

## Quality Engineering and Design of Experiments, Spring 2017

### Homework #4

Due: 2017/05/04, 09:10

1. (20 pts) A manufacturer of ball bearings requires that the tolerances of the diameter and the hardness of each ball be as follows:

Tolerance of diameter:  $m_1 \pm 0.6 \mu m$

Tolerance of hardness:  $m_2 \pm 2.0$

where  $m_1 (= 10)$  and  $m_2 (= 30)$  are the target values of the diameter and the hardness, respectively. The production rate is 80,000 balls per day at a cost of 30 cents per ball. Defective balls cannot be reworked and are scrapped. The diameters and the hardness numbers of 20 balls are measured and recorded as follows:

Measurements for the diameter:

10.3	10.0	9.9	10.0	10.3	10.2	10.1	9.8	10.6	10.4
9.8	10.1	10.0	9.6	10.5	10.4	9.8	10.0	10.0	10.2

Measurements for the hardness:

29.0	28.4	29.6	29.0	30.6	30.4	28.8	28.7	29.8	29.6
29.6	30.5	29.7	30.6	30.6	29.1	29.3	29.1	29.3	28.7

- (a) Find the quality loss coefficients for the diameter and the hardness of the balls.
- (b) Determine the average quality loss functions for the diameter and the hardness of the balls.
- (c) What are the average quality losses (in cents) for the diameter and the hardness of the balls?
- (d) Assume that there are 250 working days per year. Based on the quality losses obtained in (c), find the difference between the two annual quality losses (in dollars; 1 dollars = 100 cents).
2. (20 pts) Consider the ball bearing manufacturer in Problem 1. Assume that the manufacturer can shift the means of the data to the target values.
- (a) After the adjustment, what is the average quality loss (in cents) for the diameter of the balls?
- (b) Assume that there are 250 working days per year. Based on the quality loss obtained in (a), find the annual quality improvement for the diameter of the balls (in dollars).
- (c) Repeat (a) for the hardness of the balls.
- (d) Repeat (b) for the hardness of the balls.