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INDUSTRIAL ORIGAMI A REVIEW

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ABSTRACT- The industrial product design has been evolving in a nontraditional way from last century. The evolution of computers has made the manufacturing as easy as it has ever been. The attempts to make products from a single sheet of metal have been being carried out in the late 50's. The process used to convert these 2D sheets in to 3D object was like bending followed by cutting. The main issue raised in these methods was the stress development. The paper origami which has been used in JAPAN and CHINA from ancient times came to help this manufacturing field. This paper takes a review of Origami used in Industry now a days and various products which are changing the mind sets of manufacturers. Also it discusses about the technology or term "INDUSTRIAL ORIGAMI".

KEYWORDS – Industrial Origami, Sheet Metal, Forming, Bending, I.O

I. INTRODUCTION

The term ORIGAMI invented with the invention of papers back in the 105 A.D. It has been invented in CHINA but flourished in JAPAN since centuries. The paper is the main material used for this purpose. The paper has been treated as a precious material and used for religious ceremonies and important occasion.

II. DEFINITION OF ORIGAMI DESIGN

"Origami design is defined as forming a piece of two-dimensional medium into a particular form with certain desired properties by folding and cutting" - (Demaine, 2001) as in [1] and [5]

III. ORIGAMIC STRUCTURED INDUSTRIAL PRODUCT

The Industrial products which are manufactured with the origamic techniques are called as Origamic structured industrial products. The process of manufacturing of these types of products is very easy.

First a flat sheet of the material with which we are going to make a particular product is cut into a certain shape. This shape depends upon the function of the product. Next step is to fold that sheet into decided form or shape. The folded metal can be held at its site by two newly introduced methods vise.

1. Strengthening the material by bending
2. Creating a self lock structures by considering the elasticity of thin sheets.

These kinds of products are competent to the products manufactured by the traditional methods. But the real advantage is that the low manufacturing cost. The materials which are used for the purpose are sheet metals, plywood, plastic based sheets or paper based sheets. The use of sheet metals in manufacturing industry is due to advantages like, rigid structure in folded state and flattened state in unfolded stage. In short we can say that the flexibility of the sheet metal plays an important role in manufacturing.

Because of their relatively low cost, high strength, and short lead times for tooling, formed sheet are important to industrial designers. Sheet metal is used mostly in large or small home appliances. It is also important in residential and office furniture or accessories and in commercial showcase and displays.

IV. USING SHEET METAL

1. A sheet is normally defined as metal that is less than 6 mm -0.25 inch- thick (T). A sheet thicker than 6mm is generally called a plate.
2. Sheet metal forming usually involves relatively thin materials that are available in wide variety of thickness. It is thin, hence low weight; sheet metal products require little material.
3. Briefly, low material cost and relatively small inventory and ease of transport are the advantages of using sheet metals
4. Sheet metal is easy to cut by punching, nibbling, laser cutting, and plasma cutting, and also easy to reshape by press brake bending, deep drawing, pressing, and roll forming.
5. In other words, by means of its good mach inability property, it is required relatively little power and energy for cutting and reshaping of sheet metals.

6. In addition, sheet metal can be joined in many ways by riveting, screwing, and folding, whereby parts from sheet metal have ease of assembling and demounting.
7. In addition to these advantages, sheet metal is also recyclable and environmentally safe.

V. FORMING

Industrial origami mainly involves the sheet metal forming. Which is been discussed further in brief.

V.I FORMING PROCESSES

These processes which modify metal or work piece by deforming the object, that is, without removing any material. Forming is done with a system of mechanical forces and, especially for bulk metal forming, with heat.

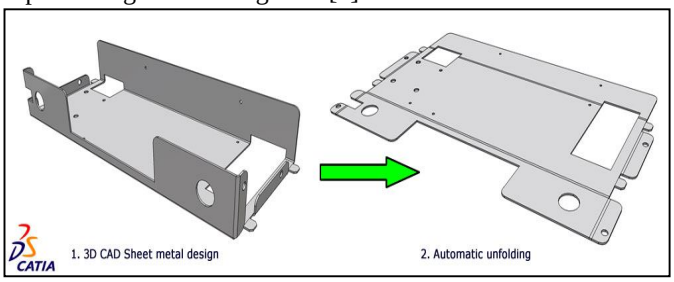
V.II SHEET METAL FORMING PROCESSES

Following are the types of forming process involve the application of mechanical force at room temperature as in [7]

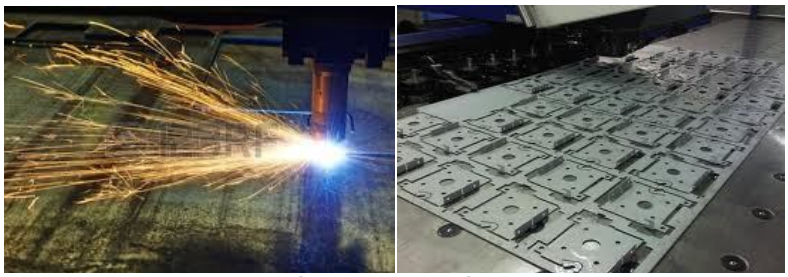
- Bending
- Coining
- Decambering
- Deep drawing (DD)
- Flow forming
- Hydro forming (HF)
- Hot metal gas forming
- Hot press hardening
- Incremental forming (IF)
- Spinning , Shear forming or Flow forming
- Raising
- Roll forming
- Roll bending
- Repoussé and chasing
- Rubber pad forming
- Shearing
- Stamping
- Super plastic forming (SPF)
- Wheeling using an English wheel (wheeling machine)

VI. THE PROCESS

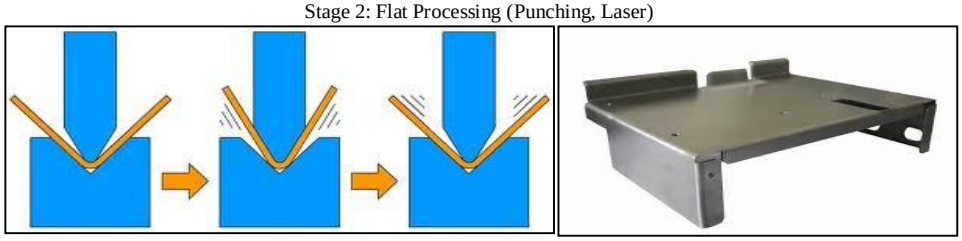
The possibilities of the shapes formed by the sheet metal have largest variety. The shapes and sizes which are formed by the forming of sheet metal are sometimes so unique that it is very difficult to obtain such shapes by other manufacturing techniques. In most instances formed sheet metal parts do not require additional mechanical processing. Press brakes provide the possibility of creating products that ideally all welding joints can be replaced by bending process. The production time gets decreased when Folding is used instead of welding. Also it prevents the material casualty since in welding there is a high risk of casualty by distortion. The sheet metal process is chain of various processes such as, designing, processing, obtaining finished product. The designing is a crucial part though the processing involves lot of work which is carried out at this stage. The processing also involves flat processing and bending as in [6]



Stage 1: Designing and Unfolding



Stage 2: Flat Processing (Punching, Laser)



Stage 3: Bending Process

Figure 1 Sheet Metal forming process as in [8]

VI.I DESIGNING SHEET METAL

Designing of the sheet metal starts with the 2D and 3D drawing and models of the product which is to be produced. A photo realistic 3D model plays an important role in this case. Various 3D CAD systems are used to design a model. The use of simulation and animations is crucial since this gives an idea about the folding and unfolding of the product. Thus by using these 3D tools it possible to determine the problems such as cross section, overlapping, or missing cutouts beforehand production. The 2D drawing of the faultless unfolded state is passed on to the programming system for flat processing. In principle, designing sheet metal is not different from other semi-finished products such as solid stocks, metal profiles, or parts that have been cast or forged. The material selection depend upon characteristics and mechanical properties of sheet metal, which should be considered and also which affect on the bend ability, plasticity, elasticity; machinability, ductility, brittleness, hardness, toughness, etc. Thus only by considering the characteristic of sheet metal and the advantages afforded by modern sheet metal processing in the design process, a functional and economically manufactured product is obtained. The setup time can greatly be reduced when designing a sheet by using maximum use of standard geometric forms. It should also be considered the possibility of making large inner cutouts in order to use waste part, further for producing the smaller finished parts. Besides these design considerations discussed above, there are also important factors must be considered such as bending radius, shortening factor and resiliency as in [6]

VI.II. SHEET METAL BENDING

Sheet metal forming by press brake bending is a process that a metal work piece is bent along a straight line. The major devices used for bending are presses and dies. Sheet metal bending operations involve placing sheet metal on a die up against a back gage to precisely locate the part. At this time, the machine is commanded to close the gap between the punches and die until the part is bent into the cavity of the die.

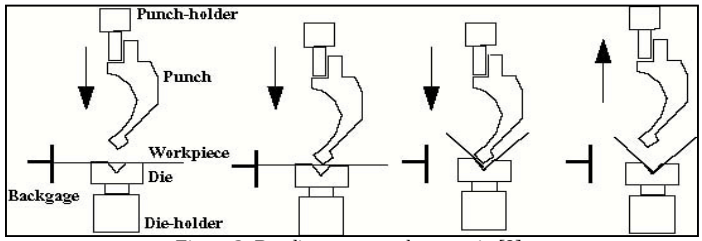


Figure 2. Bending process phases as in [8]

VII. ORIGAMI APPLICATIONS

VII.I APPLIANCES

Industrial Origami's low force folding technology allows manufacturers to transform production, improve process flow and gain competitive advantage in the appliance industry. It has solution which offers innovative approaches that highlight greater precision, reduced part count and lower material cost.

Figure. 3 Home appliances made by Industrial origami as in [8]

VII.II BEARING RETAINERS

Bearing Retainer is the another advanced application of industrial origami that dramatically improves Bearing performance and manufacturing flexibility through improved roller positioning, reduced mass and modular construction. The retainer captures a roller with four contact points while reducing total mass.

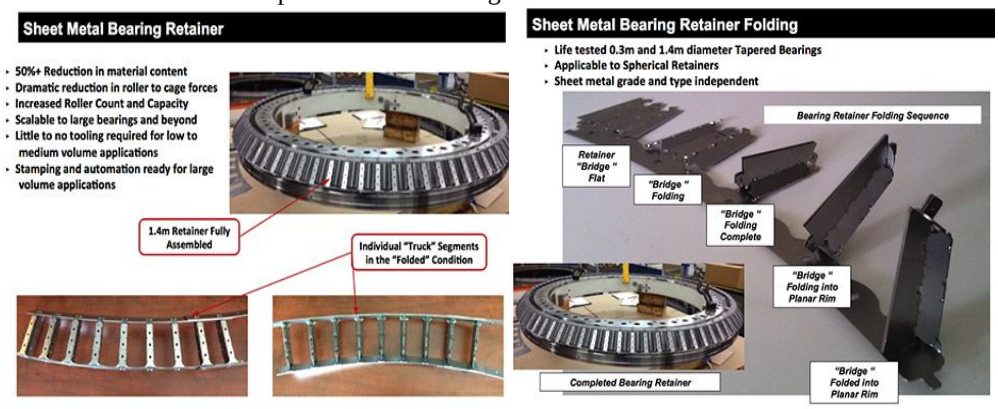


Figure 4 Industrial Origami Bearing Retainers as in [8]

VII.III. STRUCTURAL FRAME

A very complex part for a major Agricultural Equipment Manufacturer. Industrial Origami was able to reduce parts by 35% while retaining strength.

DIGGER ARM: Patent pending (Patent Application No.: 12/028,713) IO design for a large construction equipment manufacturer:

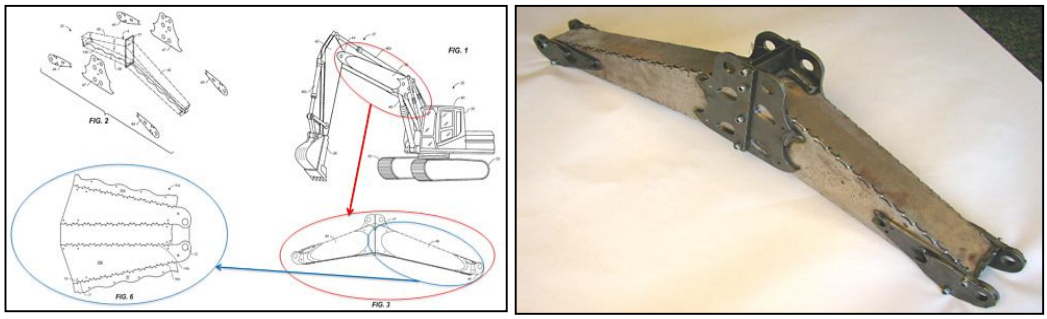


Figure 5 Industrial Origami made agricultural equipment. As in [8]

VII.IV. CONNECTED RAILAINGS

Some typical examples of connected rail constructions are:

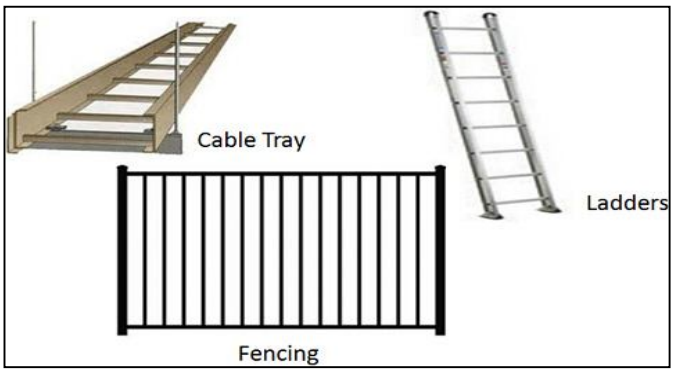


Figure 6 Industrial Origami made ladders and railing as in [8]

Industrial Origami has created a "Connected Rail" Design that:

- Can be stamped from a single sheet of metal or coil
- Has over 90% material utilization
- Is structurally rigid
- Can be stored or shipped flat
- Can serve multiple product purposes

This design can be a modified to become a ladder, fence, cable tray, or stud wall just to name a few. The technology is capable to making this design in multiple substrates, metal qualities and gauges for custom uses.

VIII. RIGID ORIGAMI

The term rigid origami deals with the folding of material with thickness. Large solar panels for space satellites are the finest example of this kind. The thickness of material plays an important role in industrial origami since it takes extra efforts to bend or form such types of sheets. However, Kawasaki's Theorem and Haga's Theorem are still valid in real material folding as in [2]. Tomohiro Tachi mentioned in his research that Rigid origami consists of rigid panels connected by hinges constrained around vertices as in [3]. The origami configuration is represented by fold angles between the adjacent panels as in [4]. Intensive Mathematical model for 3D folding was presented in his paper as in [3] and it was used in his written software Rigid Origami.

IX. INDUSTRIAL ORIGAMI ADVANTAGES

These products are easy to manufacture, easy to maintain and easy to construct Origamic-structured products have a single piece, simple, light and mostly free standing construction, which is produced by simple bending operations. They have ease of functioning, and also have multifunction. In the event of origamic-structured products are made from thin sheets, by means of the elasticity of these materials, the products are self-lockable or flat foldable, consequently flat packable. In the case of the products are made from thick sheets, it is also possible to design it stackable. These characteristics bring about the ease of transportation and packaging.

X. CONCLUSION

The term Industrial Origami is creating a new technique of sheet metal manufacturing. With the help of Industrial Origami products are produced with low production cost which is the most crucial issue of manufacturing sector. The function ability and aesthetics are again the positive points about this technology. In near future if we could see a car wholly manufactured with the help if origami may not surprise people.

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