Process Monitoring

by
Mohd Yusri Mohd Yunus
yusri@ump.edu.my

Chapter 2
Statistical Process Control

Process Monitoring

Chapter Description

- Aims
  - Analyze process performance using the SPC methodology.
- Expected Outcomes
  - Apply as well as analyze the univariate monitoring performance based on the progression of the means and range charts of SPC framework.
- Other related Information

Previous Questions of Test 1 on Chapter 1

"Fault detection and diagnosis is an important problem in process engineering. It is the central component of abnormal event management (AEM) which has attracted a lot of attention recently. AEM deals with the timely detection, diagnosis and correction of abnormal conditions of faults in a process. Early detection and diagnosis of process faults while the plant is still operating in a controllable region can help avoid abnormal event progression and reduce productivity loss. Since the petrochemical industries lose an estimated 20 billion dollars every year, they have rated AEM as their number one problem that needs to be solved". – Venkatasubramanian, *et al.*, 2003. A review of process fault detection and diagnosis. Computers and Chemical Engineering 27.

From the underlined statement, it is clearly shown that the main advantage of implementing process monitoring is to provide early warning on the possibilities of occurrence of any potential faults.

a) Please explain how conceptual statistics contribute in the implementation of monitoring system!

(10 marks)

b) Provide the explanation on how the monitoring can reduce productivity loss!

(10 marks)

Previous Questions of Test 1 on Chapter 1

"As cooling failed on the first day, evacuations were progressively ordered. By the evening of Saturday 12 March the evacuation zone had been extended to 20 km from the plant. From 20 to 30 km from the plant, the criterion of 20 mSv/yr dose rate was applied to determine evacuation, and is now the criterion for return being allowed. 20 mSv/yr was also the general limit set for children's dose rate related to outdoor activities, but there were calls to reduce this. In areas with 20-50 mSv/yr from April 2012 residency is restricted, with remediation action to be completed in March 2014. A significant problem in tracking radioactive release was that 23 out of the 24 radiation monitoring stations on the plant site were disabled by the tsunami". - World Nuclear Association, October 2014.

The description explains the true scenario as a result of Fukushima Daiichi Tragedy which was took place back on March 11, 2011. Please critically discuss the 'significant risk' of having just one monitoring station (instead of 24) which routinely operated as well as the corresponding remedy actions which should be executed to safeguard the public within the surrounded zone of Fukushima Nuclear Plant.

Previous Questions of Test 1 on Chapter 1

"Gross errors usually occur with actuators and sensors. These could be due to a fixed failure, a constant bias(positive or negative) or an out-of range failure. Some of the instruments provide feedback signals which are essential for the control of the plant. A failure in one of the instruments could cause the plant state variables to deviate beyond acceptable limits unless the failure is detected promptly and corrective actions are accom-
plished in time. It is the purpose of diagnosis to quickly detect any instrument fault which could seriously degrade the performance of the control system".– Venkatasubramaniam, 2003.

From the underlined statement, it is clearly shown that the main advantage of implementing process monitoring is to provide early warning on the possibilities of occurrence of any potential faults. Please explain how descriptive statistics contribute in the implementation of monitoring system!

Previous Questions of Test 1 on Chapter 1

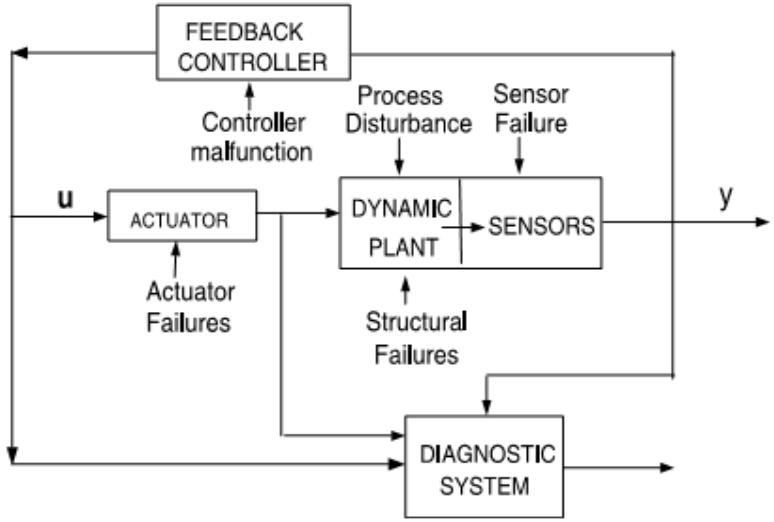

Figure A: A General Diagnostic Framework

Figure A shows the general framework of diagnostic system (process monitoring) and its relation to the feedback control system. From Figure A, the main distinctions between a process monitoring and control system can be understood particularly based from two reasons – functionality and input data. Please explain why a process monitoring is still relevant and critically required despite that a feedback controller already in place?

(10 marks)

The objectives of conceptual statistics are mainly to:

i. Understand the past behaviour;

ii. To predict how the process is likely to perform in the future based on knowledge derived from the past data.

How these two (2) objectives are interpreted in the context of process monitoring?

Previous Questions of Test 1 on Chapter 2

a) Table A shows the temperature readings in ^{0}C, based on 12 sampling times taken within 1-hour period. Develop the x-bar and R-charts based on the data of Table A subject to 3 standard deviation limit and justify the condition. (Given: D_4=2.5, D_3=0).

Table A: Temperature Measurements of CSTRwR System (1st Set)

Samples	Temperature, ^{o}C		
	Reading 1	Reading 2	Reading 3
1	50.084	50.272	50.159
2	50.004	50.166	50.143
3	50.163	50.386	50.106
4	50.190	50.198	49.935
5	50.087	50.215	49.957
6	50.284	50.287	49.953
7	50.292	50.202	49.987
8	50.200	50.184	49.923
9	50.234	50.119	49.843
10	50.225	50.203	50.058
11	50.198	50.066	50.141
12	50.272	50.223	50.035

(15 marks)

b) Another set of 12 samples were taken consecutively in the next 1 hour operation. The average value of the samples are summarized as tabulated in Table B. Develop the x-bar chart based on the data of Table B based on the limits set in question (3a) previously and justify the condition.

Table B: Temperature Measurements of CSTRwR System (2nd Set)

Samples	Temperature, ^{o}C	Samples	Temperature, ^{o}C
1	50.288	7	48.349
2	50.096	8	48.258
3	48.405	9	48.332
4	48.432	10	48.327
5	48.197	11	48.303
6	48.199	12	48.334

(15 marks)

a) One process engineer has reviewed again all the data from Table A and B. He then decided that the limits should be developed based on the combination of both sets instead of depending solely on the data of Table A. What do you expect to be happened regarding the sensitiveness of the x-bar chart in detecting the fault based on the new setting limits compared to previously?

(15 marks)

Previous Questions of Test 1 on Chapter 2

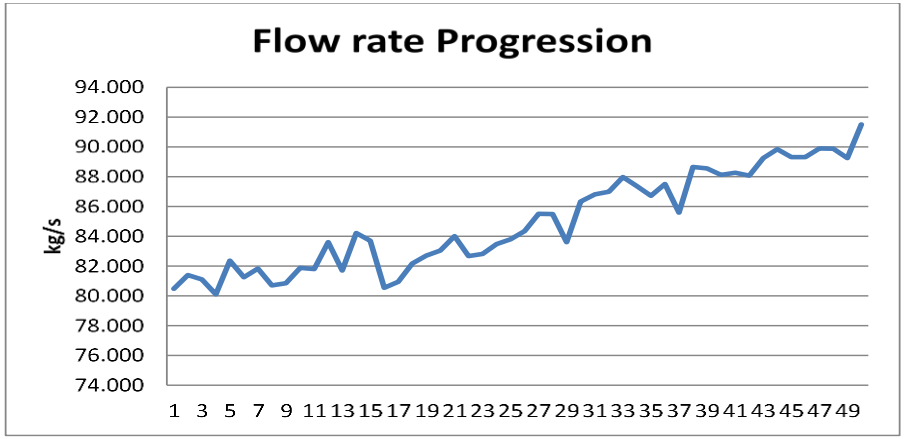

Figure B

Figure B shows the progression profile of flow rate measurements based on one particular chemical operation.

a) From Figure B, do you think the trend of the data is 'ideal' to be used for representing the Normal Operating Condition (NOC) data? Explain.

(10 Marks)

a) Draw the hypothetical control chart which is relevant and reflects your arguments in question (4a).

(15 Marks)

Previous Questions of Test 1 on Chapter 2

Table A shows the weights in grams, of 100 Mars Bars (unwrapped)! The target weight for Mars bars is 59g and production is to be controlled by weighing samples of size 5 (starting consecutively from the left of Table A).

a) Calculate the sample standard deviation for the targeted means, provided that the standard deviation of Table A is 1.50g.

(6 Marks)

b) i) Develop a control chart for means of the Mars bars which includes the warning limits as well as control limits as provided as follows.

Warning limits = $\mu \pm 2\sigma_x$; μ: sample means, σ_x: sample standard deviation

Control limits = $\mu \pm 3\sigma_x$; μ: sample means, σ_x: sample standard deviation

ii) Plot those 10 samples on the control chart that developed.

(30 marks)

Table A: The Weights (grams) of 100 Mars Bars

Samples									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
59.55	62.33	63.68	67.10	56.85	57.84	64.40	60.26	62.05	64.29
64.57	60.14	62.51	62.02	60.16	61.45	58.42	58.19	65.65	65.90
63.34	60.01	59.11	62.57	58.48	60.25	61.42	63.25	63.46	63.33
58.55	65.36	63.03	61.71	62.26	62.05	60.42	58.77	62.69	66.20
59.80	61.45	60.78	61.89	63.91	58.53	59.29	62.24	61.12	60.60
61.82	58.98	62.63	59.68	62.79	63.90	62.64	61.96	64.14	60.70
59.90	57.73	67.08	63.25	64.20	61.16	61.03	65.79	62.43	62.75
62.17	61.29	69.01	63.31	62.92	64.13	62.46	60.61	61.58	60.71
68.11	65.46	57.81	64.73	63.27	64.63	59.70	54.59	61.83	59.21
60.46	59.05	61.06	55.08	61.60	63.85	64.42	62.91	63.54	60.69

Previous Questions of Test 1 on Chapter 2

From **QUESTION 3**, five (5) more samples are taken correspondingly for monitoring and the results indicate that they are all problematic by means of variability.

a) What would be one main reason (fault courses) which contribute to this scenario? Explain.

(10 Marks)

b) Which type of control chart(s) that correspond to the judgement as mentioned in the statement that provided? Explain.

(10 Marks)

c) Draw the hypothetical control chart that reflects the findings as mentioned in the statement that provided.

(14 Marks)

d) Describe four (4) major actions that should be conducted in responding on such occasion?

(10 Marks)

References

- http://www.statit.com/statitcustomqc/StatitCustomQC_Overview.pdf
- https://www.aidt.edu/course_documents/Manufacturing_Skills/SPC/Intro_to_SPC.pdf

Authors Information

Credit to the authors: