Mechanical Engineering Assignment

Part A

i) Control charts

Engineering processes are driven by quality and precision to ensure the end-product is satisfied the end-user besides meeting safety standards. Control charts portray the capability of the manufacturing engineering process, and some variables can be used. In this context, control charts for three measures have been incorporated that is, the mean or average, the variance, and the standard deviation. Find a separate excel sheet which was used to draw the charts representing batch 1 and 2 production.

Mean, Range and SD control chart(s) for the H1 dimension

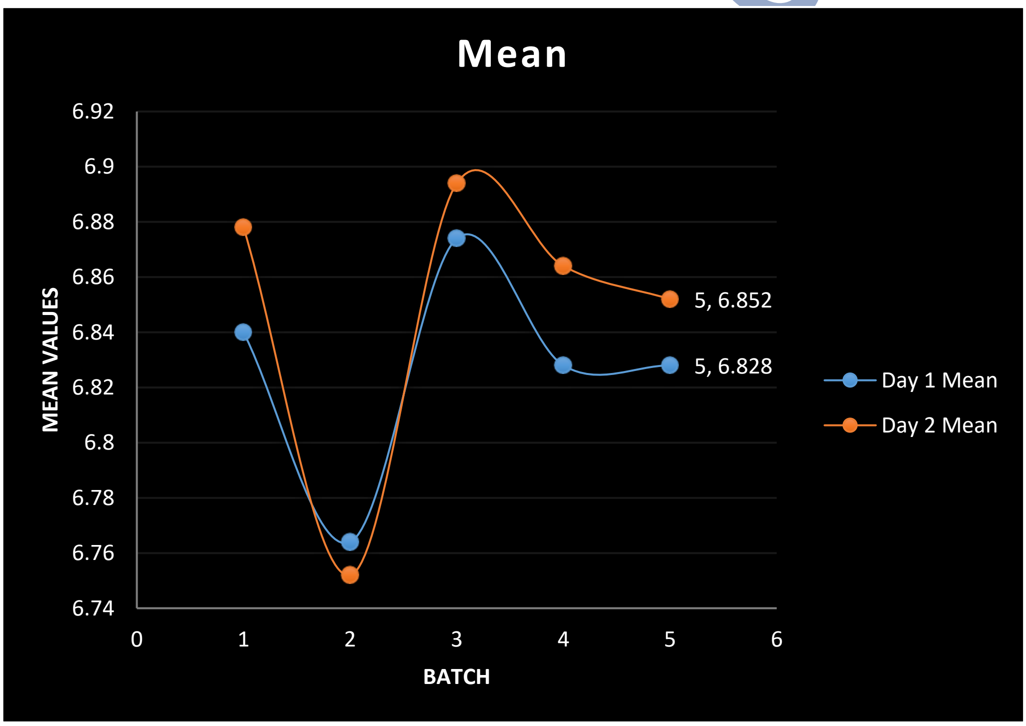

Fig. 1 shows the mean for batches produced in day 1 and 2

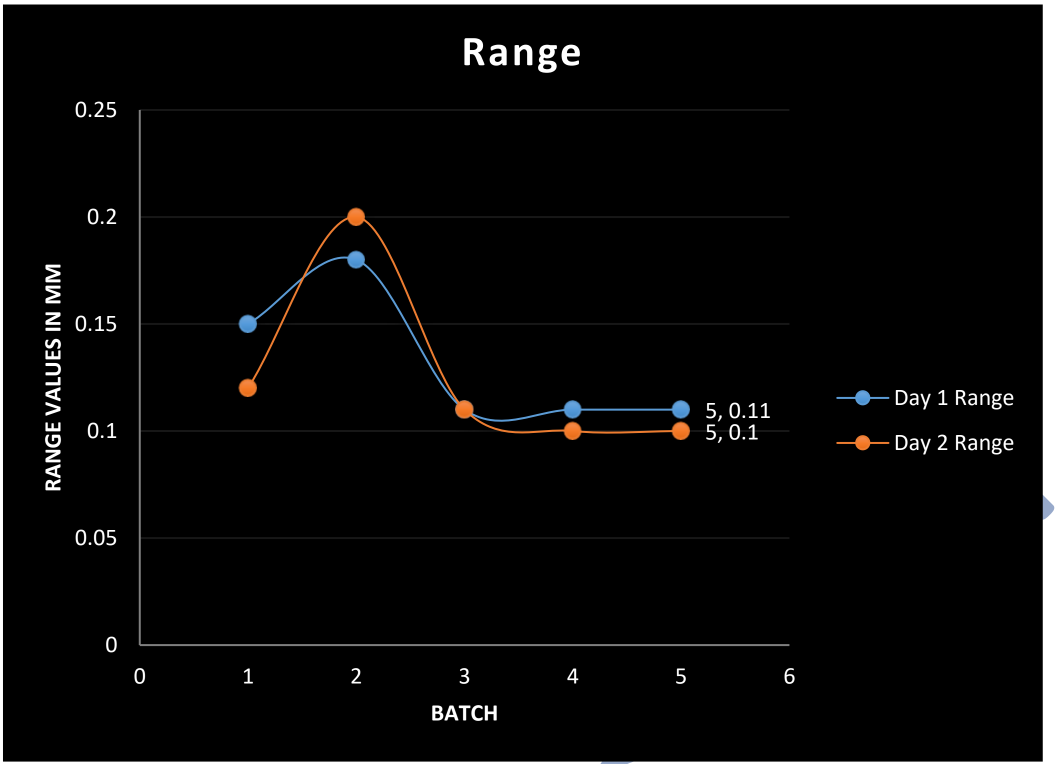

Fig. 2 shows the measurement of range during day 1 and 2

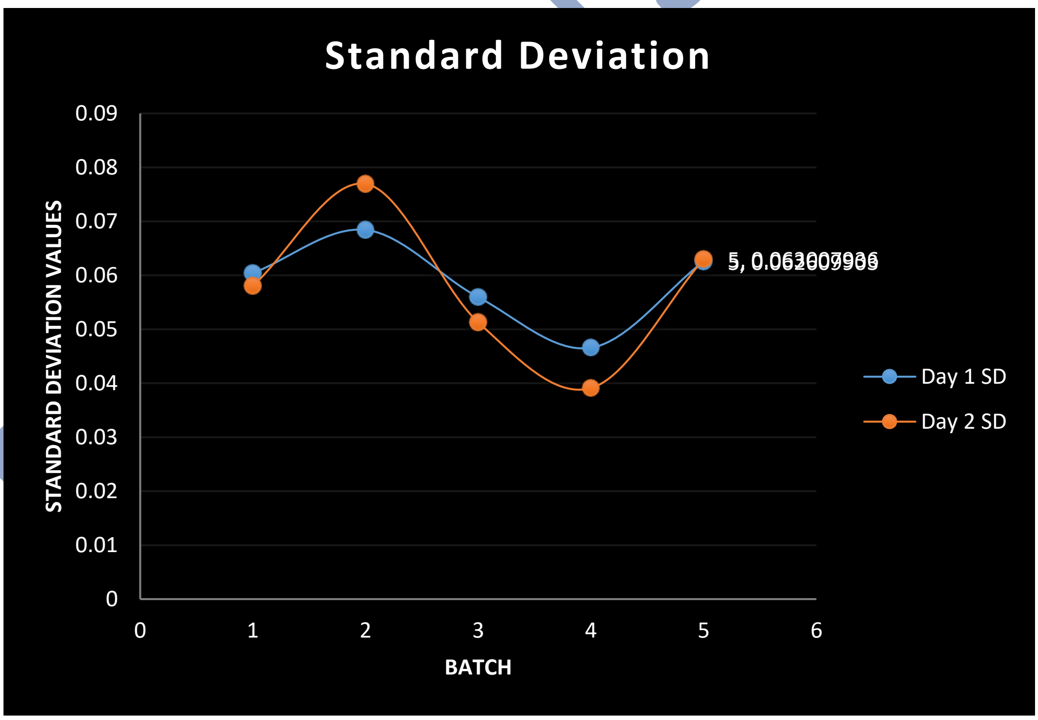

Fig. 3 shows the measurement of standard deviation for production of day 1 and 2

Mean, Range and SD control chart(s) for H3 dimension

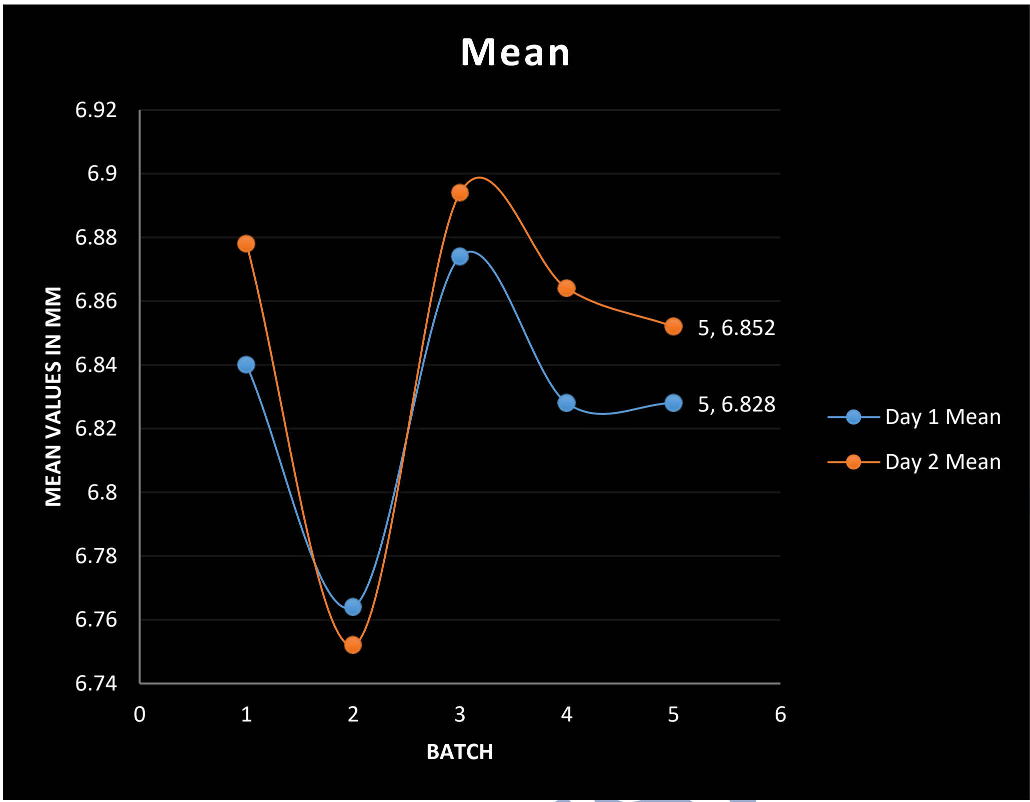

Fig. 4 shows the plot of the means of the batches produced in day 1 and 2

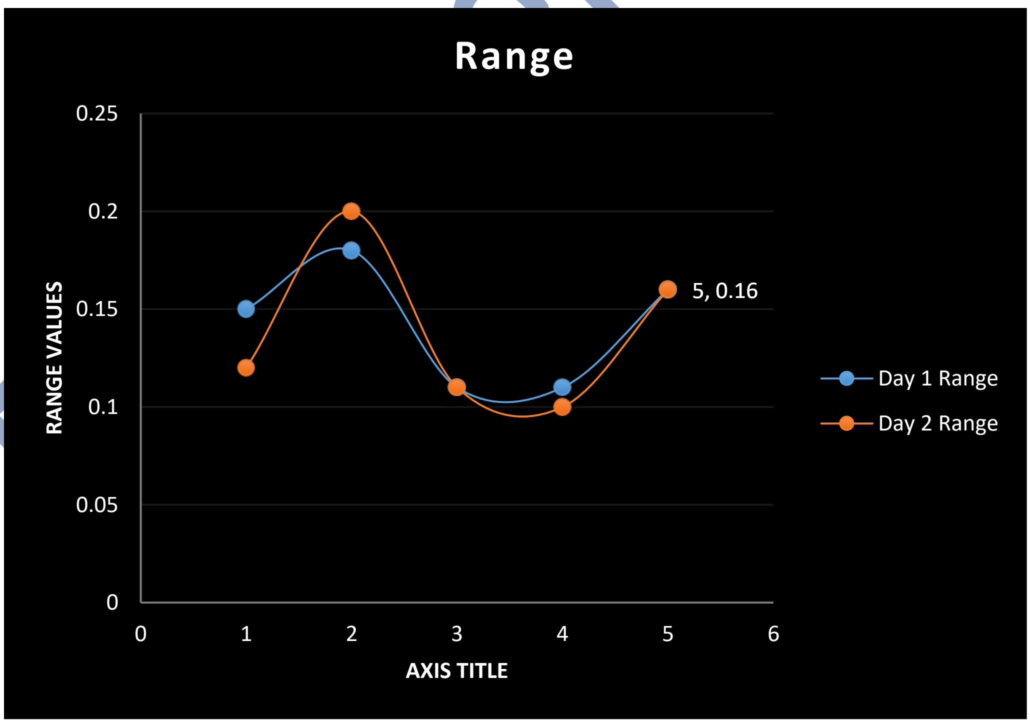

Fig. 5 shows the plot for the range for batches produced in day 1 and 2

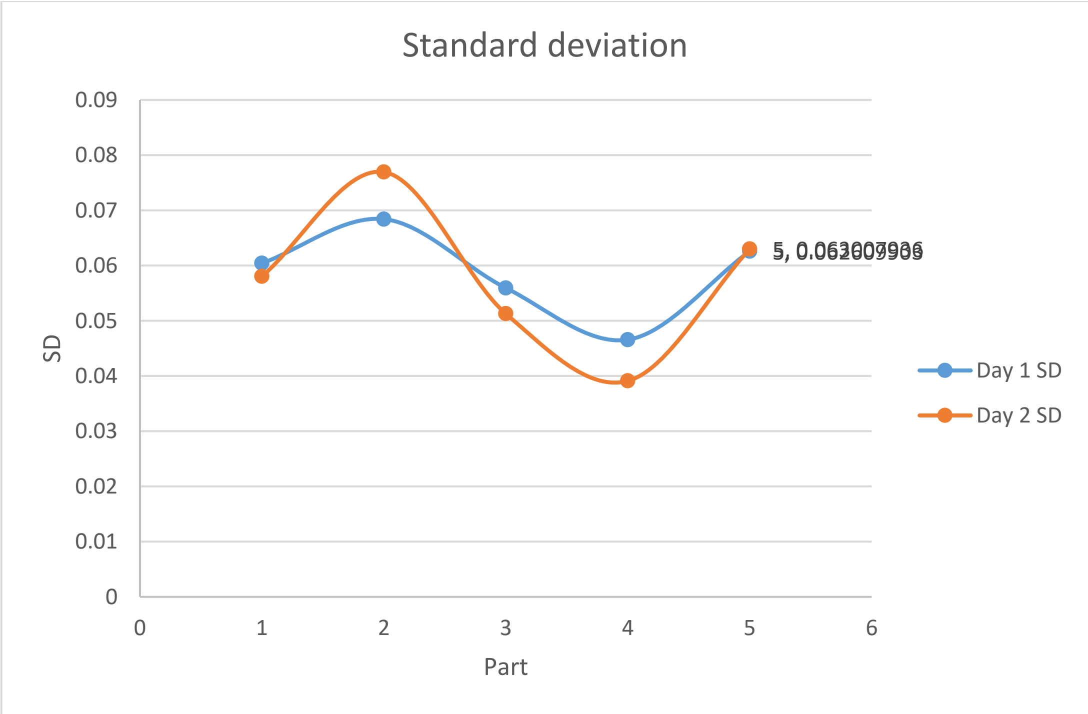

Fig. 6 shows the graph for SD for batches during day 1 and 2

Mean, Range and SD control chart(s) for N003 dimension

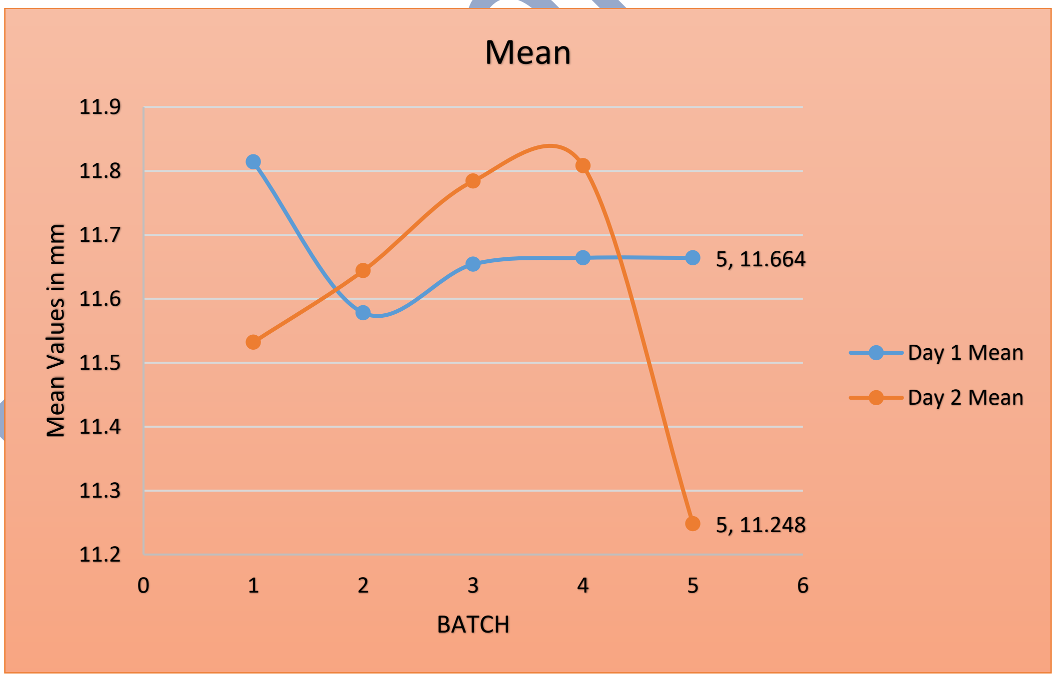

Fig. 7: plot for the measure of means for day 1 and 2 batches

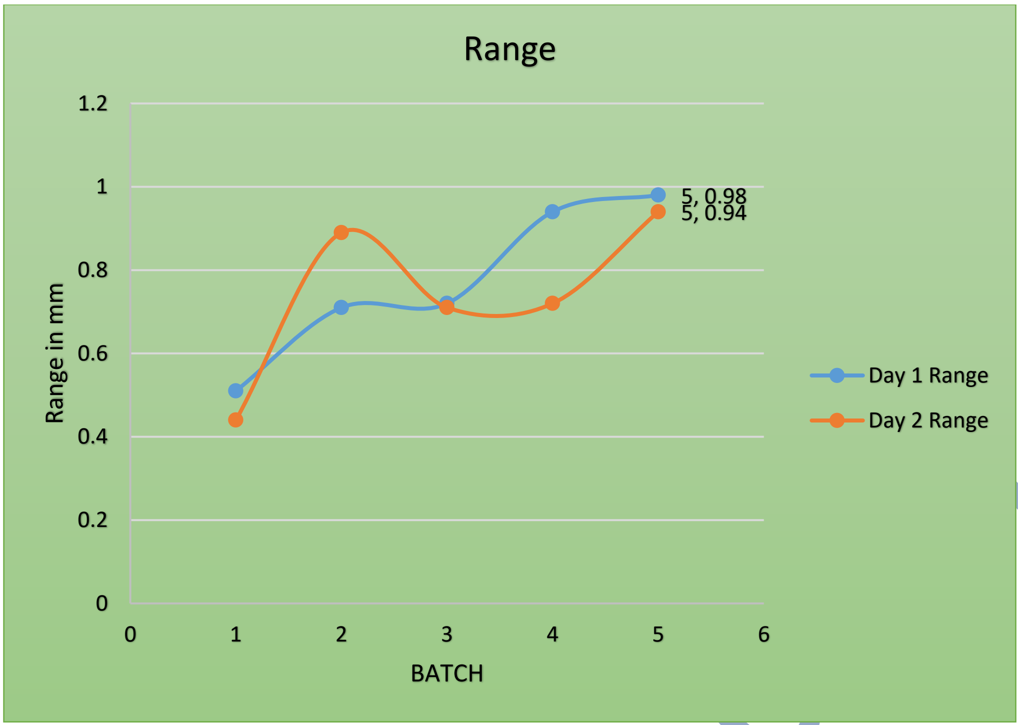

Fig. 8: Graph for the measure of range during day 1 and 2

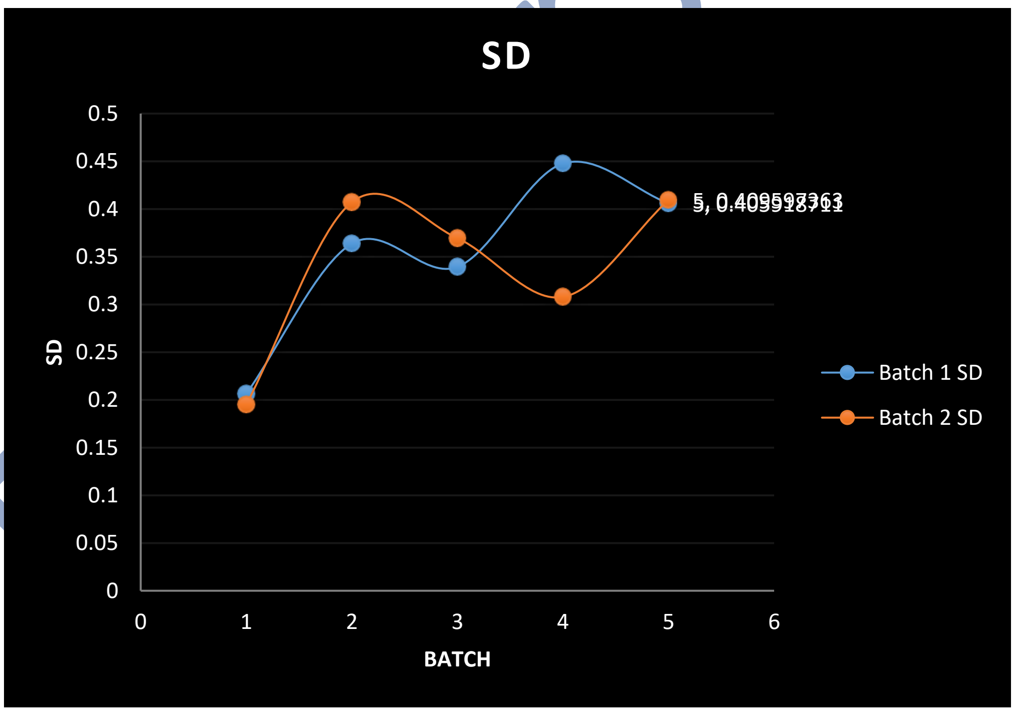

Fig. 9: plot for the measure of SD for day 1 and 2 production

Mean, range, and Standard deviation control charts for N002

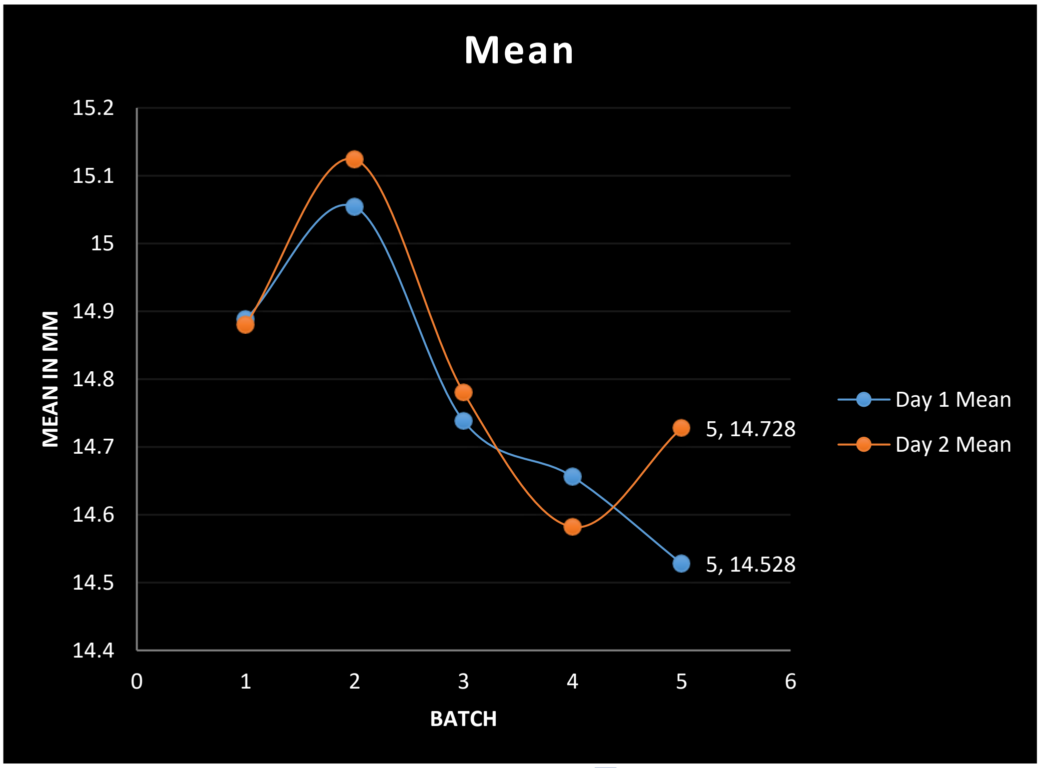

Fig. 10: plot for the measure of means batches made on day 1 and 2

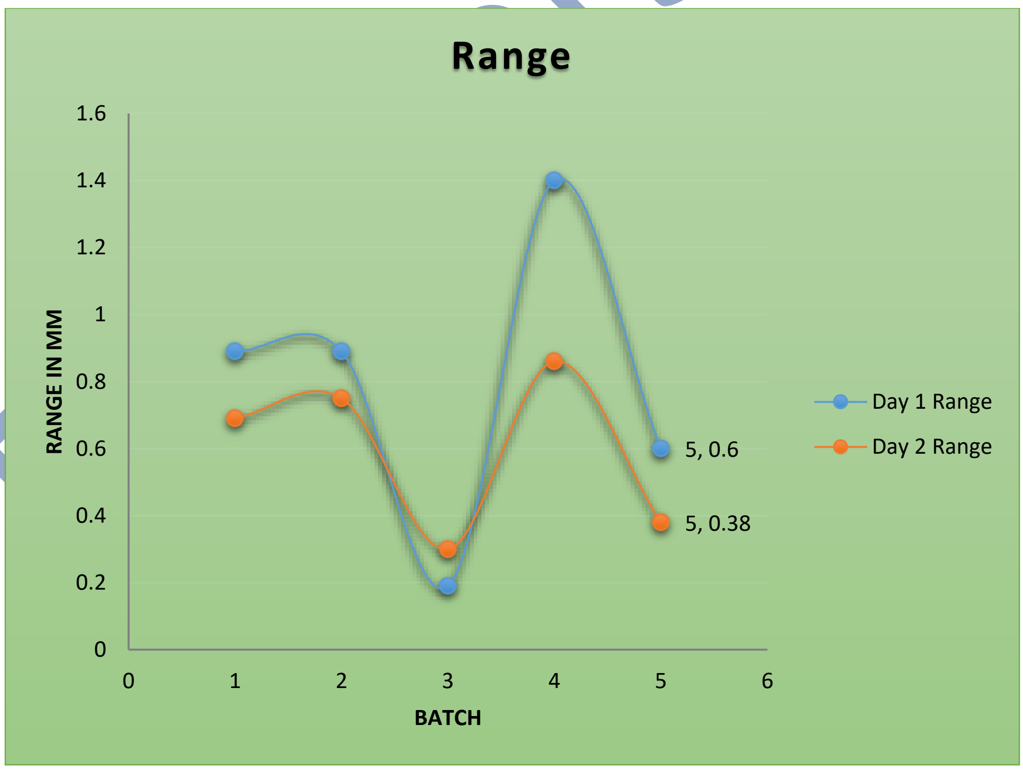

Fig. 11: Graph for the measure of range for day 1 and 2 production

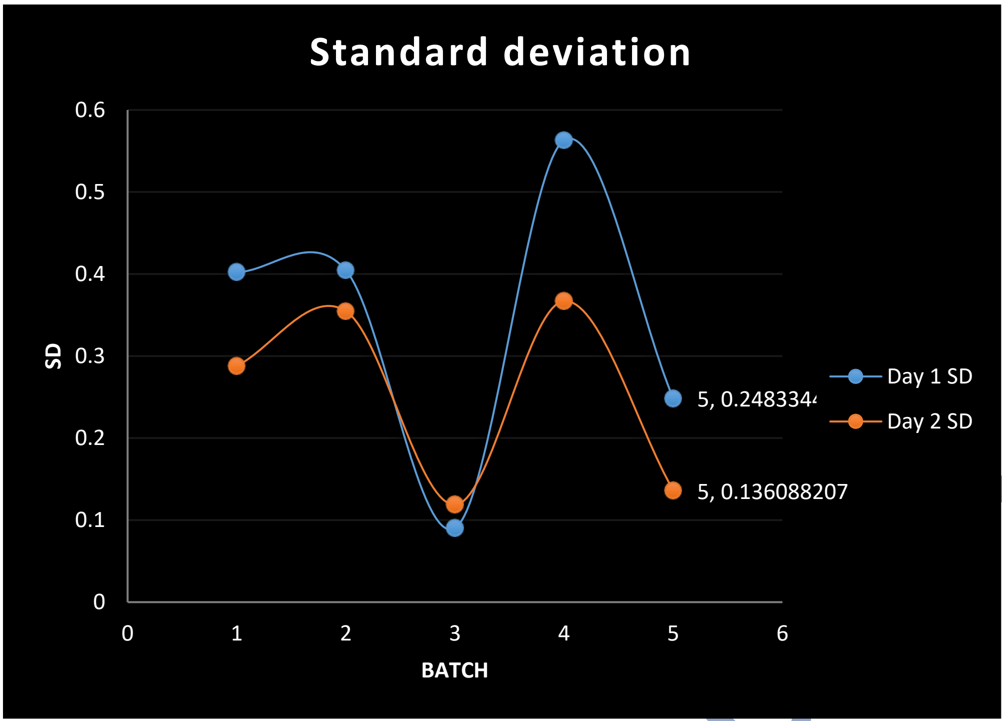

Fig. 12: Graph for the measure of SD for production on day 1 and 2

Mean, range, and Standard deviation control charts for N001

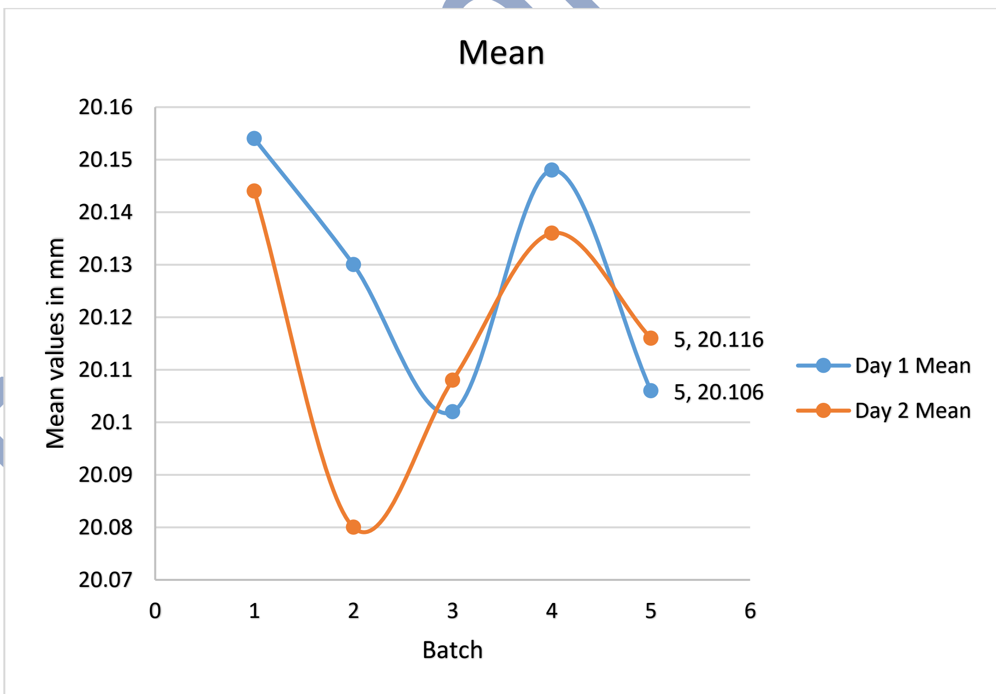

Fig. 13: Graph for the mean values obtained in day 1 and 2

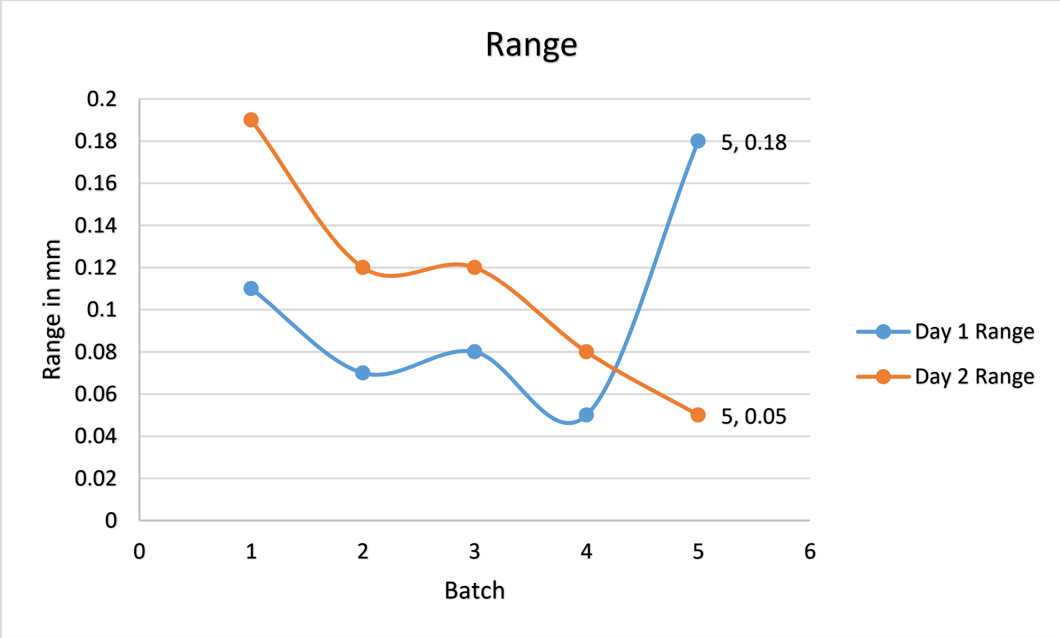

Fig. 14: Range values obtained during day 1 and 2

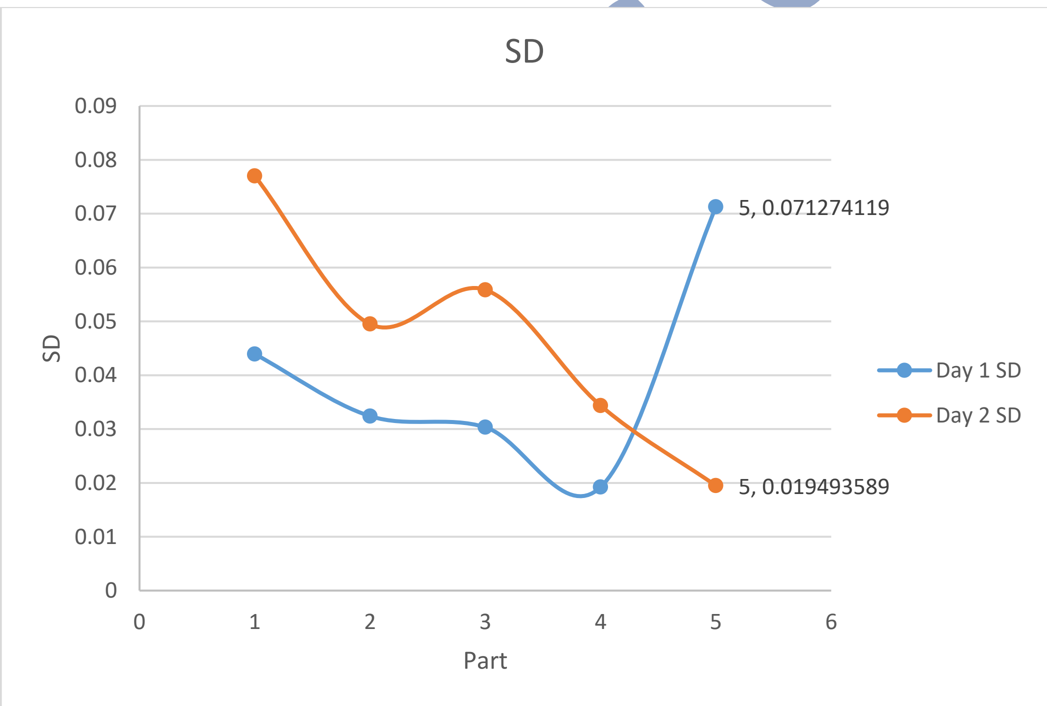

Fig. 15: SD values for day 1 and 2 production

Suitability and discussion of control chart findings

Data provided in the MS Excel file was divided into two groups, one for batch 1 and the other for batch 2 production. Data for batch1 consisted of columns 1, 3, 5, 7, and 9 (as shown in the first spreadsheet of the MS Excel file). Column 2, 4, 6, 8 and 10 represented data for batch 2. Three measures included in this analysis are the values of the mean or average, range, and standard deviation. From the graph, it is evident that the mean values of H1, H3, N001, N002, and N003 increased or decreased for the 5 batches made on day 1 and the same is repeated for batches produced on the second day. The graph shows a production process that is not smooth and non-uniform implying lack of precise manufacturing engineering process. Consider figure 1 representing a plot of the mean values of the 5 batches for the first and second day. The third batch for parts produced in the first day has the highest of 6.874 while batch 2 recorded the lowest mean of 6.764. A similar pattern is repeated for parts produced during the second day where batch 3 has a mean value of 6.894 while batch 2 recorded the least mean value of 6.752.

In regards to the values of range for *H1*, there was a similar pattern observed for batches produced during both days as indicated by figure 2. Still, these values appear not to be completely homogenous, but the last three batches show some uniformity. All other charts representing plots for mean values obtained during both days of production show a high degree of non-uniformity. This implies that while some batches recorded small differences in the measurement of range, others posted high figures. For example, batch 2 produced in the second day had a range value of 0.2 while batch 4 produced during the same day posted a range of 0.1. The chart appears to be 'sinusoidal.' The 'sinusoidal' trend can also be observed from figure 13 which shows the mean values for N001 taken during both days. Looking at the charts for the range and SD values of H1, H3, N001, N002, and N003, most of them appear to be similar.

ii) Assessment of process capability and its significance

Statistical process control (SPC) is inevitable in the manufacturing industry to determine the stability of the process involved (Kot and Lovelace, 1998: Kotz and Johnson, 2002). There is a suggestion that data gathered from a stable process can give a clear picture of the capability of the process (Deleryd, 1998). Wooluru, Swamy, and Nagesh (2015) argue that in the event the trend patterns of processes are present, acceptable, and well understood, frequent adjustments can be done to maintain the process within the limits of specifications. For instance, a manufacturing process may be having a problem of tool-wear which calls for the regular replacement of cutting tools. By doing this, the output is expected to decrease or increase though such a fluctuation is tolerated if it remains within the specified range. Indices of process capability are mainly applied to determine whether the process can produce components within a precise tolerance and on target. Conventionally, three PCIs are applied including the C_p, C_{pk}, and C_{pm}. The first index takes into account the variability of the whole process in relation the manufacturing tolerance. The second, index considers the process mean though it may not help in distinguishing between on-target and off-target processes. C_{pm} is more advanced PCI (Chan et al., 1988). Mathematical expressions for each of these indices are expressed as follows,

$$C_p = \frac{USL - LSL}{6\sigma} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$C_{pk} = \min\{\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$C_{pm} = \frac{USL - \mu}{6\sqrt{(\sigma^2 + (\mu - T)^2)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,

μ = Process mean

σ = Standard deviation

T = Target value

USL and LSL = Upper specification limit and Lower specification limit

Assume a target value, T, of **20mm** for dimension N001 and a tolerance of **0.5**. Thus, the USL and LSL is **20.5mm** and **19.5mm** respectively. Find calculations in the attached Excel file.

Table 1: C_p, C_{pk}, and C_{pm} for dimension N001

Batch	Mean	SD	C_p	C_{pk}	C_{pm}
1	20.154	0.044	3.787878788	2.621212121	0.36005118
2	20.144	0.077	2.164502165	1.541125541	0.36335233
3	20.13	0.032	5.208333333	3.854166667	0.46060962
4	20.08	0.049	3.401360544	2.857142857	0.74616011
5	20.102	0.03	5.555555556	4.422222222	0.62390109
6	20.108	0.056	2.976190476	2.333333333	0.53703669
7	20.148	0.019	8.771929825	6.175438596	0.39316972
8	20.136	0.034	4.901960784	3.568627451	0.43275964
9	20.106	0.071	2.34741784	1.849765258	0.51470429
10	20.116	0.019	8.771929825	6.736842105	0.54446892

iii) Discussion of measuring system accuracy and its impact

Conventionally, statistical process controls (SPC) use Cp and Cpk indices as simple and straightforward indicators of process capability (Ryan, 2013). High values of Cpk measure how adjacent a process is to the specification limits. Large indices indicates that the measure is less likely outside the specification limits. Looking at Table 1 above, the Cpk values are quite high which confirms the likelihood of the measures lying within the specification limits. The target value was assumed to be 20mm for dimension N001 and a tolerance of 0.5. Therefore, the USL and LSL are 19.5 and 20.5mm which means that the measures obtained should be confined between these limits. From column 2 (mean values), the values appear to be within the specified limits. For this reason, the accuracy of the system is quite impressive, but this is for one dimension only.

2. PART B

Formation of contracts and contractual agreements

Typically, contractual arrangements are legally binding agreements between two or more parties. In common law, contracts are defined as a promise (or set of promises) enforced by law. They also refer to an agreement which leads to obligations that are legally recognised and enforceable (Pannebaker, 2013). Two aspects incorporated in the formation of a contract include offer and acceptance. The doctrine of offer and acceptance forms the legal basis of contract formation in many legal systems (Pannebakker, 2013). For a contract to actualize, an offeror proposes (an offer) to complete an act (or abstain from performing it) to the offeree, and the offeree must accept the offer (Ferrari, 2012). Ferrari (2012) states that the period of forming a contract is the exact time where an offeror having an adequate level of certainty is accepted by the offeree. Contextually, there is a plan to engage three suppliers for cutting tools to help in the machining of 50 pieces (10 batches) in two days. Three suppliers have been identified but with different portfolios regarding experience and quality as summarised below.

Supplier 1

This supplier is well versed with the manufacturing industry and has interacted extensively with some manufacturing firms. For this particular firm, the supplier has been cordial and offered products at the lowest price in the market. Unfortunately, s/he has had a bad reputation in the market based on the recommendations and reviews of the clients that have used his/her tools.

Supplier 2

Though the supplier offers his/her products at a reasonable price, s/he is a new vendor in the market and has not been tested adequately. The supplier has been involved in the marketing of his/her products as well selling them in case s/he convinces a potential customer. Therefore, the quality of the cutting tools to be supplied by this particular vendor is yet to be confirmed fully.

Supplier 3

The third supplier is an established vendor having been in the market for some time and offers quality and durable tools. However, companies engaging or planning to engage with this firm have to deal with higher prices compared to the other two vendors. Therefore, firms have to spend more buying durable and quality tools from such a supplier.

Hiring based on contractual agreements

An explicit explanation of a contract has been provided in the preceding paragraphs, and it is important to analyze the terms of engagement with one of the three suppliers based on the tenets of that definition. First, contractual agreements are binding and legally enforceable. Once the agreement both by word of mouth or writing has been formalized between the offeror and offeree and accepted, both parties have obligations to fulfill. In this particular case, the offeror is the supplier of the cutting tools, and the offeree is the recipient of those tools. Often, the manufacturer places a tender or directly engages with the suppliers and agree on terms and conditions of supplying the materials. In the case of tendering, the manufacturing firm advertises a tender, and potential suppliers respond by placing a bid. A pre-qualification is done before the final evaluation of the bidders is done. Once the evaluation of the bidders has been done based on experience on similar works, financial capacity, personnel, equipment, recommendations from previous projects accomplished, and other specifications, the tender is awarded. The latter is more complicated.

It is upon the manufacturing firm to understand its obligations and those of the supplier and the terms and conditions set before formalizing the contract. Legal enforcement cannot be overlooked in this case because once the offer has been made and accepted, both parties have to meet their obligations. A review of the portfolio of the three suppliers is the first step. Accepting an offer from the first supplier means paying for substandard cutting tools at a lower price, but this may compromise the quality of the end product and capability of the manufacturing process. Second, there is a risk of engaging with new, untested suppliers because of their unknown profile. Industry dynamics and stiff competition may prove a big challenge for them to remain consistent in supplying quality and durable tools. Third, approaching an established vendor that has proved consistent and competent in supplying proper tools is a guarantee that the cutting tools that will be supplied will perform better manufacturing processes, the cutting tool(s) will last longer, and the finished product will be good. Having analyzed these conditions, it is worth paying for quality and durable tools to avoid disagreements and litigations once the purchasing agreement has been actualised. Though the first supplier is a friend and offering products cheaply, the bad reputation may be associated with poor quality end products, litigations on compensation given poorly-established contractual engagements, and poor customer reviews. Therefore, going into a contract with the third supplier is plausible irrespective of the costs involved.

Reference

Deleryd, M. (1998). On the gap between theory and practices of process capability studies. *International Journal of Quality and Reliability Management*, *15*, pp.178- 191.

Ferrari, F. 'Offer and Acceptance *Inter Absentes*', in J.M. Smits (ed.), *Elgar Encyclopedia of Comparative Law*, 2nd ed. (2012) 625, at 625 ff.

Kotz and Lovelace, C. R. (1998). Process Capability Indices in Theory and Practices, (Oxford, London: University Press).

Kotz, S. and N. L. Johnson (2002). Process capability indices—a review, 1992–2000. *Journal of Quality Technology*, **34**(1), 2–19, discussion, pp. 20–53.

Pannebaker, E. (2013).Offer and acceptance and the dynamics of negotiations: arguments for contract theory from negotiation studies. *ELR*, pp.131-141.

Ryan, T. P. (2013). *Statistical methods for quality improvement*. Hoboken, N.J., Wiley. http://rbdigital.oneclickdigital.com.

Wooluru, Y., Swamy, D. R. and Nagesh, P. (2015). Process Capability Assessment with Trended Processes: A Case Study. *International Journal of Statistics and Economics*, *16*(3), pp.1-13.