INDIAN STATISTICAL INSTITUTE
SQC & OR Unit, Hyderabad

MS in Quality Management Science: 2014-16
III SEMESTER: FINAL EXAMINATION

Subject: Trouble Shooting and Problem Solving for Quality Improvement (TPQI)

Date: 19 October 2015 **Duration: 3 Hours** **Max. Marks: 100**

INSTRUCTIONS

This paper contains questions for 130 marks. Answer as many as you can but the maximum you can score is 100 marks. You will also be given a data sheet in excel format for Question 4 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 answer sheet given to you. Also you need to submit the soft copy of your analysis if any, only in a word file format opened in your name before the end of the examination without fail.

1. A company regularly receives Crank shafts from a vendor in lots and it is mandatory for the vendor to attach the process capability analysis report for each lot sent giving Cp and Cpk indices. It is required for the vendor to supply in lots with Cpk ≥ 1.33. The specifications for one of the dimensions i.e; shaft diameter is 100 ± 2 mm. The company periodically, on receipt of the lot, checks for the conformance of the capability indices to the requirement of Cpk ≥ 1.33 by taking a suitable sample from the lot and often finds that the supplier claim of meeting the Cpk ≥ 1.33 is not correct. In this situation, the Quality Manager has asked you as a Quality Engineer to explore the reasons at company's end in getting the different Cpk values than the value declared by the vendor and outline a systematic approach to resolve the problem. Further you have been asked to specify the required size of the sample to be taken from the lot to estimate the standard deviation with a margin of error ± 0.05.

(20 marks)

2. A soft drink bottling company uses pet bottles for the filling of soft drink in capacities of 250 ml, 500 ml and 1000 ml. Fill volume is an important characteristic in view of the stringent requirements of Packaging commodities act as the fill volume cannot be less than 5% of specified volume and failure to comply attracts severe penalty to a tune of 5 lakhs with every incidence of detection in the open market. In view of this, the company adopts various QA/QC procedures to ensure consistency of the fill volumes. Filling is a high speed with an output of 100 bottles per minute and a set-up dominant operation involving multiple filling stations in the machine. With this in the background, briefly answer the following (in not more than 15 lines for each).

    a) The relevance of Juran's Control and Breakthrough approach for the characteristic of fill volume as the estimated Cpk is only 1.
    b) Steps to adopt PDCA/PDSA cycle approach for problem solving to improve the fill volume consistency and identify different problem solving/statistical tools you would be using in each step of PDCA/PDSA cycle.

c) Would you be requiring any additional or different tools/techniques if you have decided to use the 8D problem solving methodology as against PDCA/PDSA cycle approach. Suitably justify your answer.

d) Obviously the company needs to put efforts on regular basis and hence costs to ensure fill volume as per the requirements. Identify all the associated quality costs in this operation and classify them in to different categories of quality costs mentioning at least two aspects of costs in each category.

(30 marks)

3. In a study to develop a prediction model for surface roughness in turning process, data has been collected from the numerous laboratory trials carried out on the following process variables viz; Spindle speed, Feed rate, Depth of cut and Nose radius for 4 different materials. The combinations with multiple repetitions can broadly be summarized into the following table.

Levels	Spindle speed (rpm) (A)	Feed (mm/rev) (B)	Depth of cut (mm) (C)	Nose Radius (mm) (D)	Work Piece Material (E)
1	112	0.063	0.1	0.6	EN – 8
2	180	0.1	0.2	0.8	EN – 19
3	450	0.125	0.3	1	EN – 24
4	710	0.160	0.4	1.2	EN - 36

Surface Roughness is the response that is measured and in all about 1250 sets of observations available for several of the above combinations. The objective is to develop a single prediction model that will take care of different situations in the above range of the variables including the materials.

a) With this backdrop give a step by step approach that need to be adopted in building the prediction model for the surface roughness.

b) What kind of important (maximum of 5) checks that will be necessary for checking the adequacy of the model. Give brief justifications for using such checks.

c) What kind of important measures/statistics will give the existence or otherwise the outliers in the data. Give their role in influencing the model adequacy.

d) How will you judge the predictability of the equation and give the appropriate measures you will be considering with brief justification.

e) If the surface roughness is qualitatively categorized as against the actual measurement, will your model developed continue to be useful or any change in approach will be necessary in model building. If so, give a brief justification.

(30 marks)

4. Carefully read the following case study on “Optimization of Tinter quantities of Paint” and answer the questions given with appropriate analysis of the data wherever required. The data is given as an MS Excel file “Tinter Optimization Experiment Data.xls”

BACKGROUND

Tinters are used as colourants in the manufacture of different grades of paints. Generally two or more tinters are used as a combination to get the required shade. The plant R&D provides the tinter formulation to the manufacturing. As per the practice the R&D has given a new formulation for a shade namely TSD Asian Green. As this formulation is to be tried out for the first time in the manufacture, a decision has to be taken on the quantities of the tinters to be changed when the required shade is not achieved. It was felt that the developmental trials could be minimized through a scientifically designed experimental approach while simultaneously getting a reproducible result. It is also to be kept in mind the consumption of different tinters while arriving at the optimal conditions, as this increases the overall manufacturing cost.

In this TSD Asian Green shade there are three tinters used viz., CCL Green, W.T.Yellow Oxide (YO) and CCL Blue among which CCL Blue being the costliest, followed by CCL Green and W.T.Yellow Oxide. But the basic quantities required to get the shade are more for CCL Green followed by W.T.Yellow Oxide and least for CCL Blue.

THE PROCESS (Given only for a quick understanding)

Paint is a colloidal mixture of pigments and suitable binders. The materials that are used in this process are pigments, extenders, additives, solvents and binders. The general processing is dispersion of the powdered material in liquid phase.

A thickener solution is taken in a pug mixer and dispersing agents are added to it. Then all the powdered pigments, extenders and other ingredients are added to this solution. The mixer has high-speed stirrer for proper dispersion of these ingredients. After the dispersion, glue solution is added. The colour of the paste (paint) at this stage is white. The shade of the paint is adjusted by the addition of previously made concentrated colourants called tinters. This process of adding tinters is called tinting.

RESPONSE MEASUREMENT

After each step of tinting, the paint is applied on a panel in the standard and recommended way. The panel is then allowed to dry for a few minutes. The dried panel is then subjected to a scanner attached to an instrument called colour computer. This color computer matches the shade with that of the standard shade and gives four responses viz., DCRG, DCYB, DL and DE for the shade under test to determine its quality/ properties. Depending on the results and the requirements, the tinting will be continued until the final shade is achieved.

Responses and Specifications:

Response	Target	Lower Specification limit.	Upper specification limit
DCRG	Nominal	-2	2
DCYB	Nominal	-2	2
DL	Nominal	-2	2
DE	Smaller	0	4

OBJECTIVES

- To study the influence of different tinters used in meeting the specifications of the shade TSD Asian Green.

- To arrive at the optimal combination of the tinter quantities required to get the TSD Asian Green shade.

FACTORS AND LEVELS

The quantities (in Grams) of the three tinters, each to be experimented at three levels, for a mill base of 200gms, are given in the following table.

Factors and their levels

TINTER	LEVEL-1	LEVEL-2	LEVEL-3
CCL Green	0.83	0.94	1.05
Y.O.	0.956	1.092	1.228
CCL Blue	0.0182	0.0318	0.0454

a) Since this being an exploratory work in nature, that too, a new formulation, and if you feel that tinters may have interaction effect on different responses what would be an appropriate design to be carried out particularly when the plant is willing to carry out required number of experiments.
b) Will your design enable you to study the influence of quadratic and two factor interaction terms apart from linear effects?

EXPERIMENTATION & RESPONSE MEASUREMENT

Suppose the plant makes a physical layout (Refer Tinter Optimization Experiment Data.xlsx) of the experimental combinations and the experiments are randomized and conducted as per the given random order. As replication of the experiments was felt costly and hence only one replication of the experiments has been conducted. However, for each trial it was decided to collect multiple (5) observations for each of the four responses viz., DCRG, DCYB, DL and DE. The responses were measured as planned using the color computer.

All the experiments are conducted as per the plan and the responses measured are given in the Excel sheet.

c) Analyze the data and find an optimum combination that satisfies the given specifications. (Among all responses DE being derived from all other three responses and also this being the most important response for meeting the shade requirements optimize DE initially followed by other responses.)
d) Fit the models for all the responses and analyze the resposnse surfaces/contours for each of the responses. Find the optimal design space for each response and the overall optimum.
e) If it is decided to run a face centered response surface design can you build the required face centered design with adequate center runs from the given phisical layout?. If not what experiments you need to additionally run?.
f) If only main effects are to be studied, what would the appropriate Orthogonal Array (O.A) you would choose and select the appropriate experimental combinations from the given physical layout, analyze the data for the responses and give the optimum tinter level combination. Compare this combination with the optimum combination arrived in Question-(d) and offer your comments.

(50 marks)