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METAL IMPROVEMENT COMPANY, INC.

SUBSIDIARY OF CURTISS-WRIGHT CORPORATION

PEEN FORMING

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SME's

TOOL AND MANUFACTURING ENGINEERS HANDBOOK 1984

Special Forming Methods

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PEEN FORMING

Peen forming is a dieless forming process performed at room temperature. During the process, the surface of the workpiece is impacted by pressure from small, round steel shot. Every piece of shot impacting the surface acts as a tiny hammer, producing elastic stretching of the upper surface as shown in Fig. 19-27. The impact pressure of the peening shot causes local plastic deformation that manifests itself as a residual compressive stress. The surface force of the residual compressive stress combined with the stretching causes the material to develop a compound, convex curvature on the peened side (see Fig. 19-28). When curvatures are being formed within the elastic range of the metal, the core of the metal remains elastic with a small, balancing, residual tensile stress. Other mechanical forming processes that require overforming with subsequent springback induce high tensile stress. Although high tensile stress can be minimized by stretch forming techniques, stretch forming is usually not performed on tapered or sculptured sections.

The size, velocity, and angle of impingement of the shot as well as the distance of the wheels or nozzles (the wheels or nozzles propel the shot) from the workpiece are automatically controlled in specially designed machines. Peen forming can be performed with or without an external load applied on the workpiece.

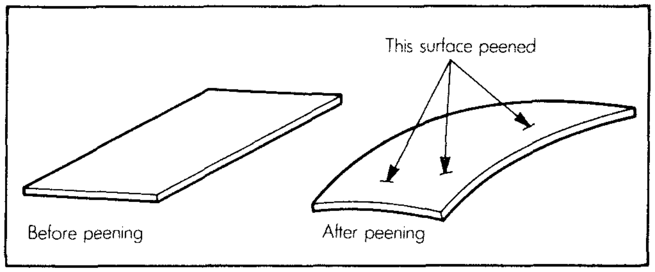


Fig. 19-28 Compound curvatures can be produced with peen forming. (*Metal Improvement Co.*)

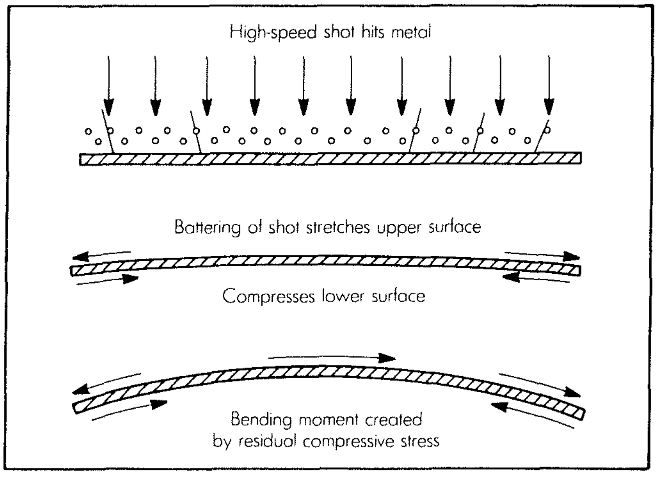


Fig. 19-27 Peen forming uses high-speed metal shot to form the workpiece. (*Metal Improvement Co.*)

Applications

Peen forming is used to form large or small panel-shaped objects that do not contain abrupt changes in curvature. The process is capable of rolling, stretching, or twisting the material to develop the shape. Obtaining compound or saddle-backed shapes is also possible. The aircraft industry uses peen forming to form the wing panels on civilian and military aircraft.

Peen forming is applicable to all metals and can be performed on tapered or integrally stiffened machined panels, honeycomb skins, and isogrid (diamond patterned) panels. This process is usually best suited for forming curvatures having radii within the metal's elastic range. Metal thicknesses in aluminum range from 0.05-2.00" (1.2-50 mm); in high-strength steel alloys, the thickness range is from 0.016-1.00" (0.40-25.0 mm). Workpiece sizes currently being formed are 14 ft. (4.2 m) wide x 100 ft (30 m) long, and contour tolerances are approximately ±0.025" (0.63 mm). Table 19-7 shows the curvatures obtained in different metal thicknesses of aluminum when the shot size is varied.

Shot peening is also used for surface preparation. For additional information on this application, refer to Volume 3, *Materials, Finishing, and Coating,* in this Handbook series.

Advantages and Limitations

Parts formed by peen forming exhibit increased resistance to flexural bending fatigue. Another distinct advantage with peen forming, unlike most other forming methods, is that all surface stresses generated are of a compressive nature. Although peen-formed workpieces usually require shot peening on one side only, both sides have compressive stresses in the surface. These compressive stresses serve to prevent stress corrosion cracking. Some workpieces should be shot peened all over prior to or after peen forming to further improve fatigue and stress corrosion characteristics. Workpieces which have been cold formed by other processes are often shot peened to overcome the harmful tensile stresses set up by the bending process. Sharp bends, such as right-angle flanges and deep-drawn or spun shapes, are not suitable to this process.

Being a dieless process, peen forming requires minimal lead time. The costly development and manufacturing time required to make hard dies is eliminated, reducing start-up cost. The process permits design changes and reworking of the part to improve fit when necessary.

TABLE 19-7
Curvatures Obtained in Aluminum Alloys of Varying Metal Thickness Using Different Diameter Shot

Material Thickness, in. (mm)	Shot Diameter, in. (mm)	
	0.093 (2.36 mm)	0.132 (3.35 mm)
	Radius of Curvature, in. (mm)	
0.125 (3.2)	11.5 (292)	10 (254)
0.19 (4.8)	26.5 (673)	21 (533)
0.25 (6.3)	47 (1194)	40 (1016)
0.31 (7.9)	85 (2159)	80 (2032)
0.375 (9.5)	150 (3810)	121 (3073)
0.50 (12.7)	285 (7239)	256 (6502)
0.75 (19.0)	980 (24 892)	790 (20 066)
1.00 (25.4)	1570 (39 878)	1260 (32 000)

(*Metal Improvement Co.*)

Machines

Peen forming is usually performed by automatic machines within a cabinet enclosure. When close tolerances are required, forming is performed manually by skilled technicians. Two basic types of machines are used, differing only in how the peen forming media is delivered to the part being formed.

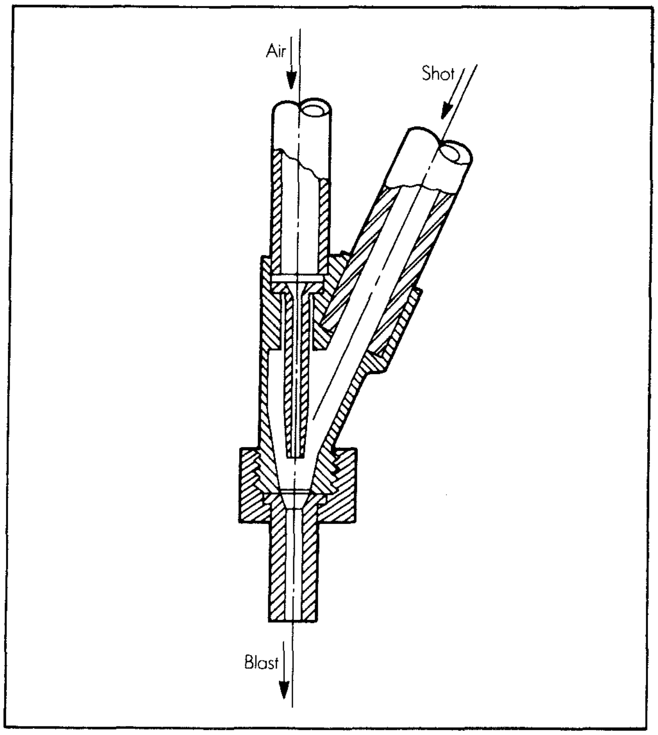


Fig. 19-29 Cross section of a nozzle used on a nozzle-type peen-forming machine (*Metal Improvement Co.*)

Nozzle-type machines. In nozzle-type machines, compressed air or gravity is used to propel the steel shot to the workpiece. These machines may have as many as 20 nozzles, and each nozzle (see Fig. 19-29) is capable of delivering 50 lb (23 kg) of shot per minute to a specific location or area of the workpiece. Each nozzle is independently controlled by a pressure gauge and shutoff valves. The nozzle direction is adjustable so that the optimum angle of impingement can be achieved when workpieces are formed containing surface areas with unusual geometry.

Nozzle-type machines can automatically compensate for varying curvature requirements along the workpiece length or width. Thickness variations, cutouts, and reinforcements, as well as distortion caused by machining stresses or heat treatment, can also be compensated for with these machines.

Figure 19-30 shows a nozzle-type, gantry peen forming machine. In this machine design, the gantry, which houses the nozzles, traverses over the workpiece while the workpiece is stationary. Another machine design has the workpiece moving through the stationary machine that houses the nozzles.

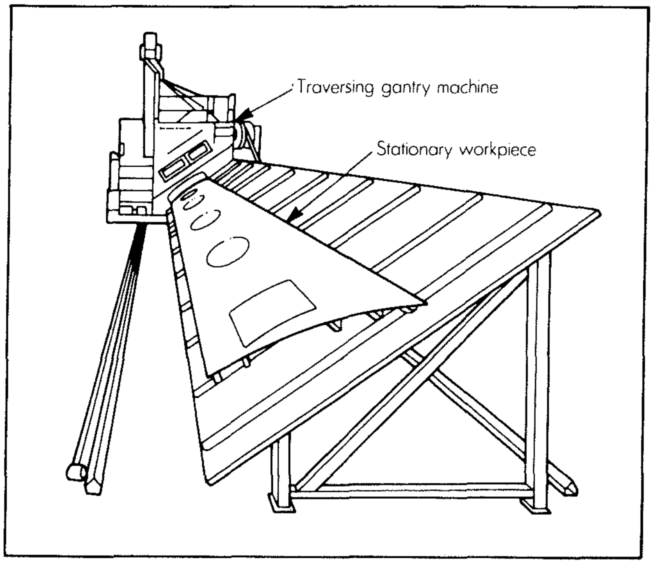


Fig. 19-30 Gantry-type peen-forming machine transverses the workpiece while the workpiece is stationary. (*Metal Improvement Co.*)

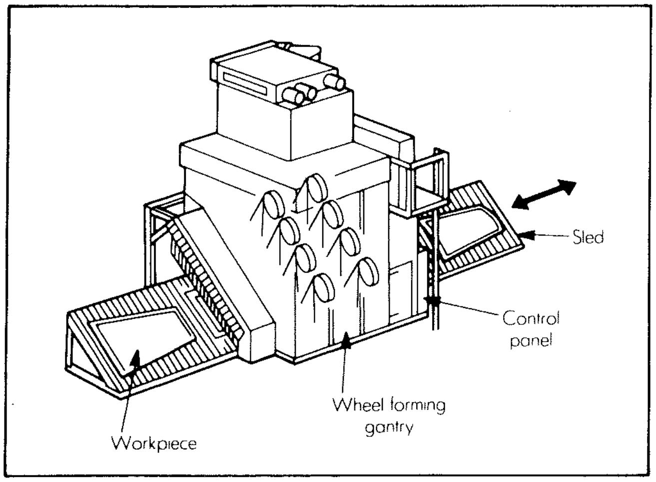


Fig. 19-31 Centrifugal wheel peen-forming machine with a movable bed. (*Metal Improvement Co.*)

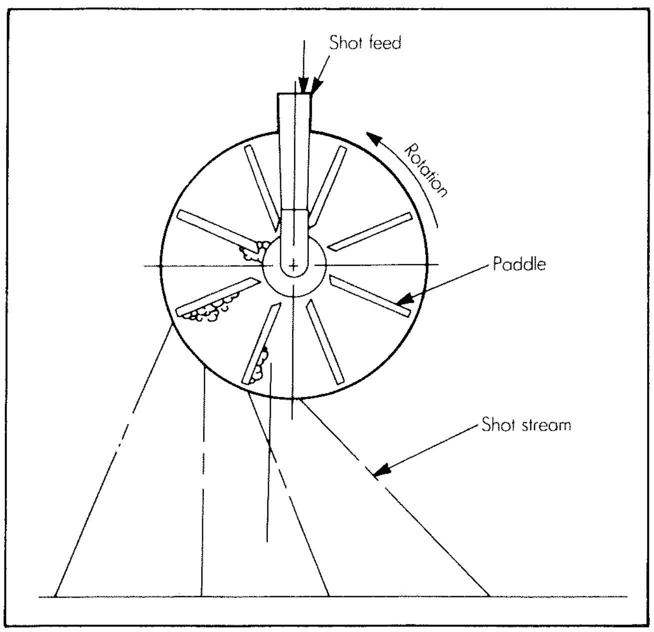


Fig. 19-32 The wheels on a centrifugal wheel peen-forming machine fling the metal shot at the workpiece. (*Metal Improvement Co.*)

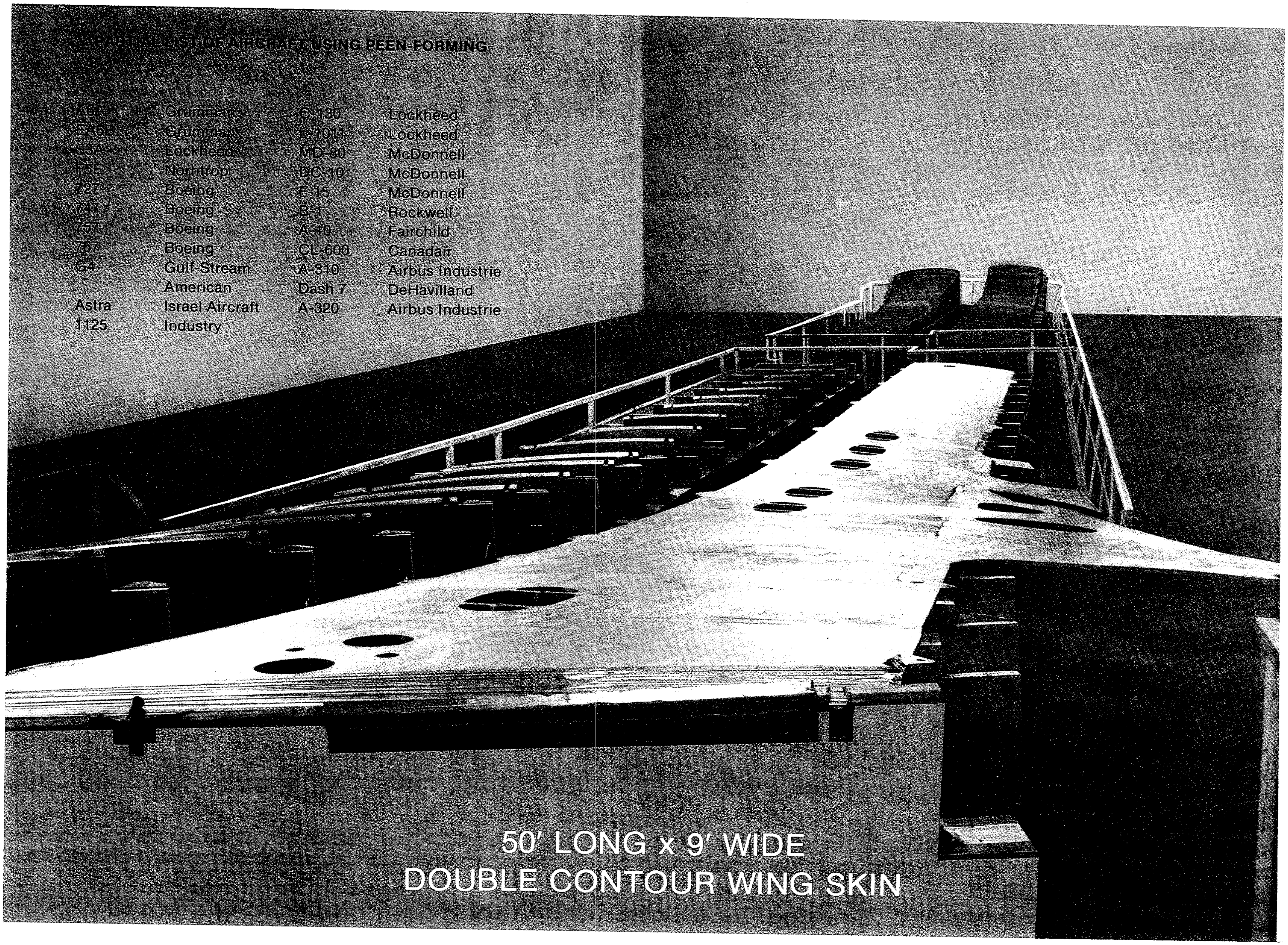
Centrifugal wheel machines. Centrifugal wheel peen forming is another method by which the shot media is delivered to the workpiece (see Fig. 19-31). These machines use solid-state electronic controls to regulate rotating speeds of a paddle wheel that flings the shot at the workpiece, as shown in Fig. 19-32. A typical wheel can deliver 300 lb (136 kg) of shot per minute. Production-type centrifugal wheel machines have 6-8 wheels, providing the machine with a capacity to peen form using more than 2000 lb (900 kg) of shot per minute. The ability to deliver shot media at a controlled velocity in such large volumes permits higher production rates on these machines than obtainable on nozzle-type machines.

Workpieces formed by centrifugal wheel machines are usually of broad, uniform cross section, with all areas accessible to the shot stream. Minor changes to the shot stream direction can be made by indexing the position of the shot delivered to the wheel paddle.

Stress Peen Forming

Stress peen forming is an auxiliary technique of applying an external mechanical load on the workpiece to assist the peen forming operation. The workpiece to be formed is stressed in an arc within 90% of its material yield point and then peen formed to the required specifications. The prestressed radii is critical and is developed mathematically and experimentally so that the material's yield point is not exceeded prior to peen forming. Mechanical or hydraulic devices are designed to deflect the workpiece for specific applications.

Prestressing increases the effect of peen forming in one direction and sharply decreases the effect in the opposite direction. The radius of curvature induced by stress peen forming on a specific thickness of metal can be as large as four times the radius obtainable by peen forming without an external load applied.


PARTIAL LIST OF AIRCRAFT USING PEEN-FORMING
A6A Grumman C-130 Lockheed
EA6B Grumman L-1011 Lockheed
S3A Lockheed MD-80 McDonnell
F5E Northrop DC-10 McDonnell
727 Boeing F-15 McDonnell
747 Boeing B-1 Rockwell
757 Boeing A-10 Fairchild
767 Boeing CL-600 Canadair
G4 Gulf-Stream A-310 Airbus Industrie
American Dash 7 DeHavilland
Astra 1125 Israel Aircraft Industry A-320 Airbus Industrie
50′ LONG x 9′ WIDE
DOUBLE CONTOUR WING SKIN