EXPERIENCES IN THE SHOT PEEN FIELD
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ABSTRACT

This paper deals with the experiences encountered over the past fifteen (15) years in both the Domestic and the International regime, as applied to Technical/Quality Control Auditing and Shot Peen problem evaluation.

KEY WORDS

Domestic Regime, International Regime, Shot Peening, Technical Process Auditing, Quality Procedures Auditing

INTRODUCTION

Shot peening has evolved from a process which, at times, gave questionable results, to a process in which intensity and coverage can realistically be verified using NC/Computer controlled systems and Almen fixtures which truly represent the surfaces peened. The experiences discussed demonstrate the progress made and knowledge acquired in the development of good shot peen procedures.

DISCUSSION

The remaining paragraphs of this paper will discuss experiences in both the Domestic and International fields with some evaluation of what was learned during the experience.

DOMESTIC

A good beginning in discussing "Domestic" shot peening is to list Metal Improvement shops audited during this period. The list includes locations in Florida, Massachusetts, North Carolina, Wisconsin, and Ohio. With the exception of the Blue Ash (Ohio) location, all of the sites surveyed used standard shot peen cabinets which were designed to accommodate the type of part most often peened (aerospace, automobile, heavy equipment etc.). All procedures were essentially similar, differing only in the fixtureing required and some special techniques. No particular problems were encountered with the exception of documentation, cleanliness, and orderliness (indications of an active, working shop).

Of the two other local suppliers surveyed, both had weakness. One supplier used rather basic shot peen systems which involved "pressure pot" shot delivery with hand operated "nozzle delivery" valves. The difficulty, therefore, was to obtain constant and non variable shot flow. Coverage of course is not a problem.
DOMESTIC (con't)

using a pressure pot system. Some approximate shot flow per unit time values are listed below:

- Pressure Pot- (11-15#/min)
- Gravity Feed- (11-13#/min)
- Suction Feed- (6-7#/min)

Variation in intensity, however, can be a problem using a "choke" valve which does not deliver constant flow. Frequent use of Almen strips is necessary in order to verify constant intensity values.

The second supplier did not have sufficient knowledge to set up shot peen procedures and therefore required assistance and process sheet approval from the prime supplier. The interesting phenomenon which occurred during the shot peen set up was shot peen pattern striation. The limitation of horizontal/vertical oscillation versus the inability to supply enough "fixed nozzles" to cover the entire area for each operation produced the striation. The pattern of striations developed was verified using the fluorescent tracer inspection method. Shot peen procedures were developed which met the approval of all parties involved. The influence of "oscillation" versus the "fixed nozzle" approach is virtually eliminated with the usage of NC/Computerized shot peen equipment. The irregularities arising from nozzle angle and location are also drastically reduced with this same type of equipment.

A Michigan source, who is no longer an active supplier, was shot peening an HPT Aft Shaft for a local prime supplier. I was there to approve the procedure. This was the first opportunity in the field to review the difficulties involved with this complex configuration. Verifying the intensity of the backside of one set of seal teeth was extremely difficult together with the fact that the outside diameter would measurably distort at the upper limit of intensity and coverage at the poor nozzle angle was not optimum. N/C/Computer controlled equipment was the best answer. Careful procedures with stringent inspection were used for the initial hardware.

One California shot peen source repeened shot peened parts returned from the field. The interesting observation was that no nozzle peening was accomplished at this location. Only wheel peening was used. Scrap part Almen Fixtures were used when supplied by the Prime supplier. Because of the method of peening a masking problem was prevalent. In order to solve this problem the company employed several female employees who were proficient at that operation.
DOMESTIC (con't)

An interesting effect which has never been discussed to my knowledge is the effect of machining on surfaces which are to be shot peened at a low intensity and then inspected using a fluorescent tracer system. One of the suppliers that I regularly visited machined parts for us. There is a standard roughness requirement for the parts I inspected. Unfortunately the supplier machined the parts with NC controlled equipment that produced a very rough surface. Most shot peen requirements are of an intensity at which the machined peaks are obliterated by the force of the projected shot. The low 2-4A Intensity requirement of some of our parts did not allow machined peaks to be obliterated therefore liquid tracer remained entrapped within the valleys of the machined surface and the percent coverage could not accurately be ascertained. In fact it was sometimes very difficult to determine whether the part had even been submitted through a peening cycle.

INTERNATIONAL

AUSTRALIA

Non standard shot peen cabinets and poor control of shot media and Almen strips present problems for these suppliers. As is the case with most overseas suppliers, media and supplies are difficult and expensive to obtain and unless a large number of parts is involved the manufacture of parts is expensive and manufacture is sometimes not competitive. A heavy teaching program was necessary with correction of oscillation and shot flow shutdown problems.

AUSTRIA

Although audited over a period of three years the only experiences were those involved with masking and fixturing.

BELGIUM

Fabrique Nationale possesses a Matsur shot peen cabinet which utilizes four(4) 45 degree nozzles and a lance which are robotically controlled. Supplier primarily shot peens disks. Some differences in coverage due primarily to the use of the lance for internal peening. The Quality Control inspectors have difficulty in determining coverage in the required areas. Evidence of "hand held" nozzle being used for "cosmetic/repair" shot peen procedures. Hand held nozzles not permitted.
INTERNATIONAL (con't)

CZECHOSLOVAKIA

An underdeveloped country which has an excellent glass bead peening facility probably due to the fact that the country produces several types of small aircraft engine. The specially designed cabinet displays no oscillation capability, however, excellent peening procedures and "scrap part Almen fixtures are available for peening small blades, vanes and disks. The method of measuring the "Saturation Point" was incorrect. It should be mentioned that an excellent glass bead peening facility should never be jeopardized by trying to convert the system to a dual purpose glass and cast steel shot peen system.

CHINA

The most experience has been gained in the cities of China during eight (8) years of experience in the international regime. This substantiates the premise that one learns more from problems than from successes.

Shenyang (Liming)

The shot peening equipment included the following:

1. Self-manufactured Deflector Hole Peening cabinet
2. Two nozzle cabinet with 4 inch horizontal oscillation
3. Four nozzle cabinet with fixed nozzles and no oscillation

No classification equipment was available therefore shot was "hand classified" through individual screens. All other operations were satisfactory. Oddly enough I had seen a "home made classifier" the year before which had evidently disappeared. Labor is plentiful in China so hand classification is no problem. I sketched a Sweco classifier so that Liming could manufacture a new classifier. The case of the "disappearing" classifier was never solved.

While working with Liming I befriended a gentleman named Wang Dao Ping who was the resident expert for special processes. On reviewing saturation curves with the foreman it was discovered the curves exceeded the 10% limit. The foreman insisted the curves were satisfactory. Mr. Wang Dao Ping pulled out his calculator, performed the calculations and persuaded the foreman to redo the saturation curves.
INTERNATIONAL (con't)

Visual examination of the shot peen coverage in the square holes in a Blade Retainer peened by Liming indicated that one side of the square hole was not being covered. A step by step evaluation indicated incorrect nozzle alignment. The foreman said the nozzle could not be realigned. We did it with a Vise-Grip. Liming then made a nozzle holder which could be clamped.

Xian (Xian)

Xian was using a Chinese manufactured shot peen cabinet with only fixed nozzle capability and part rotation. The operators were peening parts with unconditioned shot straight out of the bag, with no shot control, no fixtures, no saturation curves, and no inspection/documentation. First the operators had to be trained. Since Xian performed a commercial operation, aerospace requirements had to be taught to the personnel. A three hour lecture was given to 65 Engineers responsible for the shot peen program. It covered information concerning shot control, definitions, intensity, coverage, development of saturation curves, fixtures, methods, and inspection procedures. The shot peen cabinet was refurbished but still only possessed "fixed nozzle" and part rotation capability. Xian was awarded a complicated part and a "Simulated" shot peen fixture was fabricated. Thus began the saga of Mr. White Beard and his antagonist Mr. Blue Coat.

Mr. White Beard requested the verification of the four critical areas by developing the saturation curve. Mr. Blue Coat said "No we will peen the part." Thus the impass. Mr. White Beard said "No saturation curves, no approval. The Chief Engineer persuaded Mr. Blue Coat to run the saturation curves. The saturation curves could not meet the intensity requirements of the drawing. A program was developed for certification of the shot peen cabinet and approval of the process. To say the least Mr. Blue Coat and his associates learned a good deal about saturation curves. The following problems occurred:

1. Eroded Nozzle
2. Broken Nozzle
3. Malfunctioning Valve
4. Plugged Nozzle
5. Plugged Shot Inlet Line
6. Holes in the air and shot lines.
7. Failure of shot elevator
8. Malfunction of part rotation table
9. Unstable Nozzle Alignment
10. Incomplete Saturation Curves
11. Too short a Shot Peen Line
12. Incorrect Impingement Angle
13. Insufficient Air Pressure
14. Inoperable Inoperable Air Gauge
15. Hot Wiring an Auxiliary Air Compressor
16. Rationing of Air Compressor Time/Air
17. Undersized Shot Hopper
Most impressive was the arrival of the "Cavalry" on their bicycles to scurry up and down the shot peen cabinet ladder carrying buckets of shot to keep the shot hopper full.

FRANCE

FAMAT, a joint French/U.S. operation was processing a simple part configuration of an internal diameter. Shot peen of the diameter was accomplished with a single nozzle, French manufactured, N/C controlled shot peen cabinet. Because of the Design/Manufacture of the cabinet there was insufficient kinetic energy generated by the shot stream and an indeterminate saturation curve was generated, accompanied by poor coverage. A special visit was made to the supplier to optimize the saturation curve and instruct personnel in Quality procedures, coverage evaluation, saturation curves, shot handling, etc.

SNECMA, another joint French/U.S. venture was not visited but French procedures and standards were routinely reviewed as the representative Shot Peen Certifying Agent for the International Group. French shot peen techniques and coverage methods are different from U.S. methods but equivalent.

ENGLAND

The Metal Improvement facility at Derby, England was on a yearly audit schedule. The company is certified for both U.S. and British standards and is capable of complete and complex shot peening, hole peening, and computerized shot peening.

ITALY

FIAT, a large supplier of gear boxes, was visited in order to solve a processing problem. Part of the process was a review of the shot peen system. FIAT cabinets are standard with no indication of overall NC control. There was some indication of NC control of air pressure. The lance used for shot peen was so designed in such a manner as to diffuse the kinetic energy generated. Intensity could not be verified in the hardened spline area because the hardness (Rc 58) is harder than the shot (Rc 41-52) or remainder of the shaft (Rc 30-44).

KOREA

SAMSUNG possessed the only shot peen facility audited in Korea.
KOREA (con't)

Only a six (6) nozzle standard cabinet with one pressure gauge for six nozzles. Pressure at each nozzle was an unknown quantity. Vertical and horizontal oscillation are calibrated for time only and not for distance traveled thus there was no assurance of the distance traveled. There was no consistency in the development of saturation curves. There were "Scrap Part" Almen fixtures only for complex parts. Coverage inspection techniques were weak but shot classification was excellent and documented.

NORWAY

NORSK JETMOTOR, uses two (2) shot peen systems the best of which was an NC controlled cabinet in which oscillation, RPM, cycle time, shot flow, and air pressure calibrations are documented. Because of the complexity of parts peened, deflection peening had to be performed. In general this is accomplished with an angled, hardened lance but this firm uses an angled "reflection surface" on the fixture. Facilities for "shot fracture count" and "coverage verification" are available at the shot peen cabinet location. Reflector peening must be accomplished for critical hardware.

SWEDEN

VOLVO, maintains the highest level of shot peen operation I have ever audited or witnessed. This type of operation is not gained instantaneously, but only over a period of sustained effort. The operation meets all the requirements of every specification to my knowledge. Having worked with this operation over a period of years it is an example of what can be accomplished with dedicated effort. Having considerable experience with flow meter calibration, I was considerably impressed with the Volvo Calibration Laboratory procedure for Mass Flowmeter calibration. Every calibration required (and some that were not) was performed by the Volvo laboratory.

SWITZERLAND

DERENDINGER, utilizes a single nozzle cabinet with horizontal oscillation for shot peening a complex part, the HPT Aft Shaft. As might be expected with this type of operation, many separate shot peen operations must be conducted with the appropriate saturation curve(s). While of course, this is a time consuming process, it is a plausible process in the light of the cost of shot peen equipment.
TURKEY

TUSAS, utilizes a single nozzle computer controlled shot peen cabinet with lance, for shot peening aerospace hardware. I was fortunate enough to be involved in developing the computer programs for five (5) parts. This involved parameters, coverage, saturation curves, coverage maps and procedures. It also involved setting up the test procedures of shot fracture count, sieve analysis, Almen strip evaluation, and calibration techniques. It also involved a point of ironical humor. A good deal of time was spent on developing a shot peen procedure for a particularly complex piece of hardware. After considerable time and effort, the procedure was developed, only to receive a phone call telling us that shot peen was not required on that version of the part. Going back to the drawing and carefully reading the drawing notes, I ascertained the same information, we did not have to shot peen that part.

CONCLUSION

My final conclusion is that experience is the best teacher and we learn more from our mistakes than from our successes.