Quality Control of Shot Media by Sieve Analysis

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Abstract

Concerning shot peen processing, the governing factors to ensure high quality results are more than steering of process and capabilities of equipment.

The quality of shot media, be it manufactured from glass, steel, ceramic or any other material, is vital in ensuring satisfactory process results.

The quality of shot media is variable. One of the major problems is being able to guarantee shot sizes from lot to lot.

It can be difficult to clearly define requirements and tolerances. Problems can arise with the failure to obtain a result correlation of shot size between supplier, shot peen source and shot peen processed end product customer.

Keywords

Sieve, sieve analysis, media correlation, ASTME 11.

Shot peening is a process which requires high standards of quality controls during the manufacturing operations and at final inspections. However, the value of all surveillances of in process parameters are reduced, if the quality of the actual shot in use is unsatisfactory or questionable.

As a supplier of shot peen services to both internal or external customer, one must be prepared to accept varying requirements from customer to customer, dependent upon their specific end use expectations. Aerospace, automotive and medical in most instances, work out from varying materials and varying quality requirements.

With such a wide spectrum of customer requirements, difficulties arise very often in the procurement of the shot media. Individual customers invariably specify the condition of the process media. This situation often leaves the supplier of shot peened services with a dilemma. To hold stocks of media which is dedicated to individual customers is costly. Large stocks of often very similar media would have to be held, which ties up capital and storage facilities. Further, a continual exchanging of media in and out of the shot peening equipment is time consuming and inefficient. This type of situation is unsatisfactory for all parties, not least the customer who invariable must pay for this extra effort.

A solution to the problem of varying customer shot requirements is for the shot peen supplier to produce a common specification which meets the intentions of all customers. Invariably, this will mean that most detail has to be gleaned from the customers' requirements, with the most exacting and demanding parameters remaining. This will provide the foundation for the shot peen suppliers own internal specification. It is worthy of note, that if a customer specification appears to be well over the norm for a familiar material, it is prudent to attempt to get the specification amended to fall within common boundaries. This is beneficial for all parties.

The importance of the role of the Supplier(s) of shot peen media cannot be emphasized strongly enough. The manufacturing methods and controls required to maintain continuing high quality standards are exacting. To achieve the levels of quality materials required and in particular establish trust in a media supplier is a time consuming business. The initial on site audit, coupled with the examination of each delivery of individual media is a means of establishing a quality portfolio. Dependent upon the number of deliveries from the media supplier, a period of up to two years, with an inspection of the quality of each delivery, can be required to fully establish confidence. Once a satisfactory level of confidence is established, reduced inspection frequency can be introduced. The inspection of the media deliveries will consist of chemical analysis, hardness inspection, sieve analysis and certificate and documentation content.

The receiving inspection of shot media with respect to sieve analysis will now be discussed in depth.

The purchase order, or in certain circumstances the shot media quality plan to the media supplier, will require that a material certificate/certificate of compliance be provided with each delivery of media. This certificate will provide details of the chemical analysis, hardness, material batch number, shot size ranges in weight or percentages. If the media supplier has established a good quality record, it should be possible to accept the certificate on face value and forward the delivery to store or direct into manufacturing. However, regardless of our confidence with the stated quality of the media, should a customer during the course of an audit require a random inspection of this same media, are we certain that random sieve analysis will provide the same results as presented on the certificate of conformity? The answer to this question is most definitely NO!

Obviously, when taking a shot media sample, conditions must be established where fully representative media is obtained for the sample test.

(a) The media in its container, (be it sack or box) must be thoroughly mixed by agitation/stirring before a sample is taken. Alternatively, a sample tube can be inserted into the container in order to remove media from varying levels within the container.

(b) The sieve set must be in satisfactory condition and within calibration parameters.

(c) The scales must be calibrated.

(d) The sieve machine must be of an approved type and compatible with the type used by the media supplier.

(e) The method of conducting the sieve analysis must be in a manner which will provide meaningful results. For example, preparation, brushing and general good laboratory practices.

Having conducted the sample inspection of shot media and met all of the foregoing requirements, it is reasonable to expect a close correlation with the shot media suppliers results. Should this not be the case, what conclusions are to be taken?

The first and obvious conclusion is that the results from the supplier are incorrect! The normal course of events will be to request that the supplier conduct a further sieve analysis, due to the differences between the correlation. Should this second result from the supplier fail to provide correlation with the sample, but is similar to the suppliers original result, the next questionable factor is the testing equipment. Should it be established that this equipment is perfectly satisfactory, the next obvious step is to attempt to ensure that both parties conduct a sieve analysis on the same sample of media, in order to ensure a correlation is obtainable! Unfortunately, again both results differ by a considerable margin. What is causing this difference? Is it equipment/calibration to tolerances or has the supplier provisioned media which is nonconforming to our quality requirements?

Investigations are conducted at both media supplier and in-house to check out equipment and ensure that calibrations have been conducted satisfactorily. It is established that sieves at the supplier both for production and laboratory analysis are fully conforming to ASTM 11. It is further established that in-house sieves fully meet ASTM 11 requirements!

To clarify exactly what is the discrepancy and where the differences are occurring, the results of an actual sieve analysis are presented:

Taking S-110 as the example, sieve number 40 (425 uM) should retain a maximum of 5% of the shot sample under test. The rest of the shot sample should pass through. However, sieve number 40 with nominal opening of 425 uM has a tolerance of ±19 uM! In other words, sieve number 40 can vary from 406 to 444 uM.

During the investigations to establish why correlation was unobtainable, it was established that the in-house testing resulted that over 5% of the sample was retained in the number 40 sieve. The media suppliers number 40 sieve retained less than 5% shot and therefore was conforming to specification. The cause of the discrepancy was the fact that although both sieves met ASTM 11 standard, the suppliers sieve was 430 uM and the in-house sieve was 419 uM. Actual results are thus presented:

	SIEVE ANALYSIS S-110			
SIEVES NO.	SIEVES uM	REQUIREM.	SUPPLIER	NORSK JETM.
35	500	0	0	0
40	425	5% max	5	14
45	355	••	56,9	••
50	300	85%min.cum.	90,1	91
80	180	6%max.	••	9
425+300+180um=min.96% on sieves			99,8	100

The differences between the two results are very obvious. In order to verify further our suspicions that the analysis results from laboratory to laboratory could be extremely variable, we established a "Round Robin" exercise with Volvo Flygmotor in Sweden and SNECMA in France. Using the same shot media sample as we received from the media supplier, the exercise was commended. Both companies requested to conduct the "Round Robin" were extremely cooperative and interested to analyze the exercise results. Actual "Round Robin" exercise results are thus presented:

		SIEVE ANALYSIS S-110				
SIEVES NO.	SIEVES uM	REQUIREM.	SUPPLIER	NORSK JETM.	VOLVO FLYGM.	SNECMA
35	500	0	0	0	0	0
40	425	5% max	5	14	9,5	2,32
45	355	••	56,9	••	47,5	61,93
50	300	85%min.cum.	90,1	91	85,5	86,65
80	180	6%max.	••	9	13,6	13,35
425+300+180um=min.96% on sieves			99,8	100	99,1	100

Again it is very obvious that the results have a large variation. (Note that the same media sample was tested by both companies.) These results in no way support Norsk Jetmotors opinion that the media suppliers analysis was incorrect, despite the fact that the results are outside specification requirements. In fact, these results serve to increase the concern that a meaningful correlation appears impossible to achieve.

The statistics for four independent sieve analysis are now available. It has been verified that all four laboratories have conducted the sieve analysis in a like manner, with calibrated and conforming equipment.

At this stage an opinion can be raised, which would point to the fact that the large tolerance bandwidth of 38 uM, on a No 40 sieve graduated at 425 uM, must be causing the large variation in sieve analysis results from laboratory to laboratory.

S110 shot has a nominal diameter of 315 uM, and should all the shot in a delivery meet this nominal, regardless, a small variation will show up during sieve analysis. The degree of variation will be dependent on the tolerance of the actual sieve used by the laboratory to test the sample from delivery of fully conforming nominal sized shot.

We are now faced with the dilemma of how to resolve this problem and arrive at a situation where media analysis can be conducted in a meaningful manner, and perhaps even more importantly, how can controls be tightened to ensure that the media supplier is capable of provisioning to Specification! Several possibilities spring to the forefront:

Is the media supplier the source we should exert maximum effort? By for example, insisting that they use a sieve family with a very tight tolerance of say ±1%, and accept their laboratory results as final and conduct no correlation?

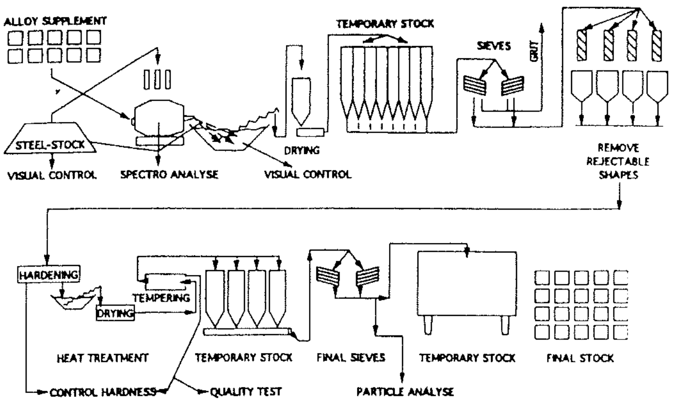
Should the specifications which establish the Quality requirements be completely amended with respect to sieve sizes?

Should we as a supplier of shot peen services to our internal and external customers, use sieves manufactured to an extremely tight tolerance bandwidth?

Should the possibilities of alternative methods of measuring media size be investigated?

Regardless of the eventual course(s) of action to be taken, it is vital that an open dialogue be maintained with the media supplier. To conclude, media supplier and shot peened services supplier must have an inspection system/method which is usable and as simple and effective as possible.

To this end communication must be established with the media supplier and see what can be achieved. The following diagram shows a simple manufacturing process cycle of a steel shot:



This process is not completely up-to-date, but assuming that the current process is very similar, we see that the final sieving operations directly before the media is packed and stored should be conducted with tight tolerances sieves (in process sieves). If the media supplier were to introduce such tight tolerance sieves into the manufacturing process, it should be possible for all media customers to conduct a meaningful and satisfactory sieve analysis, by using the same right tolerance sieves.

If we again use shot size S110 as an example, then sieve 425 uM should be nearer 406 uM in order to achieve as near as possible 0% for this sieve!

Similar, if we examine sieve 300 uM which has a tolerance of ±14 uM, should this be in the upper tolerance range band of say 314 uM, in order to pass the minimum shot to the next sieve which is 180 uM.

As this undesirable situation becomes more and more evident, it is reasonable to question whether the media suppliers are showing enough consideration and concern to their customers needs and expectations by not tightening the tolerances on the process sieves! However, the media suppliers are meeting the ASTM 11 specification, and purely on a commercial basis no supplier is going to self impose a more stringent requirement.

The question was raised as to whether as a shot peen supplier we should examine the possibilities of modifying our laboratory sieves in order to self achieve the analysis results required. In some instances this can be desirable. However, this would mean conducting a difficult modification and/or adjustment program to the sieves in order to achieve accurately the desired sizes. It is very questionable that guarantee of a good result.

We return to the specification which deals with calibration. Should this be thoroughly reviewed and possibly amended to dramatically reduce the current wide tolerance bandwidths? See the extract from ASTM E 11-87 on the next page.

Laser measuring methods is known, but relatively little used in industry due to the relatively harsh working environment and practical problems of both achieving and interpreting results. With respect to measuring shot media laser has potential but in this application is still very much at the Research and Development (R & D) stage.

Round Robin tests have proven in our experience to provide just more data which serves to confirm that current sieve methods to achieve correlation are worthless! The results have been so spread. However, some possibilities exist with this form of testing and the benefit should be considered. For example, from close examination from all test results, it could be possible to establish the actual size of an error margin that could be acceptable? This error margin could be in the form of % tolerance that we could accept outside the established tolerance. This is in some way a hypothetical question, but it would be of interest to raise the case with one's customers.

Most shot peening machines in current use are equipped with an efficient shot sorting system, which is capable of segregating over/under sized media and also deformed media. This means that should the media be of doubtful quality, with respect to size when introduced into the shot peen machine, due to the efficiency of the sorting system, the actual product being peened will be processed by conforming shot. The down side of depending fully upon the sorting system is that if the complete load of media in the machine is in the high tolerance band, the time taken for the sorting system to fully process the media will mean that the product being processed could be subjected to a higher than desirable impact by "large media" until the sorting cycle is concluded. (Depends on the sorting system.)

As a conclusion, it would appear that the most satisfactory manner in which all parties are satisfied with the quality of the products they manufacture and use is to achieve a combination of tighter sieve tolerances and in process sorting.

Media suppliers must be more critical with respect to the tolerance bandwidths of their in process/manufacturing sieves. They must monitor more carefully the tolerance of respective sieves and be constantly aware of the difficulties which can arise for a shot peen supplier, if a sieve is hard against a tolerance limit. The provision of detail of individual sieve tolerances would be useful to the shot peen supplier and if possible should be noted on the material certificates.

Shot peen suppliers must ensure that the in process sorting system is reliable and sorts in an efficient manner. Further, by knowing more exactly the % of the range of sizes of media they receive, they can run sorting programs for established periods prior to commencing processing of products. ❍

TABLE 1 Nominal Dimensions, Permissible Variations for Wire Cloth of Standard Test Sieves (U.S.A.) Standard Series

Sieve Designation, (W)		Nominal Sieve Opening, in.[C]	Permissible Variation of Average Opening from the Standard Sieve Designation (y)	Intermediate Tolerance (z)[G]	Maximum Individual Opening (x)	Nominal Wire Diameter, mm[A]
Standard[B]	Alternative					
(1)	(2)	(3)	(4)	(5)	(6)	(7)
125 mm	5 in.	5	±3.7 mm	130.0 mm	130.9 mm	8.00
106 mm	4.24 in.	4.24	±3.2 mm	110.2 mm	111.1 mm	6.40
100 mm[D]	4 in.[D]	4	±3.0 mm	104.0 mm	104.8 mm	6.30
90 mm	3½ in.	3.5	±2.7 mm	93.6 mm	94.4 mm	6.08
75 mm	3 in.	3	±2.2 mm	78.1 mm	78.7 mm	5.80
63 mm	2½ in.	2.5	±1.9 mm	65.6 mm	66.2 mm	5.50
53 mm	2.12 in.	2.12	±1.6 mm	55.2 mm	55.7 mm	5.15
50 mm[D]	2 in.[D]	2	±1.5 mm	52.1 mm	52.6 mm	5.05
45 mm	1¾ in.	1.75	±1.4 mm	46.9 mm	47.4 mm	4.85
37.5 mm	1½ in.	1.5	±1.1 mm	39.1 mm	39.5 mm	4.59
31.5 mm	1¼ in.	1.25	±1.0 mm	32.9 mm	33.2 mm	4.23
26.5 mm	1.06 in.	1.06	±0.8 mm	27.7 mm	28.0 mm	3.90
25.0 mm[D]	1 in.[D]	1	±0.8 mm	26.1 mm	26.4 mm	3.80
22.4 mm	⅞ in.	0.875	±0.7 mm	23.4 mm	23.7 mm	3.50
19.0 mm	¾ in.	0.750	±0.6 mm	19.9 mm	20.1 mm	3.30
16.0 mm	⅝ in.	0.625	±0.5 mm	16.7 mm	17.0 mm	3.00
13.2 mm	0.530 in.	0.530	±0.41 mm	13.83 mm	14.05 mm	2.75
12.5 mm[D]	½ in.[D]	0.500	±0.39 mm	13.10 mm	13.31 mm	2.67
11.2 mm	7/16 in.	0.438	±0.35 mm	11.75 mm	11.94 mm	2.45
9.5 mm	⅜ in.	0.375	±0.30 mm	9.97 mm	10.16 mm	2.27
8.0 mm	5/16 in.	0.312	±0.25 mm	8.41 mm	8.58 mm	2.07
6.7 mm	0.265 in.	0.265	±0.21 mm	7.05 mm	7.20 mm	1.87
6.3 mm[D]	¼ in.[D]	0.250	±0.20 mm	6.64 mm	6.78 mm	1.82
5.6 mm	No. 3½[E]	0.223	±0.18 mm	5.90 mm	6.04 mm	1.68
4.75 mm	No. 4	0.187	±0.15 mm	5.02 mm	5.14 mm	1.54
4.00 mm	No. 5	0.157	±0.13 mm	4.23 mm	4.35 mm	1.37
3.35 mm	No. 6	0.132	±0.11 mm	3.55 mm	3.66 mm	1.23
2.80 mm	No. 7	0.11	±0.095 mm	2.975 mm	3.070 mm	1.10
2.36 mm	No. 8	0.0937	±0.080 mm	2.515 mm	2.600 mm	1.00
2.00 mm	No. 10	0.0787	±0.070 mm	2.135 mm	2.215 mm	0.900
1.70 mm	No. 12	0.0661	±0.060 mm	1.820 mm	1.890 mm	0.810
1.40 mm	No. 14	0.0555	±0.050 mm	1.505 mm	1.565 mm	0.725
1.18 mm	No. 16	0.0469	±0.045 mm	1.270 mm	1.330 mm	0.650
1.00 mm	No. 18	0.0394	±0.040 mm	1.080 mm	1.135 mm	0.580
850 µm[F]	No. 20	0.0331	±35 µm	925 µm	970 µm	0.510
710 µm	No. 25	0.0278	±30 µm	775 µm	815 µm	0.450
600 µm	No. 30	0.0234	±25 µm	660 µm	695 µm	0.390
500 µm	No. 35	0.0197	±20 µm	550 µm	585 µm	0.340
425 µm	No. 40	0.0165	±19 µm	471 µm	502 µm	0.290
355 µm	No. 45	0.0139	±16 µm	396 µm	425 µm	0.247
300 µm	No. 50	0.0117	±14 µm	337 µm	363 µm	0.215
250 µm	No. 60	0.0098	±12 µm	283 µm	306 µm	0.180
212 µm	No. 70	0.0083	±10 µm	242 µm	263 µm	0.152
180 µm	No. 80	0.0070	±9 µm	207 µm	227 µm	0.131
150 µm	No. 100	0.0059	±8 µm	174 µm	192 µm	0.110
125 µm	No. 120	0.0049	±7 µm	147 µm	163 µm	0.091
106 µm	No. 140	0.0041	±6 µm	126 µm	141 µm	0.076
90 µm	No. 170	0.0035	±5 µm	108 µm	122 µm	0.064
75 µm	No. 200	0.0029	±5 µm	91 µm	103 µm	0.053
63 µm	No. 230	0.0025	±4 µm	77 µm	89 µm	0.044
53 µm	No. 270	0.0021	±4 µm	66 µm	76 µm	0.037
45 µm	No. 325	0.0017	±3 µm	57 µm	66 µm	0.030
38 µm	No. 400	0.0015	±3 µm	48 µm	57 µm	0.025
32 µm	No. 450	0.0012	±3 µm	42 µm	50 µm	0.028
25 µm[D]	No. 500	0.0010	±3 µm	34 µm	41 µm	0.025
20 µm[D]	No. 635	0.0008	±3 µm	29 µm	35 µm	0.020

[A] The average diameter of the warp and of the shoot wires, taken separately, of the cloth of any sieve shall not deviate from the nominal values by more than the following:

Sieves coarser than 600 µm	5 %
Sieves 600 to 125 µm	7½ %
Sieves finer than 125 µm	10 %

[B] These standard designations correspond to the values for test sieve apertures recommended by the International Standards Organization, Geneva, Switzerland.

[C] Only approximately equivalent to the metric values in Column 1.

[D] These sieves are not in the standard series but they have been included because they are in common usage.

[E] These numbers (3½ to 635) are the approximate number of openings per linear in. but it is preferred that the sieve be identified by the standard designation in millimetres or micrometres.

[F] 1000 µm — 1 mm.

[G] Not more than 5 % of the openings may fall between the limits set by the values in Column 5 and Column 6.