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Implementation of NDT in Composite Manufacturing through Automatic Spray Lay Up Process

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Abstract: *The laminated fiber reinforced polymer matrix composites (PMC'S) are finding increased used in a broad range of industrial applications, particularly in the aerospace and automotive sectors. These materials are attractive for a number of reasons, noteworthy amongst these being their mechanical properties. Composite materials can be constructed to have a range of mechanical properties by selecting the constituent materials appropriately by engineering the interfaces between constituents, and by devising the geometrical placement of the reinforcing constituent in the matrix, issues such as damage tolerance and durability, performance degradation due to aging, fatigue having a minimum Impact on the performance indices, these issues are addressed by effective inspection technique called NON DESTRUCTIVE TESTING in Automatic Spray Lay Up Process. This concept urged will comes with economic justification and quality production for the organization.*

1. Introduction

Composite materials are widely used in a number of industrial sectors from aviation, space, to boat building, automotive, and sports goods. In recent years composite structures have seen a substantial increase of their use in the new generation of airplanes. The nondestructive testing and inspection of composite structures, both for manufacturing quality assurance and for in-service damage detection, has prompted the development and adaptation of a number of methods and techniques over the years. In this paper we review the various NDT methods for inspecting composites, especially those developed by the Center for Nondestructive Evaluation at Iowa State University in its interaction with the industrial users of composites.

We will address the inspection issues of different types of composite structures including solid laminates, honeycomb- and foam-core sandwich components, and touch upon the inspection of perforated face sheets and bonded aluminum structures. The capability of various NDT methods including water- and air-coupled ultrasound, bond testing, manual and automated tap testing, thermography, and stereography will be described, with emphasis given to techniques that demonstrated benefits to the practice of composite inspection. Techniques developed by Iowa State University for performing composite inspections in the field, especially those with imaging capability, will be described.

1.1 Objectives of the Project

This research is carries with a isolated aiming to justify the composite manufacturing in a very effective way of utilizing advanced machine having ultrasonic testing incorporated in the machine part itself and is that 100% inspection by NDT and other valid techniques has a rightful place in the set of methods used by quality professionals.

1. To Automate the Spray Layup Process as Auto Wet Layup Process with NDT setup To Ensure Quality And Economy.
2. To Justify Composite Manufacturing Financially By Using NDT.
3. To Minimize The Wastage of Resin and Polymers In Production.
4. To Optimize The Composite Manufacturing Process.

To Develop An Advanced Machine to Lay up And Detect Defects by NDT Ultra sonic Test in Production Line.

2 History

Early manufacturing was carried out by journeymen and apprentices under the supervision and tutelage of master craftsmen. The masters negotiated, designed, and directed while the journeymen did most of the crafts work and the apprentices were labor, gofers, and power sources. For instance, an apprentice in a woodworking shop would have to turn the giant wheel over which a leather belt sped along turning the lathe. The journeyman held the tool to turn the chair leg, for instance, on the lathe. The master

would judge if the two front legs for the chair turned out similar enough. If water power were available, the job of the apprentice might be easier.

Apprentices were usually indentured servants for a period of 6 to 10 years. They were supposed to look over the shoulder of the journeyman to learn the trade. Some teaching (on-the-job-training) went on, as the master wanted the apprentice to be promoted to journeyman at the end of his indenture. An industrious father would want his son to be indentured to a good master who would bring the boy up into the business. The boy's hard work was considered training, not child labor

What is NDT?

Nondestructive testing (NDT) has been defined as comprising those test methods used to examine an object, material or system without impairing its future usefulness. The term is generally applied to non-medical investigations of material integrity.

What is the purpose of NDT?

NDE is vital for constructing and maintaining all types of components and structures. To detect different defects such as cracking and corrosion, there are different methods of testing available, such as X-ray (where cracks show up on the film) and ultrasound (where cracks show up as an echo blip on the screen). Although history does not provide a precise starting date for non-destructive testing, its use dates back many, many years. It is said that that flour and oil were used during Roman times to find cracks in marble slabs. For centuries, blacksmiths used sonic NDT when listening to the ring of different metals as they were being hammered into shape; a technique also used by early bell makers. One of the first recorded uses of NDT was in 1868, when Englishman S.H. Saxby relied on the magnetic characteristics of a compass to find cracks in gun barrels.

3 Existing System (Present Composites Manufacturing System):

1. Spray Lay-Up
2. Wet/Hand Lay-up
3. Vacuum Bagging
4. Filament Winding
5. Pultrusion
6. Resin Transfer Moulding (RTM)
7. Other Infusion Processes
8. Prepregs
9. Resin Film Infusion (RFI)

Advantages:

• Capital and operating cost savings.
• Engineering design flexibility and improved manufacturing cycle times.
• Improved product quality and product performance.
• Environmental benefits.
• Energy production and energy conservation benefits.
• Incremental royalty streams to the U.S. Minerals Management Service.
• Knowledge diffusion benefits.

Disadvantages of Existing Systems:

• Resins need to be low in viscosity to be workable by hand. This generally compromises their mechanical/thermal properties.
• Low to medium number of parts.
• Long cycle times per molding.
• Not the cleanest application process.
• Limited to constant or near constant cross-section components.
• Heated die costs can be high.
• Low viscosity resins usually need to be used with lower mechanical properties.
• Quality is related to the skill of the operator.
• Low volume process.
• Longer cure times required.
• The waste factor can be high.

4. Proposed System

Scope:

- Machine Design
- Software (Autocad)
- Company Support

Machine Design :

Machine Design or mechanical design is primarily concerned with the systems by which the energy is converted into useful mechanical forms and of mechanisms required to convert the output of the machine to the desired form. The design may lead to an entirely new machine or an improvement on an existing one. Thus machine design is the production or creation of the right combination of correctly proportioned moving and stationary components so constructed and joined as to enable the liberation, transformation, and utilization of energy. The basic procedure of machine design (Mechanical Engineering Design) consists of a step by step approach from given specifications of functional requirement of a product to the complete description in the form of blue prints of the final product. The following steps are involved:

First Step: In the very first step a complete list of specifications for the functional requirement of the product is to be prepared. The requirement may

include, for example: Output capacity; Service life; Cost; Reliability; etc.

Second Step: After a careful study of the requirements the designer prepares rough sketches of different possible mechanisms of machine and depending upon the cost competitiveness, availability of raw material, and manufacturing facilities, the possible mechanisms are compared with each other and the designer selects the best possible mechanism for the product. For example for designing the Blanking and Piercing Press the following mechanisms may be thinking of:

1. Mechanism involving the motion of the electric motor
2. Mechanism involving free flow of resin, polymer, sensors and ultrasonic waves which results in simple and cheap configuration but having high efficiency.

Third step: In the third step of the design procedure a block diagram is to be prepared which showing the general layout of the selected configuration.

Fourth Step: After selecting the required or deciding the configuration of mechanism / machine in third step above. The design of individual components of the selected configuration is to be done in this step. It consists of the following stages:

Fifth Step: The last stage in design process is to prepare the blue prints of assembly and individual component. On these drawings, the material of the components, dimensions and tolerances, surface finish and machining methods are specified. The designer prepare two separate lists of components Standard components to be purchased directly from the market; Special components to be machined in the factory; Thus the machine design or mechanical design process is a systematic step-by-step approach from known specification to unknown solution.

Car Dash Board Design:

Company support

Company support for this project is very good .While designing the machine there practical input are very valuable and they extended their support in designing the car dash board 3D model and using there infrastructure.

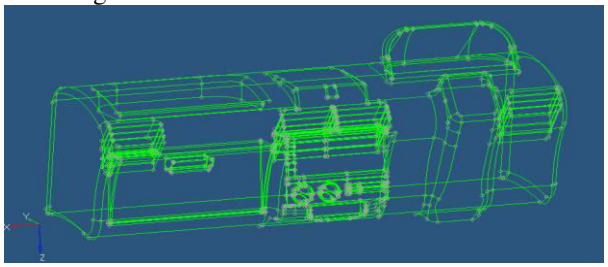

Fig. Wire Frame Model of The Car Dash Board

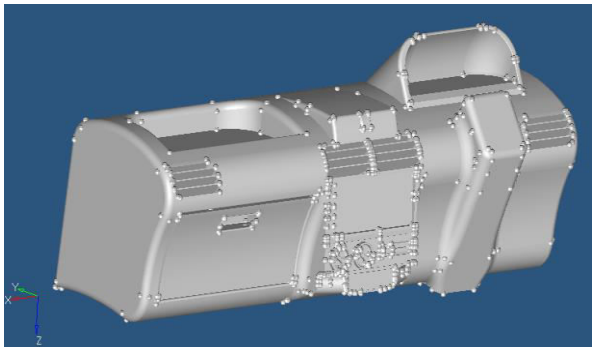

Fig. Solid Model of Car Dash Board

Machine layout:

Machine without nozzle setup is been illustrated below

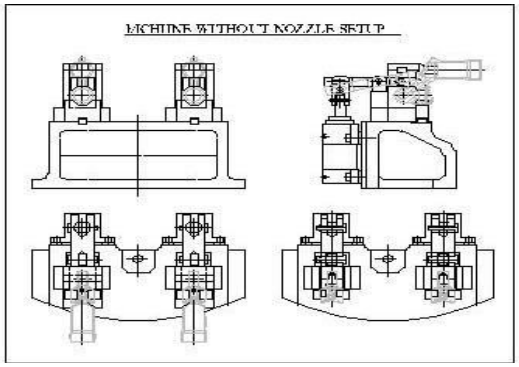

Fig. Machine layout(Mould Fixture)

Nozzle Design(Proposed):

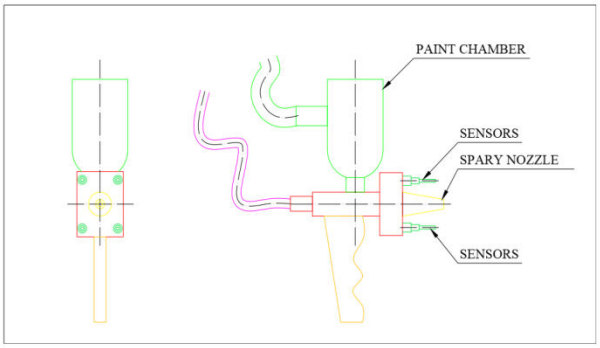

Fig Nozzle design(For Auto wetlayup process)**Paint*Resin**

5. Design Requirements:

Software Requirements

Software specifications are used for designing the prototype of the REV in AutoCAD. So that design can be easily understood. The required software for this project is:

AUTOCAD

AutoCAD is a software application for both 2D and 3D computer-aided design (CAD) and drafting-available since 1982 as a desktop application and since 2010 and since 2010 as a mobile web and cloud

based application. Currently marketed as AutoCAD 360.

Developed and marketed by AutoCAD was first released in December 1982 having been purchased a year prior in its original form by Autodesk founder john walker. The software is currently marketed in its eighteen generation.

As Autodesk's flagship product, by March 1986 AutoCAD had become the most ubiquitous microcomputer design program worldwide, with function such as "Polylines" and "fitting". Prior to the introduction of AutoCAD, most other CAD programs ran on mainframe computers or microcomputers, with each CAD operator (user) working at a graphical terminal or workstation.

AutoCAD is used across a range of industries, including architects, project managers and engineers, among other professions with 750 training centers established world wide as of 1994.

AutoCAD was derived from 197 program called interact CAD, which was written proprietary language (SPL) by inventor Michael Riddle who later co-founded Autodesk to market AutoCAD. This early version ran on the Marin chip systems 9900 computer (Marin chip was owned by Autodesk co-founders John Walker and Dan Drake). While initially walker and riddle and a profit-sharing agreement for any product derived from Interact, in the end walker paid riddle US$10 million for all the rights. When Marin chip software partners (later known as Autodesk) formed, the founders decided to recode interact in C and PL/1.They choose C because its seemed to be the biggest upcoming language. In the end the PL/1 version was unsuccessful. The C version was at that time one of the most complex programs in that language. Autodesk had to work with a computer developer, lattice to update C enabling AutoCAD to run. Early releases of AutoCAD used primitive's entities-lines, Polylines, circles, arcs and text to construct more complex objects. Since the mid 1990's AutoCAD supported custom objects through its C++ application programming interface (API). AutoCAD uses its own fork of the ACIS geometry modeling kernel.

The modern AutoCAD includes a full set of basic solid modeling and 3D tools. The release of AutoCAD 2007 includes the improved 3D models. The mental ray engine was included in rendering and therefore it is possible to do quality renderings. AutoCAD 2010 introduced parametric functionality and mesh modeling.

The latest AutoCAD releases are AutoCAD 2014 and AutoCAD 2013 for MAC. The 2014 release marked the 28th major release for the AutoCAD for windows. The 2013 release marked the third consecutive year for AutoCAD for MAC.

Hard Ware Requirement (Ndt Tools)

NDT APPLICATIONS:

NDT is used in a variety of settings that covers a wide range of industrial activity, with new NDT methods and applications, being continuously developed. Non-destructive testing methods are routinely applied in industries where a failure of a component would cause significant hazard or economic loss, such as in transportation, pressure vessels, building structures, piping, and hoisting equipment. And Weld verification, Structural mechanics, Radiography in medicine.

3D Scanners: 3D Scanners use optical, laser, or other methods to capture 3-dimensional information about objects. The resulting data can be used to reverse engineer an object, measure it, convert it to a digital image, and other applications.
Ultrasonic Instruments: Ultrasonic instruments use beams of high frequency, short wave signals to inspect, monitor, and measure materials and components.
Calipers: Calipers typically use a precise slide movement for inside, outside, depth or step measurements. Some caliper types are used for comparing or transferring dimensions.
CMM Probes: Coordinating measuring machine (CMM) probes are transducers that convert physical measurements into electrical signals, using various measuring systems within the probe structure.
Thread Gages: Thread gages are dimensional instruments for measuring and/or verifying thread size, pitch or other parameters.
Surface Profilometers: Surface profilometers are contact or non-contact instruments used to measures surface profiles, roughness, waviness and other finish parameters.
Metallurgical Microscopes: Metallurgical microscopes are used for metallurgical inspection including metals, ceramics, and other materials.
Magnifiers: Magnifiers enlarge the appearance of objects when viewed through a lens. These facilitate the inspection of fine details and the assembly of small components.
Dimensional and Profile Scanners: Dimensional and profile scanners gather two-dimensional (2D) or three-dimensional (3D) information about an object.

Dimensional Gages and Instruments: Dimensional gages and instruments provide quantitative measurements of product or component dimensional and form attributes such as wall thickness, depth, height, length, inner diameter (ID), outer diameter (OD), taper or bore.

6. Working of (ASLUPP) Machine:

The machine is employed with the nozzle and the nozzle is fitted with resin at one end and the polymer is connected at the end. The nozzle is advanced with the ultrasonic wave propagator where it employed for testing air gaps so as to eradicate porosity. Finally nozzle arranged with four sensors where these work for finding the thickness of the resin and polymer spreading it will not move forward unless the required thickness is attained.

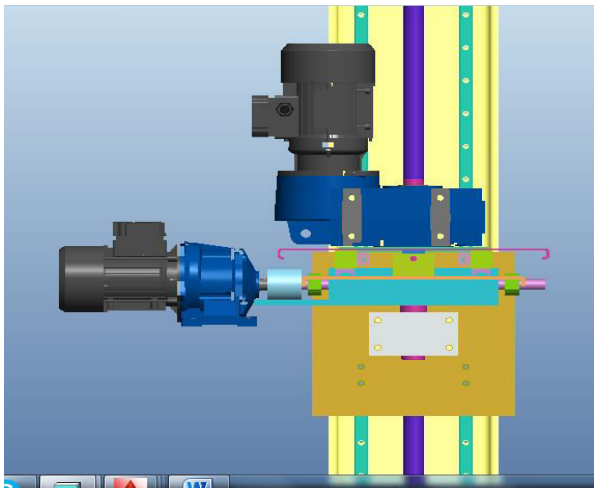

Fig Servo motor setup on the rail

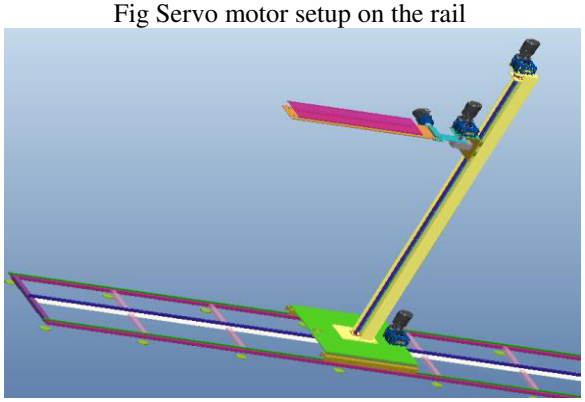

Fig. 3D view of the machine model concept

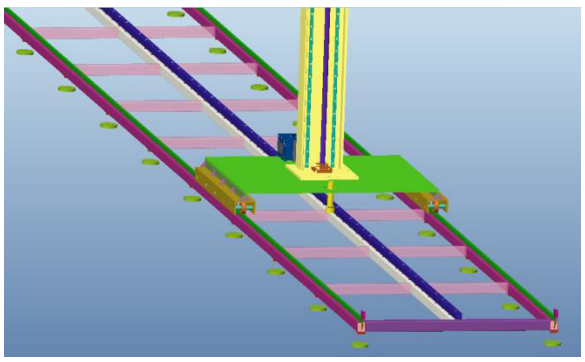

Fig. Machine model run on rail

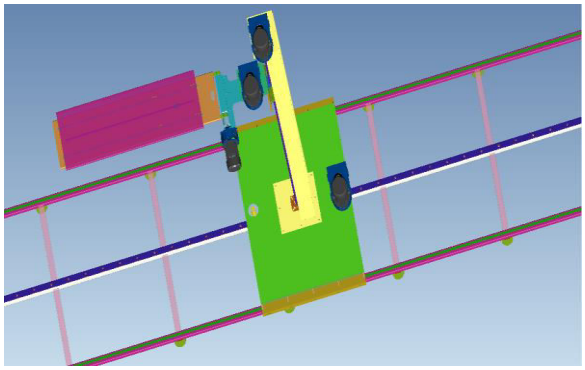

Fig. Top view of the machine

Working:

The machine shop is designed in a optimistic way where a component holding unit is designed to hold the die (car dash board) which is flexible and is fix when the right place is addressed. The component holding machine is fitted just parallel to the railing on which the machine is equipped and can be moved in 3 dimensionally, and it is operated by PLC control unit. PLC unit consists of servo motors, sensors pneumatic piston cylinder arrangements and plc programming.

Car dash board is fitted on the holding machine and the layup machine will adjust its setup program and the nozzle will perform up down motion in which the layup process is carried, here the nozzle consists of 4 sensors and 2 openings in which resin departs from one and polymer from one opening, 2 of 4 sensors are thickness measurement sensors and remaining 2 sensors are for ultrasonic test. Thickness sensors won't allow the machine to move forward unless required thickness attained and ultrasonic sensors won't allow machine to move forward unless the work is fully tested and passed this carried for each and every mm by this the rejection of components will be reduced while inspection.

Major Parts of (ASLUPP) Machine:

Mould Fixture.
Cross Rail (Bottom).
Column.
Radial Arm With Forks.
Numerical Control And PLC.
Servo Motors(4).
Nozzle.
Resin Chamber.
Sensors.

6 Conclusion:

As the use of composite increases, especially in the next generation components in

aerospace, automotive and pharmacy sector, there will be a greater need for nondestructive inspection procedures for quality assurance by the manufacturers. The challenges will include efficient inspection of thick primary structures. Specific field inspection needs of the new generation of composite-intensive airplanes may not arise until they are in service for a number of years. More bonded structures are now classified as primary structures and will receive more inspection attention. The use of foam-cored sandwiches is also on the rise, with the accompanying NDI needs. Since the disposition of a composite structure depends on the nature and severity of the detected flaw or damage (for example, a certain degree of core damage may be tolerable in a sandwich structure but a core-to-facesheet disbond may not be), the ability to nondestructively characterize the detected flaws or damage will continue to be in demand. So by automating the spray lay up process and attaching UV testing method beside spray nozzle so that we can provide quality composites by inspecting it by every time interval. For that we have made this manufacturing process more quality and simple.

6.1 Benefits of Project:

1. Financial Justification of Product.
2. Capital and operating cost savings.
3. Increase in Production by Automation.
4. Engineering design flexibility and improved manufacturing cycle times.
5. Reduction of Wastage.
6. Improved product quality and product performance.

7. Future Enhancement (Scope)

Composites research is attracting grants from governments, manufacturers and universities. These investments will find new fibers and resins to create even more applications for composites. Environmentally friendly resins will incorporate recycled plastics and bio-based polymers as composites the feed the demand for stronger, lighter and environmentally friendly products.

Recommendations:

- Nozzle moments in 3 axis will a great advancement for the technology.
- Increasing the viscosity of the resin without minim sing quality will be a great thing.
- Advanced Sensor installation for ultrasonic wave test will result in 100% inspection

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