A unique double whammy of benefits for the shop floor in one hand-held

Fast easy coating thickness measurement and practical production process diagnosis at the same time. Fischer Instrumentation (GB)Ltd explains how this concept can be applied to the shop floor.

Not only does the FMP100 handheld deal efficiently with any coating thickness measurement you throw at it, it is soon to be compatible with Fischer's Factory Diagnosis Diagram (FDD®) – a new software which will highlight 'at a glance' weaknesses in your manufacturing process or production line without the need for additional data analysis. The FDD has already proved itself to be immensely popular, particularly in Germany, with Fischer's MMS bench system. To have it shortly available with Fischer's new, hi-tech hand-held will make it invaluable to the UK market, whose preference is to measure 'in-situ' on the shop floor.

The FMP100 hand-held has all the functionality of a coating measurement bench system in a slim compact unit, with a range of probes to measure the most awkward of surfaces. It has a bright graphical user interface and utilizes CE Windows technology; these features making it ideal for integration with FDD® for 'at a glance' manufacturing process diagnosis in addition to coating thickness measurement data.

How the FDD® can be used is demonstrated in the diverse application examples of pin manufacture for needle bearings and automotive body coatings, although it can be applied to nearly all areas of production.

The Factory Diagnosis Diagram (FDD®) – an efficient tool for quality control

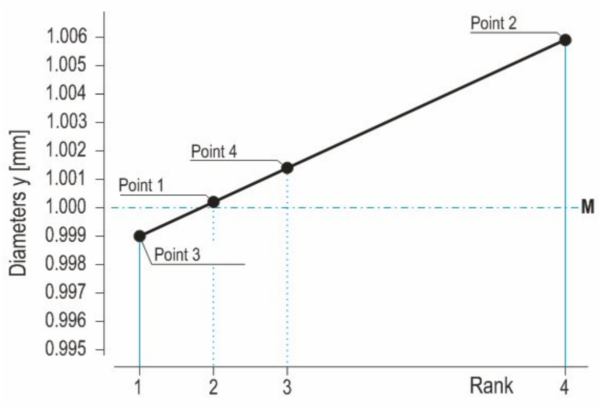
During electroplating or heat treatment, operations parts are usually mounted on plating or charging racks that can, for practical purposes, be described as position matrices. An optimized production process should show no significant changes in the quality characteristics of the products after going through the production cycle, regardless of the product's position within the matrix. Measurement results taken from a random sample of finished parts over a number of predetermined rack locations can be displayed easily in a Factory-Diagnosis-Diagram (FDD®). The descriptive nature of this diagram truly provides an "at a glance" display of essential quality related information. Weaknesses in a manufacturing process or a production line become evident, without the need for complex data analysis.

The Factory Diagnosis Diagram (FDD®) is based on a rank diagram typically used in probability charts. As such it has many areas of application as a simple yet efficient instrument of quality management. Its distinctive feature is that the test results of a certain quality feature, which is demanded to be of the same value at several locations of a product, are fundamentally always reproduced as a plot in the form of a straight rank line. This simple presentation method allows the production manager to arrive at quick and remarkably reliable information regarding the current production quality without the need for additional evaluation steps.

Application: pin manufacture for needle bearings

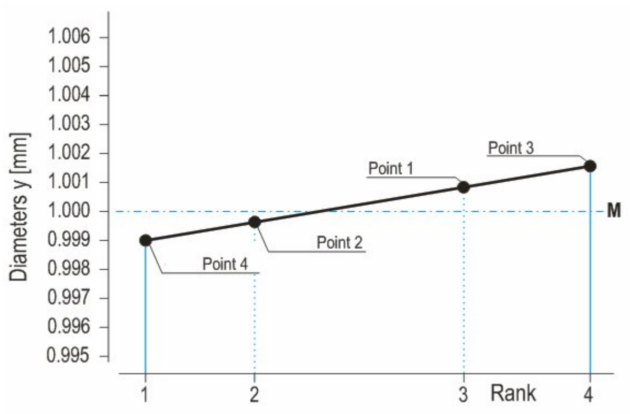
How to arrive at a Factory Diagnosis Diagram can be demonstrated in a simple manner using the manufacture of pins for needle bearings as an example: For a pin, (target length L

= 20.00 mm; target diameter D = 1.000 mm) taken from a defined location, a diameter value is determined according to the test instructions at four equally spaced measurement locations, namely at 4 mm, 8 mm, 12 mm and 16 mm, with the reading carried out to 0.1 µm (“estimation point”); this provides the following result, Fig. 1 below:



Ranking of pin diameters			
Rank no. 1	Rank no. 2	Rank no. 3	Rank no. 4
Point 4	Point 2	Point 1	Point 3
ø 0.9990 mm	ø 1.0002 mm	ø 1.0014 mm	ø 1.0059 mm

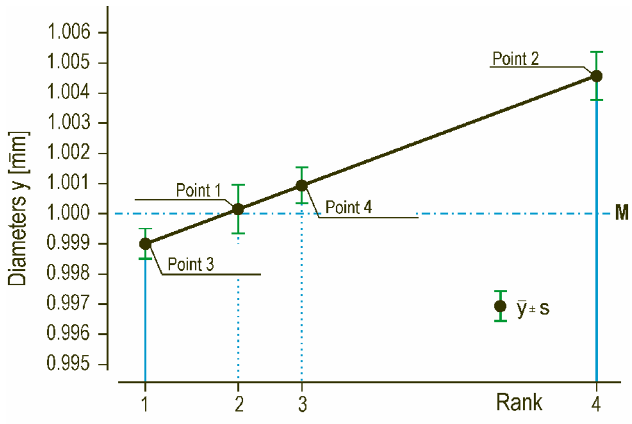
Fig. 1. Rank order of diameter values measured on four specified places of a defined pin



Ranking of pin diameters			
Rank no. 1	Rank no. 2	Rank no. 3	Rank no. 4
Point 4	Point 2	Point 1	Point 3
ø 0.9990 mm	ø 0.9997 mm	ø 1.0008 mm	ø 1.0016 mm

Fig. 2. Analogous to Fig. 1: Rank order of a further pin after realizing a quality improvement

The diameter reading at 8 mm (2nd measurement location) deviates in a “significant” (systematic) manner – according to a subjective evaluation – and results in the relative “steep slope” of the straight rank line. A readjustment of the production machine, carried out as a result, leads to a recognizably “better” result for the next pin, Fig. 2. The slope of the rank line is significantly less steep; in addition, the (changed) order and more uniform distribution of the measurement results over the rank distance suggest that the differences between local diameter readings are “purely coincidental”. “At a glance” one is able to draw the conclusion of a “quality improvement”.



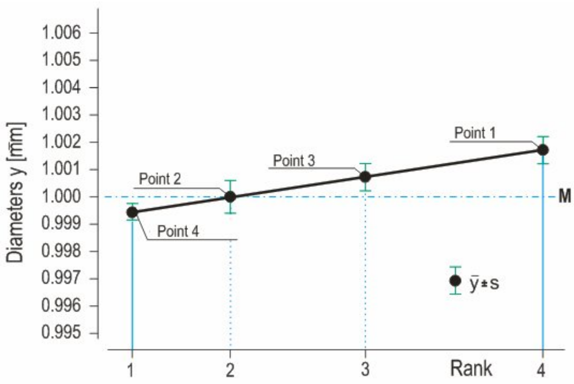
Ranking of pin diameters			
Rank no. 1	Rank no. 2	Rank no. 3	Rank no. 4
Point 3	Point 1	Point 4	Point 2
$\bar{y}$ = 0.9990 mm	$\bar{y}$ = 1.0001 mm	$\bar{y}$ = 1.0009 mm	$\bar{y}$ = 1.0046 mm
s = 0,0005 mm	s = 0.0008 mm	s = 0.0006 mm	s = 0.0008 mm

Fig. 3. Rank order of x, s-values (n = 4) obtained at four specified places of a defined pin

To increase the reliability of the information, the “testing accuracy” has been raised for this production by carrying out four diameter measurements at each of the four positions mentioned, each time advancing the angle by 45º. The four diameter values at each longitudinal position can be interpreted as random samples (sample size n = 4), because the advance in the angle was not carried out against a defined starting point. One can deduce from Fig. 3, again at a glance, that the diameter at the 2nd measurement location (i.e., at 8 mm) deviates significantly and not randomly from the other measurement locations. The measurement data scatter (“scatter bar”), visualized using the standard deviation (± s), does not indicate significant scatter differences between the four measurement locations.

The necessary readjustment of the production machine provided a significantly “better” result, ref. Fig. 4. With a comparable scatter of the diameter values at the four measurement locations, the mean values are now distributed with a satisfactory uniformity across the length of the “gently” increasing rank line of the Factory Diagnosis Diagram.

In many cases, maintaining a tolerance is required for the quality feature under observation. In the example above, the specification limits for the pin diameters were determined with 1.004 mm (USL = upper specification limit) and 0.996 mm (LSL= lower specification limit).



Ranking of pin diameters			
Rank no. 1	Rank no. 2	Rank no. 3	Rank no. 4
Point 4	Point 2	Point 3	Point 1
$\bar{y}$ = 0.9995 mm	$\bar{y}$ = 1.0000 mm	$\bar{y}$ = 1.0008 mm	$\bar{y}$ = 1.0018 mm
s = 0.0003 mm	s = 0.0006 mm	s = 0.0005 mm	s = 0.0005 mm

Fig. 4. Analogous to Fig 3: Rank order of a further pin after realizing a quality improvement

Application: Auto body coating

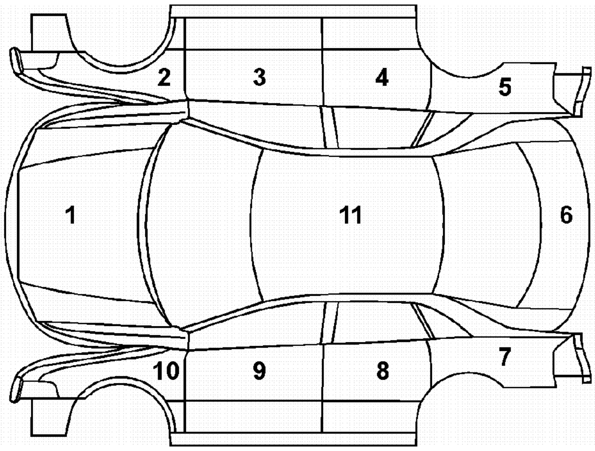


Fig. 7. Top view of an auto body (butterfly diagram)

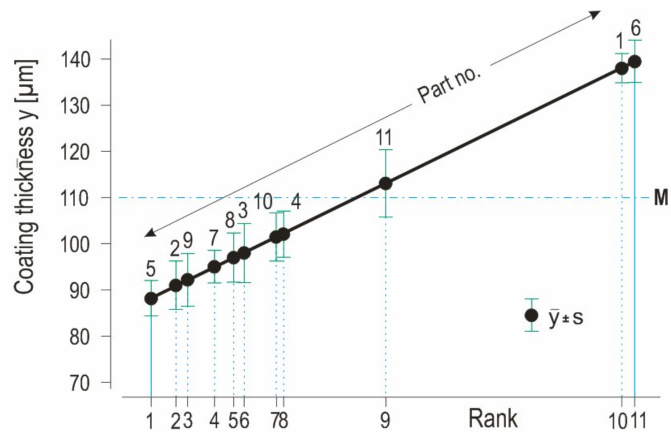


Fig. 8. Factory Diagnosis Diagram of an auto body based on the evaluation values of Table 1

For auto bodies, the multiple sections explained above arise practically “by themselves”, ref. Fig. 7. For the k = 11 (clockwise) consecutively numbered individual parts of the auto body evaluated here, the thickness of a new type of coating structure (target value d = 110 µm) was to be monitored in the course of a pilot trial; according to test instructions following a specified measurement plan, n = 5 measurements were to be performed for each individual part.

Coating thickness y in µm	**Part designation**	**Part number**	**n**	***s***	**s**	**Rank*) i**
137, 133, 139, 141, 140	Engine hood	1	5	138.0	3.16	10
95, 87, 86, 89, 98	Front end right	2	5	91.0	5.24	2
98, 95, 103, 89, 105	Front door right	3	5	98.0	6.40	6
107, 103, 95, 99, 106	Rear door right	4	5	102.0	5.00	8
90, 83, 86, 89, 93	Rear end right	5	5	88.2	3.83	1
137, 143, 140, 133, 144	Tailgate	6	5	139.4	4.51	11
97, 93, 100, 91, 94	Rear end left	7	5	95.0	3.53	4
98, 95, 103, 89, 100	Rear door left	8	5	97.0	5.34	5
90, 87, 96, 89, 99	Front door left	9	5	92.2	5.07	3
103, 100, 110, 98, 97	Front end left	10	5	101.6	5.22	7
111, 117, 125, 109, 107	Roof	11	5	113.8	7.29	9

*) Ranks: i = 1 to k = 11

Table 1. Coating thickness of an auto body – measurement and evaluation results

Table 1 shows the measurement and evaluation results for a certain auto body; Fig. 8 shows the corresponding Factory Diagnosis Diagram. Here, it can be deduced (subjectively) that the scatter is not characteristically different from one body part to the next but the mean coating thickness deviates significantly upward for two ranks. The body parts represented by these ranks are, therefore, responsible for the relatively steep slope in the rank line. If one additionally inserts the specified coating thickness tolerance (USL = 140 µm; LSL = 80 µm) into the Factory Diagnosis Diagram, then it becomes immediately apparent (Fig. 9) that measures for improving the quality are recommended.

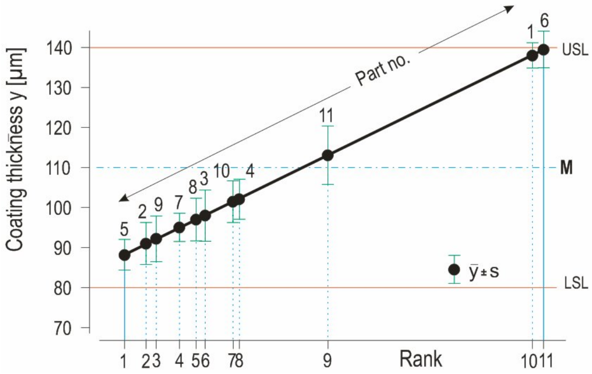


Fig. 9. Analogous to Fig. 8: Introduction of specification limits (USL / LSL)

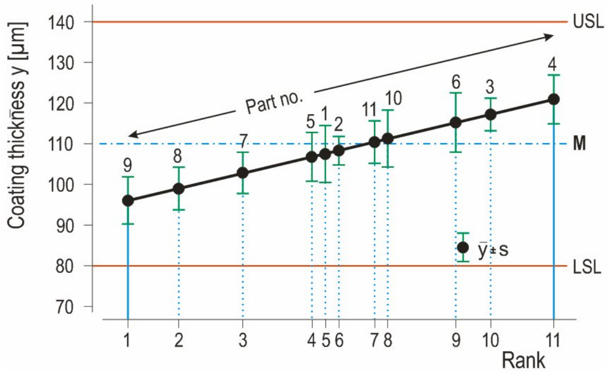


Fig. 10. Analogous to Fig. 9: Factory Diagnosis Diagram of a further auto body after realizing a quality improvement

At the end of these measures, the next auto body of this series provides the following Factory Diagnosis Diagram, ref. Fig. 10. The scatter of the coating thickness values of the individual parts has apparently not changed significantly. However, the rank line now runs very satisfactorily within the tolerance, with the upper/lower ranks at a sufficiently safe distance from the respective relevant specification limits (USL / LSL). With this now significantly gentler slope of the straight line, the mean values are distributed in a satisfactory uniform manner along the rank distance as well. It can be concluded (subjectively) that there are no noteworthy (systematic) differences between the parts of this auto body with regard to the coating thickness. This condition of the system is to be maintained for the future.

The application examples mentioned above already indicate the enormous potential inherent in the Factory Diagnosis Diagram. A measurement device such as the FMP100 has a clear graphical user interface where the measurement data and a corresponding FDD can be displayed for 'in-situ' fast information. This can be downloaded directly to a PC for further inspection. Position, slope and point arrangement of the rank line as well as the size and the uniformity of the associated scatter bars can be evaluated at a glance. In most cases, a production manager familiar with his manufacturing devices and quality features will quickly gain valuable insights that can help achieve significant and often sufficient progress in quality management, without requiring the use of complex statistical evaluation methods.

A more detailed version of the Paper can be found at http://www.fischer-material-analysis.co.uk

The FDD® has been developed by the Institute for Electronics and Measurement Technology Helmut Fischer in Germany, innovative leaders in the field of coating thickness measurement, materials analysis, microhardness testing, electrical conductivity and ferrite content measurement as well as for density and porosity testing. Fischer Instrumentation (GB) Ltd is the sales and distribution centre for the UK and now handles most hand-held assembly, soon to include the new hi tech FMP100.