

Newfangled Joining systems for Furniture Manufactured from Sheet Metal

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Introduction:

Sheet Metal cold forming, by drawing or by pressing, is considered one of the most important methods of metal forming. Such method can be considered as a stem from which two different permanent mechanical joining systems can be developed to join furniture parts and products manufactured from different kinds of sheet metal.

The first system is seaming. Seaming is a permanent mechanical joining technique, a type of cold forming, that neither uses welding nor any of the additional fasteners, e.g. screws or rivets. The joint in this method is the point of joining. Joining is achieved by using only the two pieces manufactured from sheet metal that needs to be joined, without applying welding or even using any additional fasteners as shown in Figure (1).

The second system is clinching. Clinching can be the most widely used technique in the metal furniture industry. In fact, it can replace welding, screwing or riveting in many cases. Clinching is a permanent joining of sheet metal furniture parts and products by forming interlocks at various points of the edges of the parts to be assembled as shown in Figure (2). The product undergoing this process does not require any further finishing stages neither after the clinching nor prior to painting.



Figure (1)



Figure (2)

There are different reasons why newfangled permanent mechanical joining systems, i.e. seaming and clinching, are gaining higher special importance in the manufacturing of metal furniture. One of these reasons is that heat is not the ideal solution in joining sheet metal of different types and thicknesses, especially thin sheets that have small thicknesses. Another reason is that other joining techniques, i.e. screwing and riveting, require pre-punched holes or pressing and they have their control problems regarding the pressure.

Research problem: How do the mechanical techniques of cold forming of sheet metal affect and contribute to developing and improving permanent joining systems of furniture manufactured from sheet metal?

Research objective: The research aims at developing mechanical cold forming methods and techniques in order to allow permanent joining of sheet metal furniture parts and products of

different types and thickness. This is done on the way to apply the process on a larger scale, so as to make it subject and comparable to the Egyptian industry criteria.

Research methodology: The research follows the descriptive approach in defining the mechanics and the resources relevant to the mechanical joining by seaming and clinching. It also follows the analytical approach in explaining the systems and techniques of cold mechanical joining, with the purpose of defining the technical and geometric criteria to achieve precision, accuracy, quality and maximum durability of the permanent joining of metal furniture parts and products.

First: Mechanical joining of metal furniture by seaming

Flange: It is the process of hemming and folding/rolling the sheet metal edge over onto itself to reinforce the manufactured part, hide burrs and rough edges, and improve the appearance. The process starts by bending the edge of the sheet to an acute angle in order to flatten the flange to be on the same sheet level. Flanges can take two forms: open or closed. They can be done to be completely flat or rolled/rope-shaped.

1- Seaming techniques for metal furniture joining

A seam is defined as joining two or more sheet metal parts by hemming and folding the edges of these two parts together in order to join them.

Joining by seaming uses hemming and folding techniques to join two sheet metal parts together so that the inside part will be used in the closing while the outside part is the regular. This technique is used for joining the parts while maintaining the surface appearance and the paint (if painted). It also reinforces the product parts. Figure (3) illustrates different seaming forms.

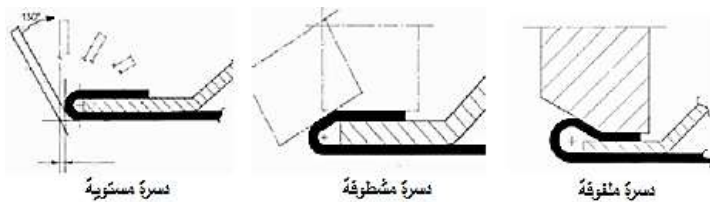


Figure (3)
Seaming forms used in metal furniture joining

Providing a tight seam, by hemming and folding, is of crucial importance as it significantly affects both the durability of joining and the outside surface appearance. Hence, it is a critical factor in the final quality of the metal furniture product. Seaming is a type of cold forming that can be done manually or by using electric or hydraulic presses. The strength/durability of seams relies mainly on the properties of the sheet metal materials, how they are produced, how ductile they are to be cold formed, and the minimum radius of bending required for the seam. The following are critical factors in this respect:

- The alloy from which the sheet metal is manufactured (structure and heat treatment)
- The thickness of the sheet metal used
- Factory record of forming sheet metal and parts
- The reference values for hemming and folding processes

Generally, adhesives can be applied as in figure (4), and their function is to provide corrosion (rust) protection for the gaps that may exist in the flanges forming the seams of the sheet

metal. Seaming, principally, produces adequate strong mechanical joining of the parts of the assembled furniture. In addition, applying adhesives, which can be widely used in flush seams, adds more strength and durability to the product joined parts as well as more crash resistance during its functioning life expectancy.

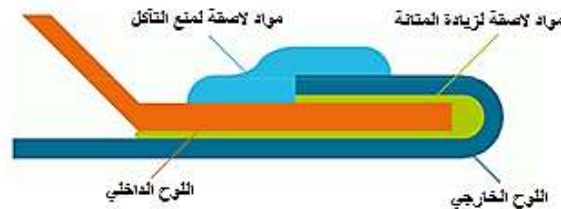


Figure (4)

Applying adhesives to seams to enhance cohesion and corrosion protection

2- Seaming systems for metal furniture joining

Various seaming systems are determined according to technical and geometric criteria that are applicable to metal furniture parts and products. Other factors include: production volume, precision requirements, minimum measurements for the flanges and gaps within seams, required practical reliability, costs, etc. Different seaming systems should serve what they were built for, i.e. joining sheet metal furniture parts and products. Joining by seaming can be implemented using various systems which include:

a. Flat seams: Regular hems/seams where the flange is bent all over the two parts (under the manufacturing process) by hemming with the proper tools and equipment. They are suitable for quantitative production.

b. Rope seams: An industrial robot directs the hemming rollers to form the locking flange. Then, the rope hems/seams are formed gradually through guiding hemming rollers to form them as required. Applying this technology to form this kind of joining hems is a really flexible process whose costs are less than the costs required for flat hems. However, doing rope hems takes longer time from the starting point of rolling the seam to the track formation that was previously designed to be implemented.

c. Grooved seams: These seams are groove-shaped. This method is considered one of the methods that can be widely used for joining furniture parts and products that are manufactured from different kinds of sheet metal. Grooved seams consist of two hems that are locked together by a groover.

d. Flat lock seams: They are used for joining rectangular-shaped parts and products.

e. Standing lock seams: They are widely used to join cuboid-shaped or cube-shaped parts and products manufactured from sheet metal of different types and thicknesses.

f. Slips: A method to join two flat parts manufactured from sheet metal. The ends and the dimensions of the seam vary according to the product type, parts measurements, the width of the flanges, etc. Figure (5) illustrates S-shaped slips. There are also double "S" slips, which are formed to join product parts that require the two parts to be on the same level when

overlapping of metal sheet is not required for joining. Standing S-shaped slips are also formed.



Figure (5)
Examples of slips

Second: Joining metal furniture by clinching

Clinching is a high speed method for joining two or more sheet metal by flexible local deformation without using any additional fasteners nor applying heat. This kind of joining is an easy implemented low-cost method as it requires only a punch and a die. It consists of two parts, the upper (male) part for pressing and the lower (female) part, i.e. the die. Metal sheets are located between the two parts of the die. Then, pressure is placed statically or mechanically on the joining points which results in deforming the sheet metal inside a cavity interlocking the product parts in a form of a strong/durable joint.

Technically, clinching is defined as a single-step or multi-step process. This process aims at joining furniture parts and products made from sheet metal by interlocking the two parts to be joined in such flexible local deformation by cold forming, so as to form different lock-shaped forms resulting from the clinching.



Figure (6)
Clinch joining
The geometric shapes for the local deformation of joining points

Clinching joining as a method consists of two major actions/stages. These actions are forming and drawing which result in the creation of the interlock between the sheet metal layers. The most significant advantage of clinching is the formation of the joining points from the materials used in the manufacturing of metal furniture parts, in order to join them together. Some metal parts that are joined by clinching may have the same thickness or may have different thicknesses and they may be made of different types of sheet metal. The wide variety of geometrical shapes for clinch joints shown in figure (6) and the illustration of the tools used for this purpose enable the informed choice of the suitable joining system for each application based on the material, the product usage, and the available technology for metal furniture industry.

Clinch joining can be the most widely used method in metal furniture industry as the sheets under the manufacturing are not subject to shearing (closed lock). The two parts are closed as a single element by doing a lock by pressing the side at its two ends as well as press-joining various points/spots between its ends. Joining the sheets and interlocking them by clinching can replace spot welding in many cases as static and dynamic forces can be used in this type of joining.

Joints made by clinching - cold forming – offer considerable savings when it comes to the costs of metal furniture joining. They also save energy and time compared to spot welding. Additionally, the average life expectancy of the machinery, tools and dies used in clinching joining exceed thousands of work-cycles. Besides, there is no need to apply pre-cleaning or any process-specific surface pre-treatment to the product. There is also no need for any post-treatment or subsequent finishing processes for the surfaces. Moreover, clinching, as a type of cold forming, provides a quiet and clean work environment as it generates little noise with no sparks, flashes or fumes. It also has another advantage which is the avoidance of damage to the coatings integrity that may affect the surface of pre-coated metal furniture parts and products. It also eliminates corrosion, scratches, and degradation.

Clinching systems are available in all sizes, different operation types, and different speeds. Options of tools and machinery can vary from handheld units as shown in figure (7) to multi-head systems with double-acting punch and die and self-centering heads. There are different systems to do joints by clinching which are interlocking the material with incision or interlocking them without incision.



Figure (7)
A handheld tool for
clinching joining
of metal furniture parts⁽⁹⁾

1- Clinching with local incision

Clinching with local incision is a permanent joint for joining sheet metal furniture parts and products under the combined action of shear and penetration processes which join materials together. This type of joining is a result of the penetration and incision in the joint region which is limited by the incision. Cold compression processes have also their effect. Under these processes, the sheet metal is pushed out of the sheet plane. Then, it is compressed and flattened forming a joint. Clinching joining can be a multi-step or a single-step process where the joint is created by the action of an uninterrupted stroke by the male part/punch (which consists of a single tool component). In a multi-step process, clinching joining is formed under the successive motions of the die components.

Based on this principle, clinching joints can be developed to be of different geometries. To determine the strength of these joints, the shear area as well as the depth of the clinching area are determined and controlled, as the strength of the joints increases with shear area increase and depth reduction.

2- Clinching without local incision

The clinch joints are visually appealing. They suit all surface treatment processes, paints and coatings. They also suit the parts manufactured from pre-coated mild steel sheet. Besides, they have high corrosion and fatigue resistance. The clinch joint can be round, cylindrical, or rectangular. The researcher claims that this type of joining is generally preferred for joining sheet metal furniture parts and products, as there are three types of clinch joints without local incision:

a. Clinching using solid dies without moving parts

This type of joints can be explained in its simplest form as the process of pressing a round single punch. The overlapping materials are pressed into the die cavity while the continuous force increases leading to the pressing of the materials which are horizontally drawn and spread outwards to take the shape of the rim surrounding the lower part of the die. Then, the material is contained by the wall of the die and pressed to form a ring-shaped channel in a mechanically locked anvil to in order to make a strong joint. The result is an aesthetically round joint as shown in figure (8). It can also be distributed on the product part as an ornament. The joining points join metal furniture parts and products without any burrs or sharp edges as the material strain in the neck reduces sharp edges and results in the high retaining forces. The researcher recommends the technique of clinching using solid dies without moving parts as a technique to be most widely used in Egypt for joining sheet metal furniture parts and products.

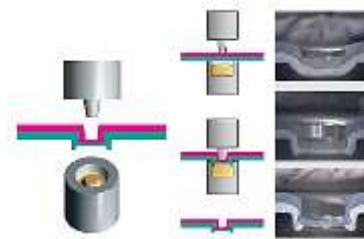


Figure (8)

The mechanism of deforming clinch joints

b. Clinching using dies with moveable parts

In clinching joining systems that employ a die with moveable parts, sheet metal furniture parts and products are clamped by a punch side stripper. Then, the metal sheet is drawn inside the die forming a cup. The sides of the die are sectioned into two or three round segments that remain closed. Once the sheet metal part touches the die anvil to form a cup, these segments open and the metal sheets flow laterally as a result of the pressure exerted by the punch, and a strong interlock is formed. The moveable die segments are pushed outwards, sliding on a base to a distance where the punch-to-anvil reaches a pre-set value. Hence, a mechanical button-like interlock is formed in the sheet metal furniture parts. Finally, the punch is returned to the start position by the operator or by pneumatic timer. Then, the moving sections in the die walls close again.

Various designs are available for the die that contains moveable parts for clinching without local incision. The die contains two or more moveable segments, as shown in figure (9), which are pulled back together by a spring or a part of similar mechanism. These moving segments enable adequate interlocking of materials and the formation of an adequate joint for joining metal furniture parts and products.



Figure (9)
The Die with moveable parts
is used in clinching without local incision

3- Quality criteria in joining metal furniture by clinching

Clinching joining requires an open flange that allows accessibility to both sides of the parts to be joined. The flange must be wide enough to receive the interlocking lock with all its different forms and sizes during the application of the joints. As a general rule, the clearance between the joint center and the outer edge of the flange should be proportional to the diameter of the pressing tool (punch). The clearance between the flange inner edge and the joint must be large enough to allow the access of the tools in order to make the joint. Clinch spots should be spaced so that the strained area around each spot is avoided. Nevertheless, there should be enough joining points/spots to guarantee the strong joining of the parts and components of the metal furniture product.

Applying a pre-clamping step may be helpful in case the flange width to be joined is closed to the minimum width. Furniture parts to be joined should be fully closed after the clamping stage as poor fit-up and alignment are the main reasons that result in poor and inconsistent clinch quality. One of the judgment criteria of joining is the visual evaluation of joints while considering the measurement of the governing dimensions and the geometric parameters.

The quality of the joining processes should be controlled by measuring the governing dimensions and comparing these data, throughout the production processes, to the parameters that have been pre-set and determined based on the design and the laboratory tests. This is done on the way to provide reliable quality assurance for clinching joining of metal furniture.

Findings and Implications:

1) Joining sheet metal parts and products, whether by seaming or by clinching, can technically be considered as 'cold welding' of metal furniture.

- 2) Mechanical joining systems, whether by seaming or by clinching, are used as alternatives for traditional methods such as welding, screwing, or riveting of metal furniture made from sheet metal.
- 3) Seam joints as well as clinch spots guarantee a reliable joining of sheet metal furniture parts and products of different types and thicknesses.
- 4) Seaming as well as clinching joining systems are quick to apply and do not need such efforts required by the other joining systems that use welding, screwing or riveting.
- 5) Newfangled permanent mechanical joining systems can be used in light construction structures that are made of metal sheet of different types.
- 6) Newfangled mechanical joining systems decrease the costs of metal furniture products.
- 7) Newfangled permanent mechanical joining systems techniques enhance pre-fabricated systems for light construction structures, interior metal cladding, and metal furniture.
- 8) Newfangled joining systems correspond to the design variables of metal furniture while achieving the required level of quality assurance.
- 9) It is recommended to use newfangled mechanical systems in the joining and assembly of parts and products by the entities and institutions involved in metal furniture industry in Egypt.