLEM SOLVING FRAMEWORK (SSBE)**

Date: 11 November 2016

Duration: 3 Hours

Max. Marks: 100

INSTRUCTIONS

This paper contains questions for 125 marks. Answer as many as you can but the maximum you can score is 100 marks. You will also be given soft copy of this question paper for using data for analysis. You are free to use appropriate statistical software for analysis but the answers will have to be given in the normal answer sheet (Hard copy) given to you. Question - 3 is compulsory. You may provide graphs/charts/diagrams etc. (if any) on the soft answer booklet [word file: Final Exam Answer Booklet (Student name).doc] by clearly writing your name on the answer sheet as well as on the soft copy and submit before the end of the examination without fail.

1. State whether the following statements are correct or wrong with justification for your answer briefly.

(10x2 = 20 Marks)

- a) Value Stream Mapping (VSM) is a technique used to effectively map complex process where the process steps add high value to the product.
- b) Simple Problem Solving tools such as Pareto Analysis, C&E diagram etc. are useful only for seeking solution to simple process problems.
- c) The probability distribution of a sample of observations drawn from a population is known as sampling distribution.
- d) As per central limit theorem sample averages follow normal distribution irrespective of the population distribution and is independent of sample size.
- e) In Analyze phase the need for Inferential Statistics (Estimation, TOH etc.) is because the BB/GB cannot identify the root causes using his domain knowledge.
- f) Chi Square test is the most appropriate test when we are testing for equality of more than two population proportions or establishing associations.
- g) Nonparametric tests are more efficient than the parametric methods when the sample sizes are small.

- h) Design and Analysis of Experiments (DOE) are required in Six Sigma when the Black Belt fails to identify any potential root causes in analyze phase.
- i) In the application of regression analysis when R^2 value is above 0.8 (80%) then the variables are definite causes (X's) of the response (effect).
- j) Statistical Process Control (Control Charts) are only required in control phase of any Six Sigma project to monitor the input process variables.

2. The QC manager of a mobile phone manufacturer "Samking" wanted to know whether all the 5 QC inspectors are equally good at final checking of the mobile phone as accepted or defective for further inspection as the company is facing a problem of higher customer complaints. He selected 5 phones and without the knowledge of the inspectors asked them to inspect 5 attributes. The chief inspector was asked to provide the standard status. The following table gives the inspection results along with the standard.

Sl. No	Mobile Phone	Inspector	Result	Standard	Sl. No	Mobile Phone	Inspector	Result	Standard
1	MP1	Inspector A	A	A	15	MP3	Inspector B	A	A
2	MP2	Inspector A	D	D	16	MP1	Inspector B	A	A
3	MP3	Inspector A	A	A	17	MP2	Inspector B	D	D
4	MP1	Inspector A	A	A	18	MP3	Inspector B	A	A
5	MP2	Inspector A	A	D	19	MP1	Inspector C	A	A
6	MP3	Inspector A	A	A	20	MP2	Inspector C	A	D
7	MP1	Inspector A	A	A	21	MP3	Inspector C	A	A
8	MP2	Inspector A	D	D	22	MP1	Inspector C	A	A
9	MP3	Inspector A	A	A	23	MP2	Inspector C	D	D
10	MP1	Inspector B	A	A	24	MP3	Inspector C	A	A
11	MP2	Inspector B	D	D	25	MP1	Inspector C	A	A
12	MP3	Inspector B	A	A	26	MP2	Inspector C	A	D
13	MP1	Inspector B	A	A	27	MP3	Inspector C	A	A
14	MP2	Inspector B	D	D					

Perform suitable analysis and suggest which inspector(s) need to be trained and on which attribute.

(20 Marks)

- Identify 15 important Six Sigma tools and techniques, 3 each for the five (DMAIC) phases of Six Sigma. Similarly list down three important activities/steps in each of the DMAIC steps. Map each of the 15 techniques with each of the 15 activities/steps in order of their applicability. You can use the following notation;

NA - Not applicable,
 CA - Can be applied and
 HA - Highly applicable.

(15 Marks)

- You are working with "Quality Cab" a multinational company which provides cabs using GPS based mobile application. As the GPS based cab services are relatively new the CEO of the company is very keen to understand the customer requirements well to design the cab services so that the company can become the best service provider in the country. Presently there are two more similar cab service providers ALO cabs and BEUR Cabs. The most important CTQ is response time and the specifications are Target 10 minutes with upper and lower specifications of 15 and 5 minutes respectively. The company provided you with the following data and asked you to provide useful inference and action plan.

(20 Marks)

Cab Data - 1

Different types of complaints the customers using the Quality Cab Services	
Accidents	2
Cab Maintenance	152
Head Light not working	3
Rash Driving	50
Driver not familiar with the routes	76
Higher cab charges	9
Breakdowns	7
Delayed Arrival	43
Driver Behaviour	70
Driving without proper documents	8
Sudden Cancellations	80

Cab Data - 2

Sl.No	Cab Request Time	Response Time in Minutes	Cab Type	Sl.No	Cab Request Time	Response Time in Minutes	Cab Type
1	12:00 AM	14.1	Big	21	12:15 PM	9.2	Small
2	12:15 AM	8.9	Big	22	12:30 PM	5.9	Big
3	12:30 AM	10.2	Small	23	12:45 PM	9.2	Small
4	12:45 AM	9.8	Small	24	1:00 PM	8.4	Big
5	1:00 AM	10.7	Big	25	1:15 PM	9.3	Big
6	1:15 AM	11.3	Small	26	1:30 PM	11.4	Big
7	1:30 AM	6.6	Big	27	1:45 PM	6.8	Small
8	1:45 AM	12.1	Big	28	2:00 PM	12.7	Big
9	2:00 AM	10.5	Small	29	2:15 PM	9.9	Small
10	2:15 AM	5.3	Small	30	2:30 PM	15	Small
11	2:30 AM	5.4	Small	31	2:45 PM	10.3	Small
12	2:45 AM	5.6	Big	32	3:00 PM	7.6	Small
13	3:00 AM	13.8	Big	33	3:15 PM	13	Big
14	3:15 AM	6.8	Small	34	3:30 PM	12.1	Small
15	3:30 AM	12	Big	35	3:45 PM	7.2	Big
16	3:45 AM	6.1	Big	36	4:00 PM	9.5	Big
17	4:00 AM	9.7	Big	37	4:15 PM	13.5	Small
18	4:15 AM	9.8	Big	38	4:30 PM	8.6	Big
19	4:30 AM	12.1	Big	39	4:45 PM	9.8	Small
20	4:45 AM	9.3	Small	40	5:00 PM	10.6	Small

5. In a tire manufacturing, the quality of tire compound (a mixture of natural and synthetic rubbers, process oils, carbon black, pigments, antioxidants, accelerators and other additives) plays a very important role as it is used to make different components of tire. The quality of the compound determines various functional characteristics of the tire in actual usage and as well as during manufacturing of the components in meeting the component specific requirements. Due to this significant role every compound lot that is produced is tested for various quality characteristics on an equipment/instrument called Mooney Viscometer. The quality characteristics tested on Mooney Viscometer are Mooney Viscosity also known as MV at ML (Melting at Low temperature) and Mooney Scorch (MS). Among these two properties, MV is tested for every batch of the compound that is produced and whereas MS is tested only for few batches as the test is time consuming. Usually, about 1800 batches of compound are produced daily on 5 Banburys (compound making machines).

As MS determines the compound processing ability at subsequent stages, the production department would like to get these tests done more frequently than present for better controllability. However, if the periodicity needs to be increased additional testing equipment(s) need to be procured which calls for a capital investment. The current practice of testing is to test MV followed by changing the settings to test the MS due to its different and higher testing temperature.

With this back drop, it was thought necessary to develop an accelerated test condition for MV at the same temperature as that of MS so that the setting time can be saved and as well as increase in productivity due to reduced testing time for MV. Further the time saved can be utilized to increase the number of samples of MS as desired by the production.

Imagine that you have been entrusted as a Project Team Leader with the job of developing an accelerated test procedure for MV so that uniformity in testing conditions can be adopted for MV and MS. With this back drop, answer the following:

- a) Make a suitable project charter.
- b) Identify the customers in this scenario and list the VOC for each customer.
- c) Carryout Kano Analysis for identified VOC.

Further, as the MS is tested at 127°C and the normal test condition for MV is 100°C it is decided to develop a suitable test procedure at 127°C which will enable the MV to be tested in lesser time due to faster melting. The current procedure for MV is to keep every compound sample for 1 minute stabilization and 4 minutes to test at 100°C.

So your team has decided to conduct the study and collect the data in the following manner.

Data Collection:

- 8 adjacent samples collected from same batch.
- Two samples tested under each test condition:
 1. MV(1+4)@100°C
 2. MV(1+1)@127°C
 3. MV(1+1.5)@127°C
 4. MV(1+2)@127°C
- Test repeated for different batches.
- Data collected on various compound batches.

Sample Preparation:

Big sample from each batch (preferably from a batch with good consistency) of 4 to 6 batches of every final compound code were collected from freshly mixed compound. In the case of the compounds which are not mixed for more than 3 or 6 batches, only 2 or 3 batches sample were collected for this experiment.

As four test conditions were decided for this experiment, two samples for each condition were prepared from each batch sample with same test sample weight.

A particular Mooney viscometer was selected for this testing to eliminate variability due to various instruments. Large rotor was used in the instrument for this testing.

All the samples were tested according to the plan under different test conditions and results were recorded. **The summarized data is given in the table below for compounds used for one important tire component called Tread.**

- d) Carryout appropriate analysis to find the best new test condition among the three that will test results close to the existing test condition.
- e) Develop a calibration equation to know the MV value at the existing given the best new condition value.

- f) Arrive at the specification for your best new condition if the specification for this compound is in the existing condition for MV is 56-68
- g) Develop a control plan that need to be implemented for achieving consistent readings under the new condition.

(5+5+5+10+10+5+10 = 50 Marks)

COMPOUND	Sample	TEST CONDITION			
		NEW	NEW	NEW	EXISTING
		ML 1+1 @127°C	ML 1+1.5 @127°C	ML 1+2 @127°C	ML 1+4 @100°C
A	1	61.5	59.4	56	61.5
A	2	63	59.1	57.3	63.3
A	1	61.8	59.8	56.9	62.1
A	2	61.7	58.4	57.1	62
A	1	63.1	59.9	57.8	63.6
A	2	61.6	58.2	57.2	62.1
B	1	61.9	58.1	55.3	61.5
B	2	60.6	58	55.3	61.3
B	1	58.4	55.2	53.3	59.1
B	2	60.8	56.8	54.9	60.8
B	1	58.9	55.3	54.3	59.1
B	2	61.5	58.1	55.1	61.5
B	1	60.5	57.1	54.5	61.6
B	2	58.3	55.7	53.8	59.1
B	1	60.9	55.9	55.2	60.8
B	2	58.6	56	53.6	59.1
C	1	54	53.8	51.5	56.4
C	2	54.1	56	53.3	58.2
C	1	55.2	54.8	52.3	57.1
C	2	54.1	54	51.5	56.5
C	1	55.6	56.3	53.8	58
C	2	54.4	54.7	52.4	57.1