

Six sigma quality at flyrock tires



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Executive Summary The process of creating tires at Flyrock Tires involves 20 different steps to take the rubber from bales to final curing. Given this complexity and the high production volume (the factory produces about 10,000 times per hour), it takes only a small margin of error in each of these steps to begin to compound and result in a high defective rate. For both public safety and their reputation, Flyrock strives to minimize the number of defects. The answers to the questions asked by this case form a good base for evaluating the production and extrusion process at Flyrock.

The company begins by setting expectations for what defect rates should be under ideal conditions as well as setting expectations for defect rates when machinery has become worn out. This allows them to detect things like worn bearings in machinery. The case also begins the framework for evaluating the process from a six-sigma perspective and how this might help control defects. Under ideal conditions, the extruder should produce tires that meet specifications 98.67% of the time, meaning only 1.33% of tires are defective. When the bearing is worn out, the defect rate increases three-fold to 4.7%. This means that more than one in twenty-five tire sheets is defective. If testing samples of ten sheets per hour, the machine operators could expect to find a defective every two and a half hours. In testing whether the extrusion process is in control or not, the three sigma control limits recommended by Susan Douglas will narrow the bandwidth of acceptable tires from 400 ± 10 thou to 400 ± 3.795 thou. By implementing a stricter six-sigma system and decreasing the standard deviation, the

likelihood of producing tires within acceptable levels of thickness increases to 100%.

This becomes a near-perfect process. With this information, Susan Douglas should now take appropriate steps to count the actual number of defects that occur from the extrusion process. Having that will allow her to analyze if the process is actually in control, using various control charts. Using that, she will be able to adjust the process as needed to reduce the number of defective tires, improve quality and efficiency, and ultimately reduce costs for Flyrock. Question 1 The mean, confidence intervals, and standard deviation are provided to us. Mean (μ) = 400 thou

Confidence interval = ± 10 thou Standard deviation (σ) = 4 thou This question is a simple normal probability distribution problem. It can be restated as: What is the probability that rubber sent through the extruder will be between 390 thou and 410 thou in thickness? $P(390 \leq x \leq 410)$ We first need to find the z value for each boundary then find the corresponding probability in the normal distribution table: $z = (x - \mu)/\sigma$ $z = (390-400)/4 = -2.5$ $P(z < -2.5) = .0062$ $z = (410-400)/4 = 2.5$ $P(z < 2.5) = .9938$ $P(-2.5 \leq z \leq 2.5) = .9938 - .0062 = .9876$ Therefore, there is a 98.76% probability that the rubber will be extruded with the specifications. Question 2 To find the upper and lower control limits, the following formulas apply: Upper Control Limit (UCL) = $\mu + z\sigma$ Lower Control Limit (LCL) = $\mu - z\sigma$ where $z = 3$ $\sigma = \sigma/\sqrt{n}$ $\mu = 400$ $\sigma = 4$ $n = 10$ $z = 3$ $\sigma = 4/\sqrt{10} = 1.265$ $UCL = 400 + 3(1.265) = 403.795$ $LCL = 400 - 3(1.265) = 396.205$ Question 3 If a bearing is worn out, the extruder produces a mean thickness of 403 thou even though the setting is at 400. This means that μ has shifted to 403 and the confidence level will be lower

than the 98.7% we calculated when the bearings are not worn out. We can restate the question for number 1 to ask: What is the probability that rubber sent through the extruder will be outside 390 thou and 410 thou in thickness when the mean thickness has shifted to 403 thou? Again, we need to find the z value for each boundary then find the corresponding probability in the normal distribution table: $z = (x - \mu)/\sigma$ $z = (390-403)/4 = -3.25 > z(1.75) = 0.9599$ $z = (410-403)/4 = 1.75 > z(-3.25) = 0.0006$ $P(-3.25$

Therefore, there is a 95.93% probability that the rubber will be extruded with the specifications. However to find the proportion of defective sheets we must take $1 - 0.9593$ which gives us a defective rate of 4.07%. Assuming the three sigma control limits of 403.795 and 396.205, we can calculate the probability that a sample is out of control by first calculating the percentage of in control samples. $z = (x - \mu)/\sigma$ $z = (396.205-403)/1.265 = -5.37 > z(-5.37) = 0.0000$ $z = (403.795-403)/1.265 = 2.5 > z(2.5) = 0.9876$ P in control (0

P Out of control = $1 - 0.9876 = 0.0124 = 1.24%$ Using the proportion of defective units we can calculate the average time it will take to discover a worn bearing. $1/0.0124 = 80.65$ hours. On average it will take an operator about 4 hours to detect that the process is out of control. Question 4 Assuming our mean is still 400, but a new standard deviation of 1.667 based on a six-sigma process, we find the proportion of the rubber extruded that is within our specifications by calculating the probability that rubber sent through the extruder will be outside our limits: $= (x - \mu)/\sigma$ $P(x < 410) = P(z < 410-400/1.667) = P(z < 6.0) = 1$ --- based on our normal tables $P(x < 390) = P(z < 390-400/1.667) = P(z < -6.0) = 0$ --- based on our normal tables To

then find the probability of our extruded rubber being within specifications, we subtract $P(-6.0)$

Lower Control Limit (LCL) = $\mu - z\sigma$ where $\sigma = \sigma / \sqrt{n}$ $\mu = 400$ $\sigma = 1.667$ $z = 3$
 $\sigma = 1.667/10 = .1667$ UCL = $400 + 3(.1667) = 400.5$ LCL = $400 - 3(.1667) = 398.5$
 While these new control limits are very similar, they do narrow our range which should lead to less defects. Question 6 Assuming that we return to the case of the worn bearing in question 3 where extrusion produces a mean thickness of 403 thou even though the setting is 400 thou. , we find that the proportion of defective sheets under a six-sigma process equals 0%.
 $P(x < 410) = P(z < (410-403)/.1667) = P(z < 4.199) = 1$
 $P(x < 390) = P(z < (390-403)/.1667) = P(z < -7.8) = 0$

We can then subtract by one to find the probability of being out of control:
 $P(\text{Out of Control}) = 1 - 0.0036 = 0.9964$ This tells us that based on the control limits from question #5, the probability of a defect under a six-sigma process with worn bearings is 99.64%. Assuming that the six-sigma process produces no defects, the likelihood of the sampling each hour finding a defect is 0%. If we assume our control limits discussed previously with a worn bearing and a defect probability of 99.64%, we would find a defect in the first hour based on a sample size of 10.