ORIGINAL RESEARCH PAPER

Volume - 12 | Issue - 10 | October - 2023 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

ORIGAMI: AN ANCIENT ART OR MODERN SCIENTIFIC APPARATUS

Science

Aditya Agarwal GD Goenka Public School, Class 12

ABSTRACT

This paper explores how origami, the ancient Japanese paper-folding technique, has evolved beyond its original purpose as a beautiful craft. Today, origami is used in different industries and disciplines, including health, industry, and space science. The paper sheds light on how scientists have used origami principles to redesign instruments and processes to make them more compact, cost-effective, and efficient. In the medical field, origami-inspired instruments, such as foldscopes can be used to reach narrow passageways in the human body, making surgeries less invasive, and origami-inspired medical patches can be used to close wounds quickly and effectively. The study also mentions the ongoing research on the development of microscopic origami-inspired medical devices for procedures such as gene therapy. The paper goes on to explain how origami can revolutionize the manufacturing sector through enhanced accessibility and efficiency of products. Origami-based devices have numerous applications, including lowering transportation costs and creating bulletproof shields and foldable houses. Origami-inspired designs have even made their way into the field of space technology. Researchers are incorporating origami concepts into spacecraft by using foldable solar panels that enable satellites to make better use of their available space.

KEYWORDS

Origami in engineering solutions, foldscope, Yoshimura crease pattern, Miura fold, foldable helmet, foldable solar panels.

INTRODUCTION:

Figure 1: A Collapsible Shield Made Of Kevlar Based On A Yoshimura Crease Pattern [6]

The term "Origami" is derived from two words: "oru," which means "fold," and "kami," which means "paper," so origami is the technique of folding paper to create two- and three-dimensional objects [21]. It dates back more than 300 years and spans many different eras and countries. While it originated in ancient China, it was refined in Japan and gained popularity. Origami was traditionally used to create elaborate models and ornaments for decorative or recreational purposes only. It wasused to make small toys and trinkets, such as paper airplanes, and no one imagined it had any practical utility until scientists discovered that there were mathematical rules behind each paper fold of origami. It was at this point that origami gained recognition as a tool for cognitive development in middle school children and it was discovered that it helps them learn geometry, spatial awareness and solving math puzzles [22]. It also came to light that origami can be a practical solution for addressing structural and aesthetic problems in engineering [23].

It's time to acknowledge not only origami's value as a highly sophisticated, age-old art form but also the incredible potential of its application to science and technology [4]. Origami is a powerful tool in science because it offers innovative solutions to challenging issues. It encourages innovation and development by fusing creativity and engineering principles. Its ability to fold in a variety of ways can be used in instruments to increase effectiveness and reduce space usage, which can be used in surgeries and spacecraft deployment where space is limited and the scope of error is limited. Its foldability principle can also be used in many other fields to create complex objects from simpler materials, lowering manufacturing costs. Origami principles allow things to fit into small spaces and then be expanded later. The manufacturing industry could experience a revolution if this method could be used on materials besides paper.

Figure 2: Origami-based helmet designed by Ichiro Hagiwara [8]

Several well-known organizations, including NASA, have used origami and its ability to collapse and rise with ease to install solar panels in their spacecraft. Dr Robert Lang and Prof. Larry Howell, two of the field's current leaders, have made significant contributions. Their involvement has resulted in the development of surgical instruments that will perform the procedures with the least amount of risk. Associate Prof. Manu Prakash, a pioneering frugal science expert, used paper to create Foldscope, a microscope capable of detecting various diseases like malaria.

Origami And Engineering Solutions

Let's go over some research that demonstrates the various ways origami has been used to create engineering solutions that can improve our lives.

ORIGAMI AND MEDICINE

Since its inception as a method for making eye-catching artwork and models for ceremonial, religious, and decorative uses, origami has come a long way. Today, it is widely used in the medical industry. Modern science utilizes origami-inspired techniques to design and develop a variety of compact tools and instruments that are both less invasive and cost-effective. These surgical instruments have a wider range of motion despite their compact size. Listed below are a few more uses of origami in medicine [5].

Medical Patch

Today, surgeons and patients prefer minimally invasive medical procedures, however, the process of closing the wound during minimally invasive procedures is one of the major obstacles faced by surgeons [7]. There is ongoing research into designing microscopic devices that employ origami principles to penetrate the human body through narrow passageways, locate the source of the issue, minimize incisions, administer drugs, and thereby accelerate the healing of surgical wounds [7].

A group of engineers at MIT have designed medical patches for this purpose. The prototype of these medical patches resembles paper when dry but when it encounters the tissue, it turns into a stretchy gel and sticks to the injury. It is also designed to withstand contamination when it meets bacteria and body fluids. As time passes, it will biodegrade [24].

Surgical Equipment

According to Larry Howell, a professor of mechanical engineering at Brigham Young University, surgeons can ensure smaller incisions during operations if they use the principles of origami to place tiny surgical tools at the site of the damage while reducing the number of incisions and increasing the range of motion of the instrument. Incorporating the folding principle, he and Professors Spencer Magleby and Brian Jensen developed forceps and other medical devices that enter the body and unfold themselves before being used.

This design reduces the material needed to build the equipment by 75%. These forceps are so small they can pass through a hole of about 3mm. A variant of this is already being used in robotic surgeries. Professor Magleby believes that in the future, these tools will enable a wide variety of procedures to be conducted, including the manipulation of tiny nerves. [13]

NANOMACHINES

Origami can be used to make tiny things. The smallest paper crane ever folded is made of a piece of paper less than 1 mm, smaller than a grain of sand. Similarly, the concept of folding used in origami can be used to make nanomachines. These could be sent through the body to identify the cause of the malady, deliver drugs, etc. This concept is not entirely theoretical. At Brigham Young University, engineers have built a nanoinjector used in gene therapy to deliver DNA to cells, which is around 4 mm thick [25].

Next, we will examine a few advantages of using origami-inspired devices in manufacturing.

Advantages Of Using Origami-inspired Devices In Manufacturing

Origami, according to Dr. Robert Lang, is the process of transforming a sheet of paper into a different structure with minimal processing. Things that are manufactured using origami's folding principles are simpler to assemble, more user-friendly, and have lower production costs [26].Using origami principles in manufacturing can be hugely advantageous. Origami-inspired products are simple to put together. Since fewer components are used, fewer operational costs are involved while the functionality is enhanced.

Increases Availability

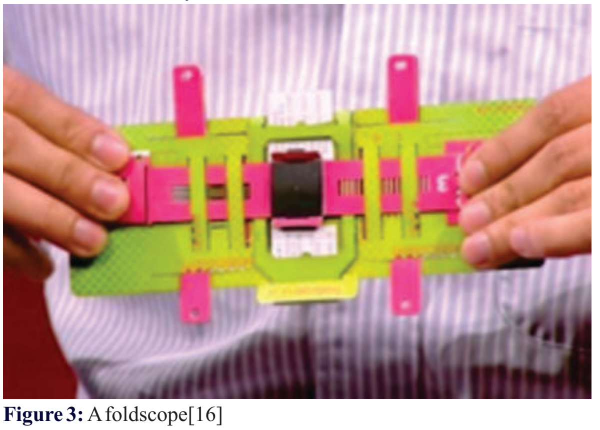

Figure 3: A foldscope[16]

Things manufactured using the origami technique are cheaper than their counterparts and provide good functionality. Professor Manu Prakash, who teaches bioengineering at Stanford University, invented the Foldscope, a powerful microscope that can detect diseases like malaria. It can be built using only a flat sheet of paper and 50 cents. There are many countries in the world, which are plagued by diseases but do not have the necessary equipment or the resources. Medical technology can be revolutionized through devices like foldscope, which are both easy to assemble and relatively inexpensive. As an affordable alternative, the foldscope makes medical technology more accessible to a larger number of people.

Easy To Assemble

Products that can be assembled and disassembled using the folding mechanism can be used by people easily without much prerequisite knowledge. Joe Gattas, a civil engineer and lecturer at the University of Queensland, came up with the concept of a foldable house that uses origami principles for structural strength and thermal insulation, and this house may be put together without the use of any tools or connection materials [27].

Cost Efficient

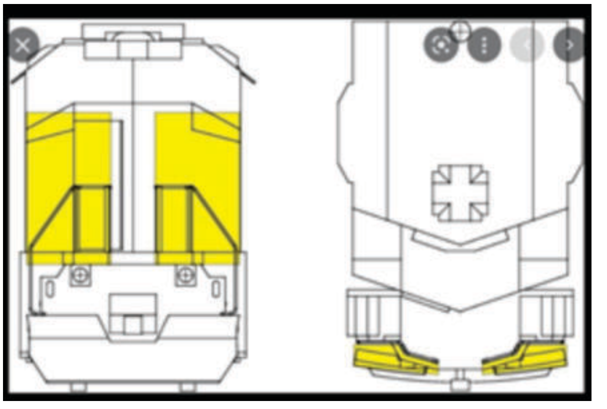

Figure 4: Origami-based nose cone on freight locomotives [3]

By using origami-inspired manufacturing methods, fewer parts are needed during production, which lowers the cost and weight of the finished product and improves functioning. This is demonstrated by the locomotive nose cone, which is made using origami principles and minimizes drag. For example - when a typical freight locomotive is traveling, there is a lot of drag, which reduces its speed. When installing an origami-based nose cone in the locomotive, it was observed the drag was reduced by 16%. It was estimated that if this was implemented, it may save a company millions of dollars' worth of diesel.

Origami In Space Management

Origami isn't only used for decorative purposes. Its intricate folds give many engineers inspiration to solve universal problems in unique ways. One such problem that has plagued the scientific community is where to fit things. This issue is faced by everyone, whether it is an engineer trying to fit all the necessary parts in a rocket to an average person trying to fit a bed and a couch in their room. Using the laws of origami, we can provide the answer to this concern. The answer is simple, folding things. NASA using the same principle has installed foldable solar panels in their satellite. They are easy to fit and can be unfolded and deployed when the location has been reached. And this is not limited to solar panels, things from foldable tables that are used in homes as they occupy less space to foldable shields that can stop bullets are being used. If you are wondering how rigid materials like polypropylene and wood can be folded, this task can be accomplished by cutting this material and adding hinges to replace the crease pattern [26].

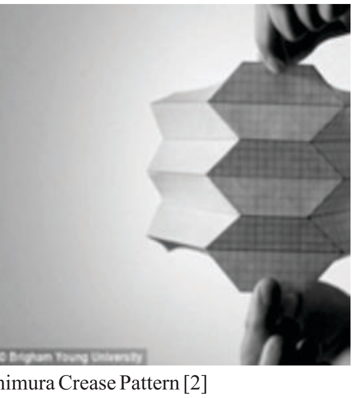

Figure 5: Yoshimura Crease Pattern [2]

Improved Convenience

By making things foldable, they become a lot more convenient to carry. This has many benefits. For example, a foldable house similar to the one designed by Joe Gattas can be easily transported to the site of a disaster and provide shelter for displaced people. The Yoshimura crease pattern-based foldable shield was created by a team of researchers at Brigham Young University and is composed of 12 layers of Kevlar with lightweight aluminum and plastic panels supporting the design in the middle. It is extremely compact and easy to carry, weighing only 55 pounds, and can protect three people at once. Recent tests show that it can stop bullets from 9 mm, .357 Magnum, and .44 Magnum pistols. It was designed for law enforcement, but Professor Howell, one of the people who contributed to its development, sees it as being adapted for military use.

Origami In Spacecraft

A Japanese astrophysicist named Koryo Miura invented the technique called the Miura fold, which has been used in origami-inspired arrays. When the structure is opened, it appears to be divided into a checkerboard of parallelograms. This design was tested on a Japanese satellite, a space flyer unit. Despite its success, the technology is still in its beginning stages of development. Researchers at NASA have been trying to use the basis of origami in spacecraft for a long time. According to Brian Trease, a mechanical engineer, this is a unique crossover of art and culture, and technology. Trease partnered with researchers from Brigham Young University to try to implement the folding of origami in spacecraft [28]. Together, they developed a solar array that folds up to 2.7 m in diameter. When unfolded and deployed, the structure becomes about 25 meters big. They didn't use the Miura fold, but a multitude of different ones. Trease's goal is to make this technology so advanced that it can be used simultaneously with small satellites called CubeSat, which are around 2kg in weight and 10 cubic centimeters in volume.

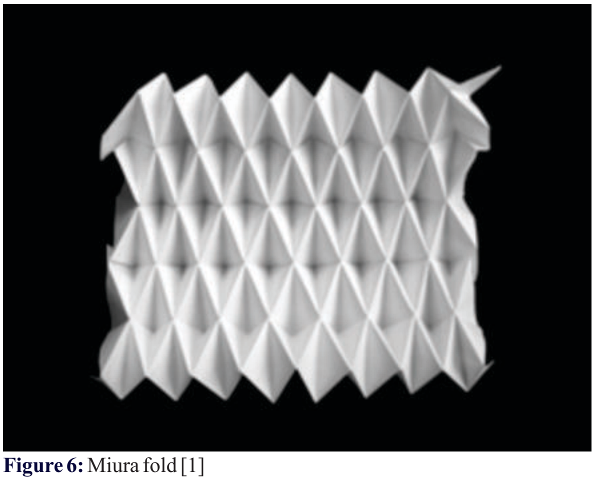

Figure 6: Miura fold [1]

CONCLUSION:

The versatile and problem-solving nature of origami continues to inspire scientists, engineers, and designers to create unique and efficient solutions in a variety of industries. Through this paper, we were able to highlight how origami-inspired techniques have found use in a variety of sectors, including medical, industry, and space exploration. In the medical field, origami-inspired medical patches provide a less invasive and efficient method of healing wounds during surgeries, while tiny surgical equipment based on folding principles reduces incisions and increases the range of motion. Origami-inspired nanomachines have the ability to transport medications and perform precise treatments within the body. Origami-inspired gadgets in manufacturing boost availability, are simple to construct, and are cost-effective, revolutionizing medical technology and generating new solutions, such as foldable residences and improved transportation systems. Furthermore, the space industry has investigated origami-inspired spacecraft systems, allowing for tiny and deployable structures such as solar arrays.

Acknowledgement:

Sincere thanks to Ph.D. Research Scholar, Ms. Akanksha Sharma for stimulating discussions and guidance.

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