AUTOMATIC LAYING OF UNIDIRECTIONAL PREPREG TAPES ON COMPOUND SURFACES

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ABSTRACT

In order to meet the repetability and reliability required to tape-lay aircraft structures, the BMO Group has developed an automated tape layup system composed of two machines working in succession. The first machine cuts the tape courses for complete part and store them in tape reel cassette. The second machine lays the cuts from the cassette onto the mold at high speed. Examples of productivity and accuracy achieved by this technology are given in this paper.

INTRODUCTION

Such strides are being made in developing and applying advanced composites that projects labelled futuristic are now becoming industrial facts.

At the present stage, the increasing needs in high performance composites structures made of unidirectional pre-impregnated fibers urge for a radical industrialization.

In response to the need for an alternative to hand layup, with respect to repeatability and reliability required to manufacture an aircraft wing, the BMO Group has developed jointly with AEROSPATIALE and DASSAULT/BREGUET, the automated tape laying system called ACCESS-ATLAS.

I - TWO STAGE SYSTEM - AN ALTERNATIVE SOLUTION

Any tape placement machine to be truly economic must not only be accurate and fast, but also 100% dependable in all its functions. Because the solutions to tape shear and tape tail control dependability were extremely difficult if impossible in practice, a new philosophy emerged splitting these functions into two machines. One to perform all the tape preparation tasks such as cutting angle and measuring course length. The other to perform only one function, that of laying the tape on the tool or mold.
II - STAGE I - ACCESS - TAPE PREPARATION MACHINE

Access is an acronym for "advanced Composite Cassette Edit Shear System". Access processes pre-impregnated tape material from original supply spools by:
- Continuously removing the tape from the original backing paper
- Cutting each tape course to length and angle
- Repositioning the course on a new backing paper
- Re-winding the course into a dispensing cassette for the stage II

The knife device, under computer control is able to cut virtually any angle, either positive or negative, compound angle and curves as well. Typically the entire laminate stacking sequence for a part is programmed into ACCESS, starting with the last course first and working in reverse such that when the tape cassette thus prepared is placed on the stage II machine, ATLAS, the proper course sequence is achieved.

III - STAGE II - ATLAS - TAPE PLACEMENT MACHINE

ATLAS is an acronym for "Advanced Tape Laying System". The prepared tapes are dispensed onto the surfaces of tools with the advantage that the machine does not pause for shearing and perform no function other than high speed actual tape laying. The main feature of ATLAS is the simplicity and light weight of its components to further improve speed by reducing inertia. It allows to install dual tape laying heads for product versatility and six axes of computer controlled motion for growth potential and contour tape laying.

IV - AUTOMATION OF THE PROCESS - PALS SOFTWARE

From the part definition to total completion of the part, all the functions of the machine are under computer control (fig. 2). To propose a free man's hand system able to master key issues of tape laying process, BMO has developed the sophisticated software PALS. PALS is an acronym for Program of Automatic laying System. It is specially dedicated to:
- Translate a mould surface definition input file into strip cutting and laying part-programmes.
- Laying tape on a dual curvature surface, with no gaps or overlaps.
- Automating and suppressing the process, printing out a log book.

V - EXAMPLES OF USE

5.1. Flat layup

The testpiece shown in fig. 3 illustrates the capability of the machine to overcome important variations in thickness. Such a component is theoretically impossible to layup as this involves deviating the fibers in the thick places. As a matter of fact, the deviation is ignored as ATLAS can force the fibers along a path, programmed along the geodesic line (i.e. programmed as a flat path)

In fig. 3, the change in thickness from area n° 1 (40 layers) to area n° 2 (140 layers) is 15 mm over a 125 mm distance that is a 12% slope. This component has been made within the prescribed tolerances, the gap between two adjacent cuts never exceeding 0.25 mm.

5.2. Developable surface layup

This is one step further in layup difficulty as compared to the previous example. For a developable surface like that of fig. 4 defining the geodesic paths amounts to defining straight paths on the developed surface. A developed surface is not the projection of a curved surface onto a plane. It is the initial surface, flattened as it were, and PALS software provides for the calculation automatically (see fig. 2).