The Method Of Corrective Shot Peening : How To Correct The Distortion On The Machined Parts

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Abstract

Most of machining process that applied on one side of aircraft parts will leaves the parts in high stress state and this condition is the main causes of distortion. There are several methods that used for correction of the distortion and Corrective Shot Peening is one of them.
Corrective Shot Peening is the combination of the art and the rule of thumb by applying of peening principle with S280 and /or S330 steel shot size to induce energy lock by lengthen specific area of the part and this will release the distortion.
This paper will prepared the corrective peening method to overcome the distortion on 7000 series of aluminum structural parts which will impact on fit, form, function and parts service life in assembly line

Key word : shot peening, correction of distortion, energy lock.

a. Introduction

Machining processes consists of milling, drilling, turning and boring. Machining process is applied to any kind of raw materials in order to meet the engineering drawing requirements. In milling process especially for one side machining only, will contribute the unbalance in term of residual stress and form a new equilibrium and followed by distortion or defection.
To minimize the distortion some improvement will be done such as improvement in machining method (depth of cut ; cutting speed and cooling system). For distortion parts will be corrected by corrective peening method.

Corrective shot peening is a cold working process in which the surface of the material is bombarded with small spherical media called shot. Shot peening of metallic materials is an effective procedure to increase the fatigue limit of alloys as well as to prevent stress corrosion cracks of structural parts.

The effect of shot peening is to induce compressive layer where residual stress exist, one of the benefit of this process has been well-known as to improve fatigue life. In a wide range of technical fields, shot peening treatment can be applied to every kind of metal product and utilized. One of the shot peening methods which is used in correcting the distortion on the machined part made of billet.

b. Corrective Shot Peening

As described earlier, the shot peening process is carried out by a stream of small spherical shots, propelled at a high velocity and under controlled conditions, are bombarded onto a surface of metallic component.

The Corrective Shot Peening is a preferred method to correct the distortion of a parts/components as it does not induce tensile stresses. Corrective Shot Peening is the combination of the art and the rule of thumb by applying of peening principle with cast steel shot to induce energy lock by lengthen specific area of the part and this will correct the distortion.

The basic force equation is equal to mass time acceleration or pressure time area. If the steel ball with mass 4/3 $\pi\rho$ [R]^3 and given acceleration, a = $\frac{dV}{dt}$ bombarded the surface of part, relation between force, mass, acceleration and pressure could be stated as equation (1)

$$\frac{4}{3}\pi\rho R^3 \frac{\partial v}{\partial t} = -\pi a^2 P \tag{1}$$

Where [P] is pressure that occur on the surface of part and [πa]^2 is dimple area due to controlled velocity of steel ball.
Relation among [P] and young modulus [E] and also yield stress, σ_y will be shown on equation (2) [1]

$$P = \left(0.6 + \frac{2}{3}\ln\frac{Ea}{\sigma_y R}\right)\sigma_y \tag{2}$$

Due to repeated the bombardments of steel shot, Hertz propose [1] [P] will be replaced with equation (3) as shown bellow

$$p = \frac{0.407}{\pi a^2}\left\{\left[\frac{\upsilon^6 m^3 R\pi E}{1+\frac{R}{R_c}}\right]\left[1-\upsilon\right]^2\right\}^{0.2} \tag{3}$$

By gradually shot peen on certain area with controlled velocity of steel shot will get locking area to prevent the distortion back to original condition.

Control intensity will be performed by using Almen strip type C. Almen strip for corrective peening is made from material SAE 1070 cold rolled spring steel with hardness 44 to 52 HRC. The difference Almen C and A is only on the thickness, both size of length and width is the same, those are 0.745 – 0.750 inch of length and 3.0 - 0.015 inch of width. The shot used in correcting the distortion on the component made of cast steel with different sizes. Usually, size S330, S460, S550 shot size with high hardness range from 55 to 62 HRC is used.

c. Experimental Procedure

c.1. Flow Diagram of Corrective Shot Peening

In the observation, we use material Aluminum 7000 series with dimension 5500 mm x 1500 mm x 150 mm. After machining process, the parts that produced will verify for distortion or deflection as shown on Figure 1. Currently, we use steel shot size S330 with hardness range from 55 to 62 HRC. Intensity verification by using Almen C should be done to determine the machine parameters prior to used for corrective peening.

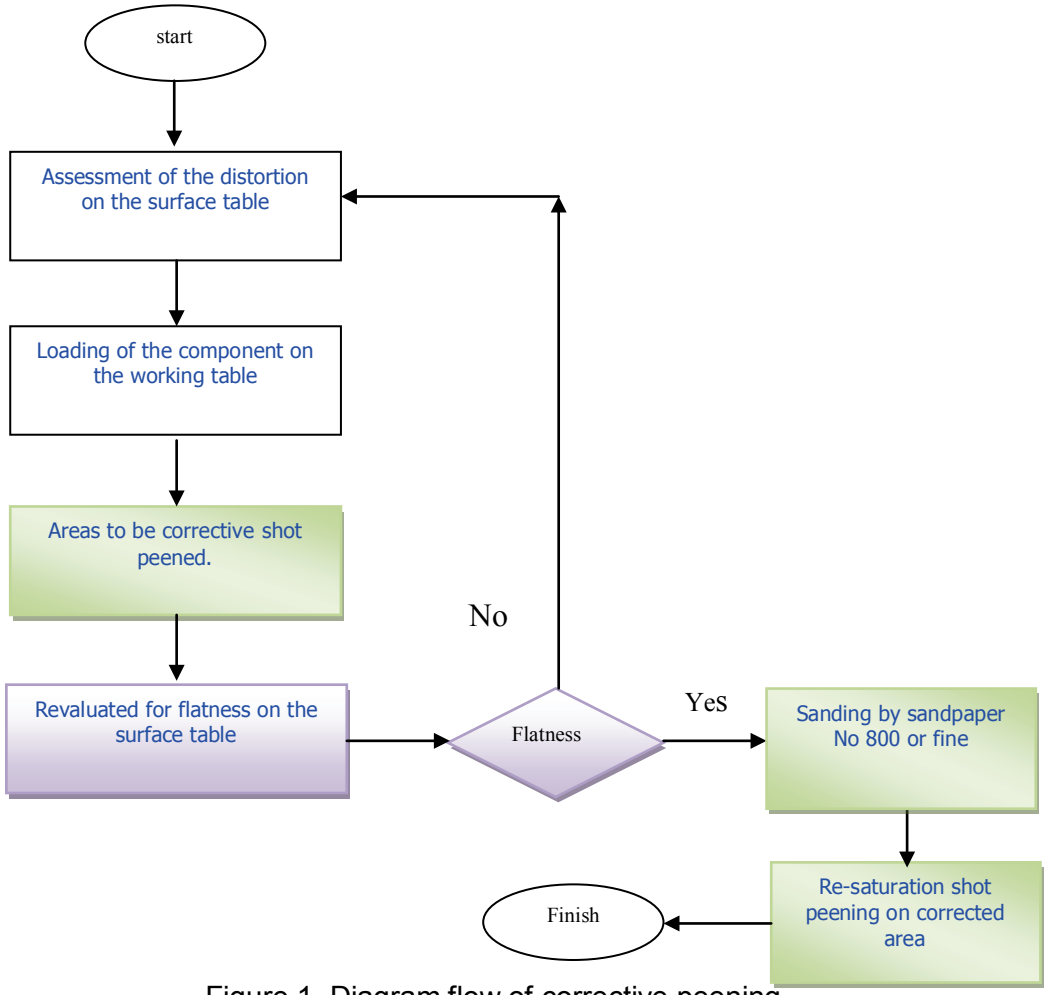

Figure 1. Diagram flow of corrective peening

c .2. Description of Process Step

1. Prior to commencing this process, the distortion or deflection needs to be assessed by placing the component on the surface table in order to evaluate the direction and the amount of the distortion.

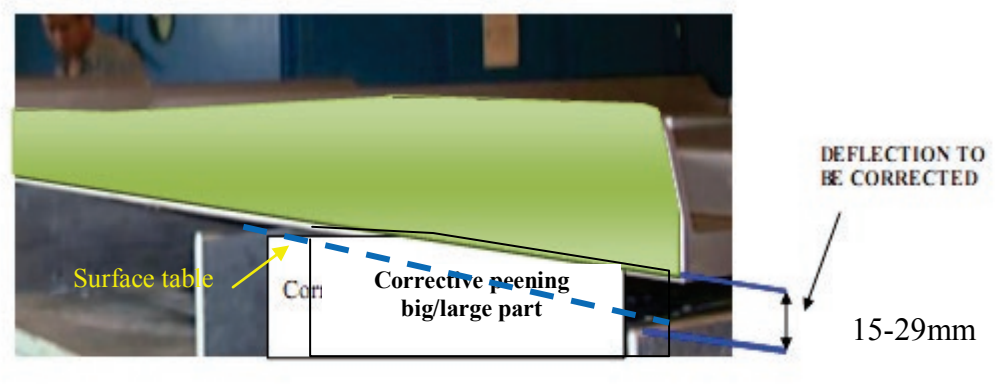

Figure 2. Assessment of the distortion of part on the surface table

2. Normally the component should be placed with the ends off the table, i.e. the component rocks side to side. There may be occasion when the component will require loading to assist the movement or the direction of movement. This normally true for shorter components, as on longer components it will move by its own weight.

3. The area which needs to be shot peened is normally above the neutral axis of the component. This stretches the top layer thus reducing the Distortion .

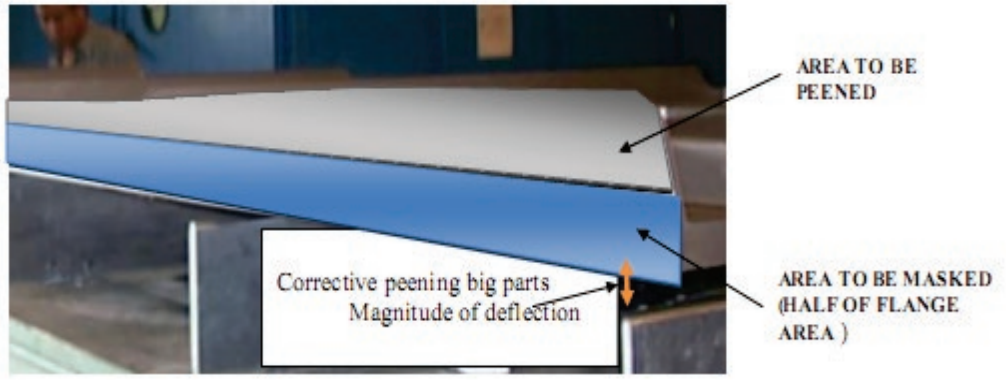

Figure 3. Area to be corrective peened

4. Once the part is shot peened the component is revaluated for flatness. Gradually area corrective peened will be enlarger, increase intensity or combine it to get flatness. Corrective shot peening should be continued till meet the maximum acceptance deflection tolerance 1 mm/meter (see fig.4)

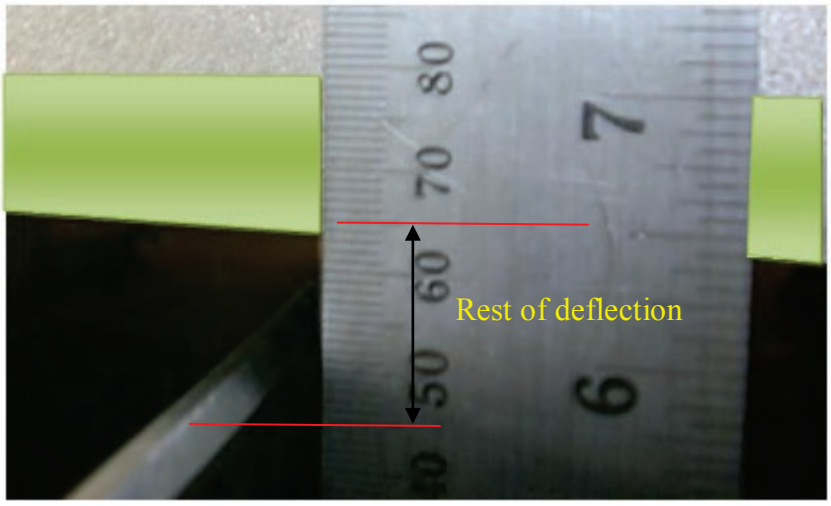

Figure 4. Revaluated for flatness on the surface table

d. Result And Discussion

1. Generally, distortion or deflection on large machined parts always occur, especially parts that milled on one side. Deflection is reflect to the how high the residual stress that exist on the raw material. In our experience during 7 years for more than 140 parts indicate that if the milling speed increased the deflection result arise 26-29 mm (compared to less than 20 mm with low speed machine). Source of the magnitude of deflection also usually as effect of :
   - depth of cut, milling speed and also effectiveness of the coolant system.
   - number of stringer and the thickness is unbalance to the width of parts.
   - Residual stress on the material it self.

2. Corrective peering is one of method to make the part become flatness. The principle of corrective peening is unsaturated shot peening. In the operation of corrective peening the parts shall be pre-stressed by clamping on the table on the deflection area prior to corrective peening. So, during operation of corrective peening, on the pre-stressed area will lock, or energy store so that return of deflection will be prevent. Due to the deflection in variation condition, the corrective peening will be performed gradually and repeated to arise flatness as per design drawing requirements. In our experience, on the engineering drawing requirements state that the normal flatness tolerance is 1 mm per 1000 mm length. For certain parts distortion can be accepted if light hand pressure can be used to reach the flatness.

3. Once all correction of distortion has been completed, the roughness of corrective peening area is high and will impact to fatigue life. To prevent of this condition, all the area corrective peening shall be sanding by abrasive paper grade 800 or fine and than component needs to be saturation shot peened to even out the stresses.

e. Conclusion And Recommendation

1. All areas especially pockets needs to be masked as so not distort/damage
2. The amount of impact energy required is determined by thickness and the amount of distortion present.
3. One important evidence of this process is the surface roughness due to the high impact energy.
4. All areas that have been corrected will require the edge roll to be removed and the surface improved by light sanding.

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