Data Article

Measurement data from bobbins of Partially Oriented Yarns: Univariate and multivariate aspects

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ABSTRACT

In this paper, we present data from measurements made in the textured fibers bobbins in two different conditions, presenting critical quality characteristics such as diameter, mass and density. In order to obtain a significant amount of information, in each of the two conditions, 270 measurements were obtained for each of the quality characteristics. Three different equipments (Automatic Package Analyzer - APA) were used in ten different parts, replicated three times for each of them. Considering the two measurement data collection, an amount of 540 bobbins measurements were obtained. Almeida et al., (2019) applied these measurement data in his study. Taking into account the multicorrelated nature of the information, we also have the representation of the principal components' scores for these measurements, besides the eigenvalues and eigenvectors of the data.

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Value of the Data

- These data can be used for several applications in a measurement system analysis (MSA), allowing the application of different techniques or analysis strategies;
- There are few works aimed at evaluating measurements in this area, so these data contribute to possible applications and analyzes of methodologies such as the six sigma application in this process.
- It is possible to use and analyze both univariate and multivariate strategies from these data, as in gage study. Thus being able to consolidate possible and new methods.

Table 1
First measurement data collection.

| n | a | APA1 | APA2 | APA3 |
|---|---|------|------|------|
|   |   | Mass [g] | Diameter [cm] | Density [g/cm³] | Mass [g] | Diameter [cm] | Density [g/cm³] | Mass [g] | Diameter [cm] | Density [g/cm³] |
| 1 | 1 | 3336 | 22.861 | 0.3994 | 3334 | 22.752 | 0.3890 | 3340 | 22.638 | 0.4031 |
| 1 | 2 | 3299 | 21.848 | 0.4371 | 3298 | 21.776 | 0.4354 | 3292 | 21.666 | 0.4452 |
| 1 | 3 | 3348 | 21.17 | 0.4768 | 3344 | 21.142 | 0.4701 | 3349 | 21.126 | 0.4754 |
| 1 | 4 | 3327 | 21.177 | 0.4717 | 3327 | 21.082 | 0.4703 | 3332 | 20.975 | 0.4794 |
| 1 | 5 | 3328 | 22.012 | 0.4345 | 3325 | 21.915 | 0.4338 | 3330 | 21.774 | 0.4433 |
| 1 | 6 | 3315 | 21.993 | 0.4322 | 3314 | 21.873 | 0.4330 | 3318 | 21.785 | 0.4393 |
| 1 | 7 | 3342 | 21.233 | 0.4723 | 3337 | 21.116 | 0.4699 | 3342 | 20.968 | 0.4845 |
| 1 | 8 | 3339 | 22.313 | 0.4220 | 3336 | 22.187 | 0.4257 | 3341 | 22.105 | 0.4273 |
| 1 | 9 | 3333 | 21.46 | 0.4565 | 3336 | 21.416 | 0.4526 | 3341 | 21.432 | 0.4576 |
| 1 | 10 | 3330 | 22.321 | 0.4227 | 3330 | 22.191 | 0.4228 | 3336 | 22.091 | 0.4313 |
| 2 | 1 | 3337 | 22.805 | 0.4025 | 3336 | 22.729 | 0.3969 | 3341 | 22.638 | 0.4056 |
| 2 | 2 | 3301 | 21.881 | 0.4359 | 3298 | 21.792 | 0.4339 | 3302 | 21.724 | 0.4407 |
| 2 | 3 | 3344 | 21.177 | 0.4659 | 3343 | 21.149 | 0.4711 | 3349 | 21.115 | 0.4744 |
| 2 | 4 | 3328 | 21.147 | 0.4697 | 3326 | 21.058 | 0.4711 | 3331 | 21.04 | 0.4740 |
| 2 | 5 | 3328 | 21.956 | 0.4383 | 3326 | 21.866 | 0.4301 | 3331 | 21.76 | 0.4446 |
| 2 | 6 | 3311 | 21.963 | 0.4320 | 3314 | 21.838 | 0.4282 | 3318 | 21.788 | 0.4388 |
| 2 | 7 | 3340 | 21.177 | 0.4706 | 3336 | 21.092 | 0.4766 | 3342 | 21.022 | 0.4787 |
| 2 | 8 | 3337 | 22.306 | 0.4244 | 3336 | 22.214 | 0.4232 | 3340 | 22.087 | 0.4305 |
| 2 | 9 | 3338 | 21.505 | 0.4539 | 3335 | 21.42 | 0.4565 | 3341 | 21.367 | 0.4593 |
| 2 | 10 | 3334 | 22.332 | 0.4243 | 3330 | 22.173 | 0.4209 | 3336 | 22.119 | 0.4291 |
| 3 | 1 | 3335 | 22.857 | 0.3977 | 3335 | 22.758 | 0.3975 | 3340 | 22.638 | 0.4057 |
| 3 | 2 | 3300 | 21.855 | 0.4369 | 3298 | 21.812 | 0.4312 | 3302 | 21.68 | 0.4419 |
| 3 | 3 | 3345 | 21.241 | 0.4716 | 3342 | 21.177 | 0.4655 | 3349 | 21.022 | 0.4828 |
| 3 | 4 | 3329 | 21.173 | 0.4712 | 3327 | 21.032 | 0.4742 | 3332 | 20.982 | 0.4802 |
| 3 | 5 | 3329 | 22.012 | 0.4349 | 3325 | 21.857 | 0.4341 | 3331 | 21.742 | 0.4422 |
| 3 | 6 | 3312 | 21.941 | 0.4331 | 3313 | 21.85 | 0.4333 | 3318 | 21.792 | 0.4390 |
| 3 | 7 | 3339 | 21.185 | 0.4713 | 3337 | 21.096 | 0.4688 | 3343 | 21.072 | 0.4756 |
| 3 | 8 | 3337 | 22.261 | 0.4277 | 3336 | 22.184 | 0.4230 | 3341 | 22.09 | 0.4310 |
| 3 | 9 | 3335 | 21.516 | 0.4501 | 3336 | 21.402 | 0.4609 | 3341 | 21.367 | 0.4584 |
| 3 | 10 | 3332 | 22.328 | 0.4222 | 3331 | 22.186 | 0.4236 | 3336 | 22.134 | 0.4290 |
1. Data

These data present the measurements of a real textured fibers bobbins process of type Partially Oriented Yarns (POY), randomly and automatically collected from specific measurements devices called Automatic Package Analyzer (APA). Data were used in the study by Almeida et al. [1]. The data present a great amount of information, describing three of the main critical characteristics of the quality, such as: diameter (cm), mass (g) and density (g/cm³). In manufacturing processes that have many quality characteristics, one must also verify the data’s multi-correlation [2], so the principal components’ scores of these measurements are also presented, along with their eigenvalues and eigenvectors. The information based on principal components was used due to the great applicability of this strategy, as in works of [3,4]. There are two distinct conditions in this data set, where each of them presents 270 information for the original data and 270 information of the principal components’ scores.

Tables 1 and 4 present the original measurement data collected under different analysis conditions (without calibration and after calibration, respectively). The scores of the main components of each data collection are described in Tables 2 and 5, respectively. Finally, in Tables 3 and 6 it is possible to verify the eigenvalues and eigenvectors of the collected data, respectively.

2. Experimental design, materials, and methods

The data collection was carried out in a textile company that is the market leader in Brazil, where the textured fibers bobbins process represents 15% of the total production of the factory. To ensure a

| n  | a    | APA1  | APA2  | APA3  |
|----|------|-------|-------|-------|
|    |      | PC1   | PC2   | PC3   |
| 1  | 1    | -2.5957 | 1.0960 | -0.1257 |
| 2  | 1    | -0.8878 | -2.2219 | -0.1062 |
| 3  | 2    | 2.0020 | 0.9055 | -0.1338 |
| 4  | 1    | 1.4690 | -0.6096 | -0.1039 |
| 5  | 1    | -0.6466 | -0.0118 | -0.0942 |
| 6  | 1    | -0.9248 | -0.9629 | -0.0676 |
| 7  | 1    | 1.6838 | 0.5127 | -0.1146 |
| 8  | 1    | -1.1924 | 0.9812 | -0.0603 |
| 9  | 1    | 0.7790 | 0.0220 | 0.0064 |
| 10 | 1    | 1.3440 | 0.3195 | -0.1396 |
| 2  | 1    | -2.4172 | 1.1313 | -0.1386 |
| 2  | 2    | -0.9286 | -2.0555 | -0.1032 |
| 3  | 2    | 1.6089 | 0.6683 | 0.1568 |
| 4  | 2    | 1.4666 | -0.5381 | 0.0010 |
| 5  | 2    | -0.4679 | -0.0531 | -0.1310 |
| 6  | 2    | 0.5645 | -1.1681 | -0.0434 |
| 7  | 2    | 1.5705 | 0.3513 | -0.0017 |
| 8  | 2    | -1.1501 | 0.8194 | -0.1331 |
| 9  | 2    | 0.7379 | 0.4204 | 0.0496 |
| 10 | 2    | -1.2395 | 0.6099 | -0.1807 |
| 3  | 1    | 1.8658 | 0.1021 | -0.0772 |
| 2  | 3    | -0.8838 | -2.1446 | -0.1049 |
| 3  | 3    | 1.7095 | 0.7395 | -0.0906 |
| 4  | 3    | 1.4938 | -0.4614 | -0.0713 |
| 5  | 3    | -0.6174 | 0.0598 | -0.1003 |
| 6  | 3    | -0.8865 | -1.2090 | -0.0421 |
| 7  | 3    | 1.6644 | 0.2773 | -0.0402 |
| 8  | 3    | -0.9975 | 0.7846 | -0.1720 |
| 9  | 3    | 0.5593 | 0.2236 | 0.1330 |
| 10 | 3    | -1.3314 | 0.4718 | -0.1233 |

Table 2
Scores for the first measurement data collection.
satisfactory amount of data, the information can be divided into two measurement data collection. In accordance with the requirements suggested by the AIAG [5], in both studies, the measurements of ten distinct parts was collected for three different operators and three replicates were carried out, characterizing in a quantity satisfactory information for applications of measurement techniques. This data collection methodology is widely used in measurement system analysis studies, such as [6,7]. It is important to note that the collection was performed in a random manner. From these data, the data of the scores of the principal components’ scores were extracted.

Table 3
Eigenvalues and eigenvector for the first measurement data collection.

|                | PC1     | PC2     | PC3     |
|----------------|---------|---------|---------|
| Eigenvalue     | 2.0491  | 0.9416  | 0.0094  |
| Proportion     | 0.683   | 0.314   | 0.003   |
| Cumulative     | 0.683   | 0.997   | 1       |

CTQ’s Eigenvectors

|                | Eigenvectors |
|----------------|--------------|
| Mass           | 0.238        |
| Diameter       | -0.681       |
| Density        | 0.692        |

Table 4
Second measurement data collection.

| n  | a  | APA1  | APA2  | APA3  |
|----|----|-------|-------|-------|
|    |    | Mass  | Diameter | Density | Mass  | Diameter | Density | Mass  | Diameter | Density |
|----|----|-------|----------|---------|-------|----------|---------|-------|----------|---------|
| 1  | 1  | 3475  | 21.923   | 0.4502  | 3473  | 21.744   | 0.4507  | 3478  | 21.726   | 0.4526  |
| 2  | 2  | 3453  | 21.091   | 0.4861  | 3452  | 20.967   | 0.4871  | 3457  | 20.957   | 0.4873  |
| 3  | 3  | 3475  | 22.062   | 0.4430  | 3477  | 21.903   | 0.4443  | 3480  | 21.892   | 0.4432  |
| 4  | 4  | 3477  | 21.613   | 0.4642  | 3478  | 21.499   | 0.4647  | 3480  | 21.5     | 0.4652  |
| 5  | 5  | 3470  | 21.534   | 0.4663  | 3469  | 21.402   | 0.4674  | 3473  | 21.456   | 0.4662  |
| 6  | 6  | 3492  | 22.868   | 0.4098  | 3489  | 22.784   | 0.4099  | 3496  | 22.728   | 0.4109  |
| 7  | 7  | 3474  | 21.97    | 0.4470  | 3473  | 21.821   | 0.4476  | 3479  | 21.815   | 0.4484  |
| 8  | 8  | 3457  | 22.195   | 0.4338  | 3458  | 22.057   | 0.4346  | 3460  | 22.027   | 0.4356  |
| 9  | 9  | 3473  | 22.642   | 0.4166  | 3473  | 22.494   | 0.4175  | 3477  | 22.444   | 0.4181  |
| 10 | 10 | 3475  | 22.119   | 0.4423  | 3474  | 21.999   | 0.4414  | 3478  | 21.991   | 0.4424  |
| 1  | 1  | 3475  | 21.882   | 0.4516  | 3475  | 21.748   | 0.4515  | 3478  | 21.725   | 0.4518  |
| 2  | 2  | 3454  | 21.099   | 0.4853  | 3451  | 20.982   | 0.4855  | 3457  | 20.95     | 0.4878  |
| 3  | 3  | 3477  | 22.062   | 0.4413  | 3477  | 21.898   | 0.4440  | 3481  | 21.896    | 0.4443  |
| 4  | 4  | 3479  | 21.587   | 0.4647  | 3477  | 21.408   | 0.4648  | 3481  | 21.449    | 0.4652  |
| 5  | 5  | 3467  | 21.542   | 0.4665  | 3469  | 21.45    | 0.4653  | 3473  | 21.427    | 0.4671  |
| 6  | 6  | 3492  | 22.907   | 0.4094  | 3493  | 22.78    | 0.4093  | 3496  | 22.75     | 0.4109  |
| 7  | 7  | 3474  | 21.907   | 0.4468  | 3475  | 21.836   | 0.4468  | 3478  | 21.789    | 0.4484  |
| 8  | 8  | 3457  | 22.17    | 0.4348  | 3456  | 22.054   | 0.4350  | 3460  | 22.06     | 0.4352  |
| 9  | 9  | 3473  | 22.606   | 0.4166  | 3474  | 22.485   | 0.4173  | 3476  | 22.493    | 0.4183  |
| 10 | 10 | 3475  | 22.114   | 0.4417  | 3476  | 22.033   | 0.4413  | 3480  | 21.981    | 0.4432  |
| 1  | 1  | 3475  | 21.878   | 0.4521  | 3475  | 21.766   | 0.4503  | 3478  | 21.717    | 0.4522  |
| 2  | 2  | 3452  | 21.096   | 0.4871  | 3452  | 21.01    | 0.4855  | 3457  | 20.939    | 0.4872  |
| 3  | 3  | 3477  | 22.041   | 0.4431  | 3478  | 21.926   | 0.4430  | 3482  | 21.849    | 0.4455  |
| 4  | 4  | 3477  | 21.581   | 0.4648  | 3475  | 21.473   | 0.4652  | 3481  | 21.473    | 0.4653  |
| 5  | 5  | 3469  | 21.525   | 0.4685  | 3470  | 21.425   | 0.4663  | 3473  | 21.42     | 0.4673  |
| 6  | 6  | 3492  | 22.891   | 0.4100  | 3489  | 22.784   | 0.4089  | 3496  | 22.743    | 0.4113  |
| 7  | 7  | 3473  | 21.967   | 0.4456  | 3475  | 21.834   | 0.4465  | 3477  | 21.755    | 0.4495  |
| 8  | 8  | 3456  | 22.18    | 0.4336  | 3457  | 22.057   | 0.4341  | 3461  | 22.056    | 0.4350  |
| 9  | 9  | 3473  | 22.661   | 0.4164  | 3471  | 22.516   | 0.4167  | 3477  | 22.51     | 0.4172  |
| 10 | 10 | 3478  | 22.128   | 0.4406  | 3474  | 21.984   | 0.4416  | 3480  | 21.959    | 0.4425  |
Table 5
Scores for the second measurement data collection.

| n  | a    | APA1          | APA2          | APA3          |
|----|------|---------------|---------------|---------------|
|    |      | PC1  PC2  PC3 | PC1  PC2  PC3 | PC1  PC2  PC3 |
| 1  | 1    | −0.0069  −0.1885  0.1416 | −0.3349  −0.1487  −0.0925 | −0.1785  −0.6023  −0.0732 |
| 1  | 2    | −3.0601  0.4647  0.1627 | −3.2877  0.4496  0.0201 | −3.0738  0.0301  −0.0033 |
| 1  | 3    | 0.3664  0.0239  0.1112 | 0.2262  −0.2647  −0.0812 | 0.3825  −0.4988  −0.1413 |
| 1  | 4    | −0.6892  −0.7911  0.1377 | −0.7977  −0.9551  −0.0127 | −0.7178  −1.1268  −0.0015 |
| 1  | 5    | −1.1702  −0.3044  0.1132 | −1.4105  −0.3265  −0.0376 | −1.1247  −0.5988  −0.0109 |
| 1  | 6    | 3.0800  −0.2826  0.1544 | 2.8343  −0.0928  0.0467 | 3.0616  −0.7194  −0.0233 |
| 1  | 7    | 0.0944  −0.0217  0.1100 | −0.1529  −0.0462  −0.0810 | 0.0954  −0.5552  −0.0827 |
| 1  | 8    | −0.0462  1.7411  0.0643 | −0.1928  1.5565  −0.1108 | −0.1652  1.3562  −0.1281 |
| 1  | 9    | 1.7295  1.0121  0.1065 | 1.5214  0.9012  −0.0766 | 1.6282  0.5311  −0.1415 |
| 1  | 10   | 0.4564  0.0726  0.1705 | 0.2870  0.0924  −0.0269 | 0.4345  −0.2574  −0.0189 |
| 2  | 1    | −0.0968  −0.2389  0.1275 | −0.2596  −0.3236  −0.0675 | −0.1573  −0.5893  −0.1001 |
| 2  | 2    | −2.9814  0.4016  0.1455 | −3.2707  0.5685  −0.0063 | −3.0965  0.0171  0.0026 |
| 2  | 3    | 0.5067  −0.1110  0.0508 | 0.2284  −0.2628  −0.0979 | 0.4030  −0.5969  −0.1036 |
| 2  | 4    | −0.6426  −0.9802  0.1102 | −0.9594  −0.9336  −0.1366 | −0.7344  −1.2416  −0.0776 |
| 2  | 5    | −1.3050  −0.0569  0.1404 | −1.2924  −0.2597  −0.0358 | −1.1857  −0.6329  −0.0237 |
| 2  | 6    | 3.1394  −0.2506  0.1975 | 3.0316  −0.4128  0.0095 | 3.0888  −0.7052  0.0082 |
| 2  | 7    | 0.0221  −0.0590  0.0135 | −0.0193  −0.1867  −0.0912 | 0.0169  −0.4901  −0.1168 |
| 2  | 8    | −0.1051  1.7079  0.0604 | −0.3004  1.7116  −0.0962 | −0.1132  1.3843  −0.0936 |
| 2  | 9    | 1.6850  0.9888  0.0550 | 1.5622  0.8169  −0.0990 | 1.6368  0.6412  −0.0619 |
| 2  | 10   | 0.4670  0.0796  0.1442 | 0.4245  −0.0478  0.0124 | 0.4925  −0.4414  −0.0139 |
| 3  | 1    | −0.1157  −0.2500  0.1377 | −0.2038  −0.2916  −0.0799 | −0.1784  −0.6013  −0.0888 |
| 3  | 2    | −3.1282  0.5328  0.2048 | −3.1897  0.5046  0.0307 | −3.0933  0.0202  −0.0323 |
| 3  | 3    | 0.4304  −0.1552  0.0781 | 0.3374  −0.3096  −0.0928 | 0.3577  −0.7296  −0.1358 |
| 3  | 4    | −0.7456  −0.8220  0.1110 | −0.9830  −0.7346  −0.0246 | −0.7076  −1.2729  −0.0401 |
| 3  | 5    | −1.2333  −0.2317  0.1098 | −1.2993  −0.3714  −0.0492 | −1.2000  −0.6408  −0.0274 |
| 3  | 6    | 3.1028  −0.2712  0.1937 | 2.8623  −0.0757  0.0148 | 3.0690  −0.7165  0.0109 |
| 3  | 7    | 0.0835  0.0821  0.0642 | −0.0134  −0.1829  −0.1036 | −0.1022  −0.4488  −0.1274 |
| 3  | 8    | −0.1055  1.8167  0.0396 | −0.2252  1.6469  −0.1236 | −0.0662  1.3033  −0.1088 |
| 3  | 9    | 1.7585  1.0277  0.1274 | 1.4782  1.0929  −0.0644 | 1.7350  0.5890  −0.0757 |
| 3  | 10   | 0.6542  −0.1384  0.1199 | 0.2628  0.0794  −0.0419 | 0.4849  −0.4436  −0.0677 |

Table 6
Eigenvales and eigenvector for the second measurement data collection.

|          | PC1     | PC2     | PC3     |
|----------|---------|---------|---------|
| Eigenvalue| 24.555  | 0.5352  | 0.0093  |
| Proportion| 0.189   | 0.178   | 0.003   |
| Cumulative| 0.189   | 0.997   | 1       |

CTQ's | Eigenvectors

| Mass    | 0.492   |
| Diameter| 0.619   |
| Density | −0.612  |

In the first data, the measurements of the original data are shown in Table 1 and the principal components’ scores of these data are shown in Table 2. Table 3 presents the eigenvalues and eigenvector data of the components.

In view of the second data collection, the Table 4 presents the original data of the bobbin’s measurements. The dimensionless data for the components’ scores are shown in Table 5. Table 6 describes the eigenvalue and eigenvector data for the scores, representing the second measurement data collection.
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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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