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Laser Guidance for Hand Laid Composites

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abstract

Graphics created by projecting vector-scanned laser light onto tooling may be used to provide quickly accessible, sharp, accurate registration patterns (templates of light) and assembly instructions for hand layup Compensation for distortions caused by projection onto complex curved surfaces is easily accomplished in this medium Brightness levels are sufficient to provide readability in high ambient light conditions, allowing quick, easy and accurate QA inspection and video documentation

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INTRODUCTION

A system providing laser guidance for assemblers can address many of the problems encountered in the production of hand laid composite parts. Application of this system will result in a more flexible, efficient, and accurate assembly process. An assembly guidance system has the capability to:

1. provide engineers with a faster, more direct method of creating or altering assembly instructions which will be used by the assemblers each time a part is laid up,

2. provide complete instructions and a clear, accurate, reference for the correct positioning of all exposed plies in a layup at any time before cure, speeding assembly and reducing errors, and

3. provide an accurate, easily accessible, reference for inspectors, either present or through video remote, to verify correct positioning of all exposed plies in a layup at any time before cure.

This system replaces cardboard templates, strings, or registration pins used for "eyeballing". The components are modular and can be upgraded through software revisions. The ability to interface this system to other computers provides unique data handling functions for hand laid assembly work. The system has the potential to eliminate paperwork in this area.

These layup reference graphics (templates of light) can be created by manually "teaching" the system the patterns required for production. Conversion can also be accomplished by going directly from CAD data to the layup graphics which will be used by the assemblers. Automated video documentation of correct layup can also be achieved. There is also a potential for automated QA inspection of layup through comparing edge recognition data with the layup reference graphic.

These layup reference graphics are easily corrected for distortions resulting from projections on complex curved surfaces. All information is readily visible under normal room lighting conditions. The lines and shapes remain sharply defined even in different areas of a contoured surface.

The basic steps in the laser guided assembly process are shown in Fig. 1. The system components, including both options for creating assembly data, are show in figure 2.

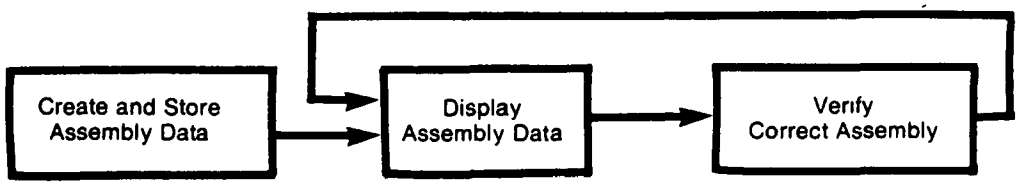


Figure 1.

Steps in the laser guided assembly process.

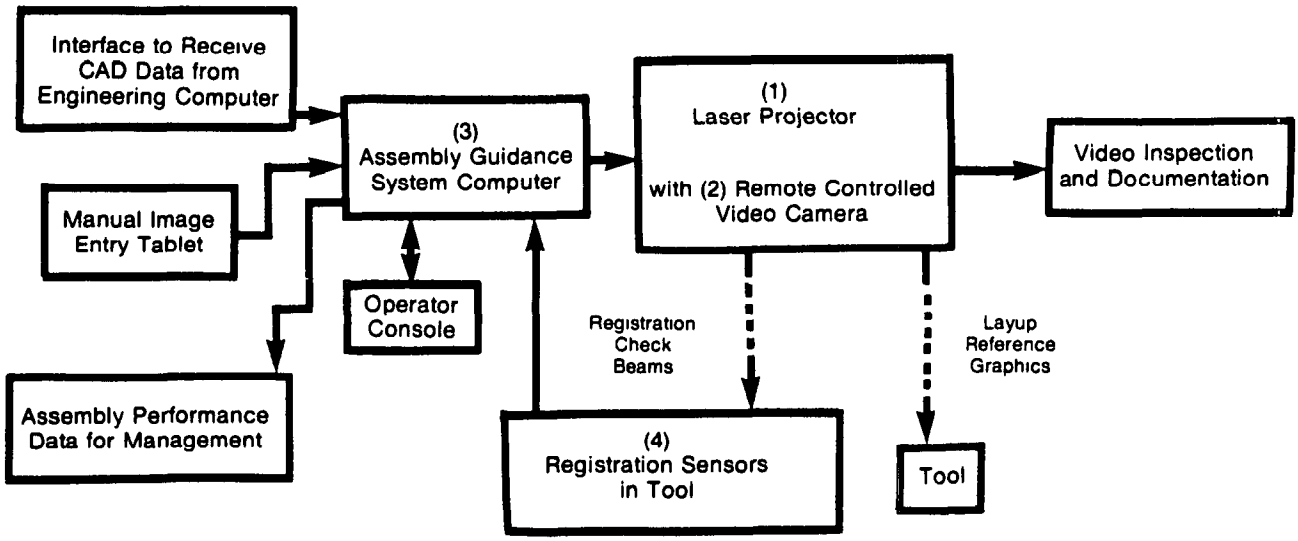


Figure 2.

System elements for laser guided assembly.

SYSTEM DESCRIPTION

The system creates graphics, projected onto tooling and plies, by vector scanning laser light. By rapidly moving a beam of laser light through a repeated series of horizontal and vertical coordinates the projector can create sharp, bright, persistent images. These images can take the form of words to describe part numbers or other assembly instructions, or registration patterns (templates of light) which are displayed in accurate registration within the tools.

There is no focus involved with a vector scanning system. The lack of divergence of laser light produces a sharp dot or line at any distance from the projector.

The main components of an assembly guidance system are:

1. A laser projector which is mounted above the work area. The projector contains the laser light source, scanners, and shutters.

2. The projector may also contain a remote controlled video camera for QA inspection and documentation.

3. A computer which responds to input from operators, registration sensors mounted on the tool, and other computers. This computer sends the control signals to the laser projector.

4. Registration sensors which are attached to the tool. These sensors are scanned by the projector to verify correct positioning the graphics on the tool.

5. A control console for the operator. The computer (described in #3 above) may control more than one projector at a time and may reside away from the assembly area.

See Figures 2 and 3.

SYSTEM OPERATION

CREATION AND STORAGE OF ASSEMBLY DATA

Assembly data is made up of graphics patterns (templates of light), indications of fiber orientation, and any text or numerical data which would be of use to the assembler. The two methods of creating this information are as follows:

1. Assembly patterns may be created from CAD data which was generated on another computer. See Fig. 4. In this case the CAD computer outputs the layup shapes to the assembly guidance computer in a standard plotter format.

   The assembly guidance computer then processes the horizontal and vertical coordinates to compensate for distortions which will result from projection on a contoured surface. This corrected graphic is then optimized for projection with scanners. The scanners are mechanical devices which have inherent geometric and inertial distortion characteristics. The pattern is then tested. A menu of image editing options is available if distortions or other problems are apparent. Text data is downloaded in standard ASCII format.

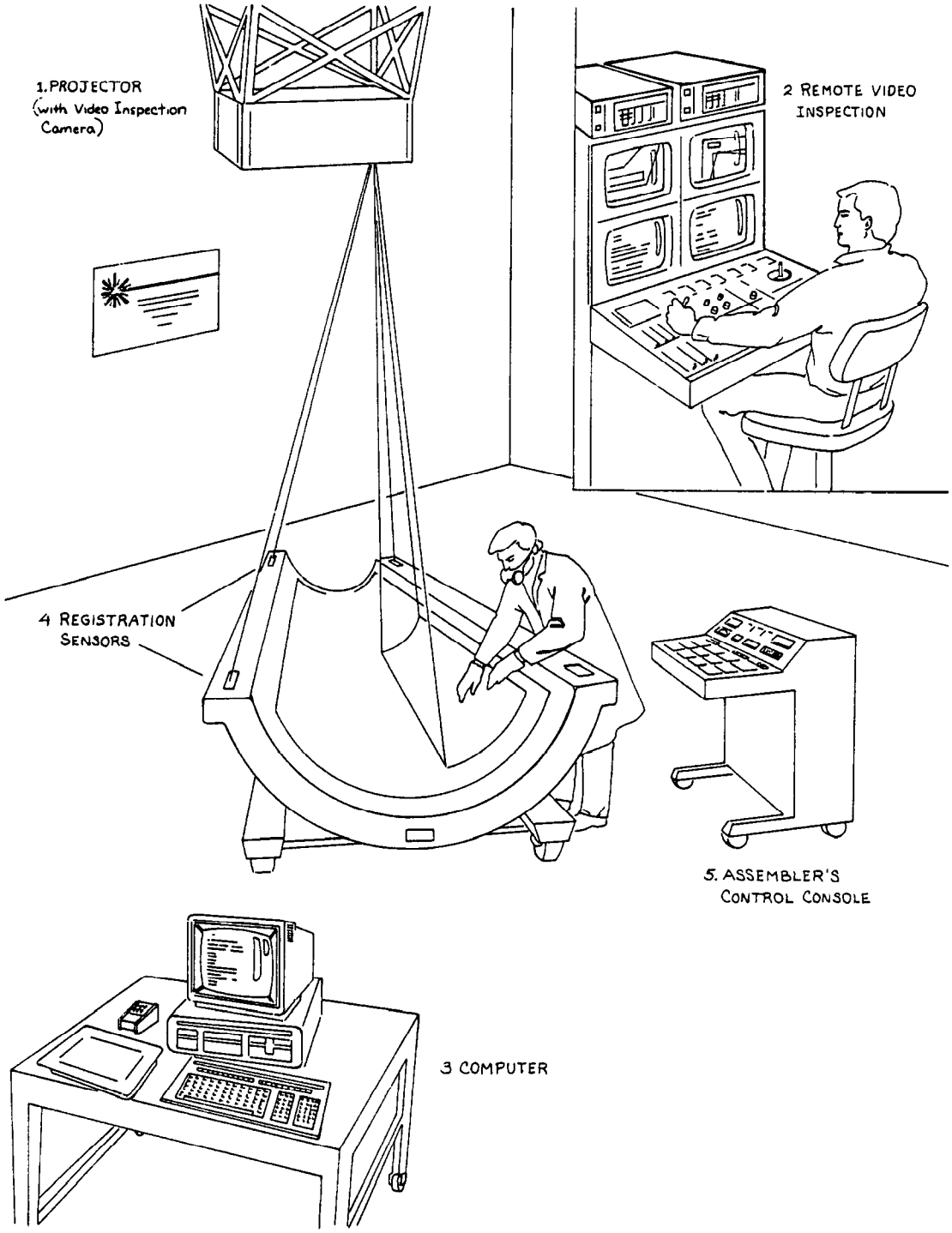


Figure 3.

System components for laser guided assembly.

The assembly guidance computer also translates this information into image files which can be displayed by the projector.

These images can be enhanced with the same variety of editing options used for the layup patterns. This editing software has been in use for several years and is used by studio technicians that do not have computer backgrounds.

These patterns and text images are then combined with other patterns and instructions which make up different steps in an assembly process.

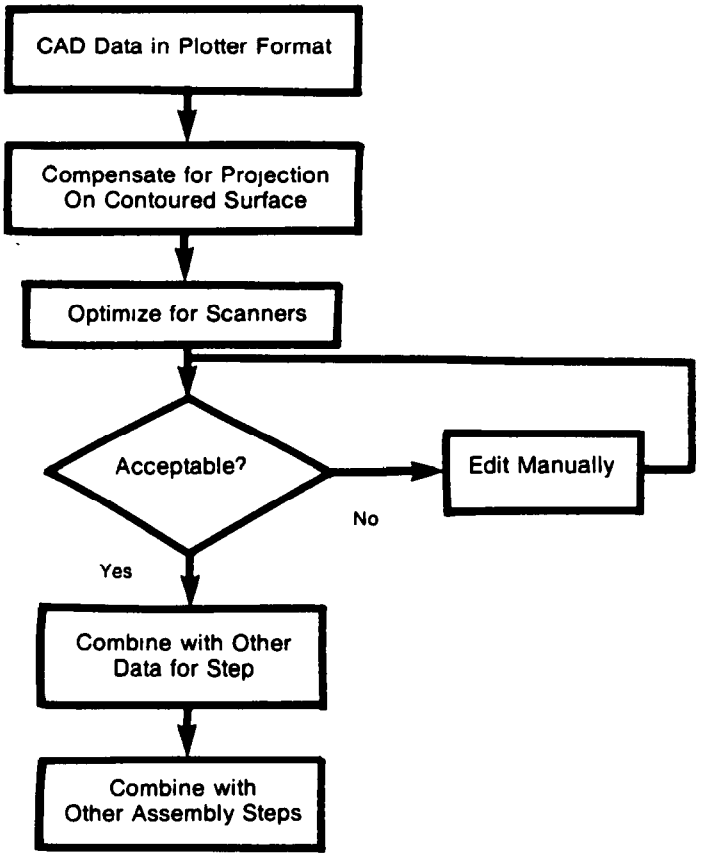


Figure 4.

Steps in creating assembly patterns from CAD data.

2. Assembly patterns can be produced manually by tracing examples of proper layup. The ply which is traced must initially be located properly using traditional measuring devices. Tracing is done using a "mouse" or digitizing tablet entry device. The image and data output is projected using the actual tool as a display device. The tracing process is quite fast due to features of the pattern entry software. Entry of six to ten simple patterns per hour is typical.

   Text data is either downloaded from an engineering computer or typed in manually. Optimizing images for scanners is done using the same editing routines as the method described in #1 above. This method empirically eliminates distortions resulting from projection on complex curved surfaces.

SYSTEM FUNCTIONS DURING LAYUP

The layup of each ply involves a complete cycle of functions for the assembly guidance system. See Fig 5. The operator selects the appropriate assembly procedure on the assembler's control console. The projector displays information on the procedure.

The system automatically emits registration checking patterns to the sensors which have been attached to the tool when the operator indicates that the procedure information has been seen. (Checks of registration takes only a fraction of a second.) The system initiates or requests correction if the tool is misaligned with the projected test pattern. The system displays layup patterns immediately if the test pattern is in registration with the tool.

The assembler lays up the part and indicates that the ply layup is complete. The system then checks registration again to be sure that the guidance patterns are in the right place. QA inspection can then be made using the projected pattern for reference. The registration of the system is checked again and the layup pattern remains until the inspector indicates that any misalignment of the ply has been corrected.

When the QA inspection is complete the system can automatically operate a video recording system which make a record of the ply shown in registration with the projected

layup pattern. At this point the system can also store or report assembly performance data (time used for layup, ambient conditions, amount of time spent rechecking layup, etc.) for later analysis by management or engineering.

The completion of the layup and inspection of a ply leads to the display of the next instructions and patterns required for the assembly.

QUALITY ASSURANCE OPTIONS

Assurance that the plies in a part are positioned accurately may be accomplished through visual inspection. This may take the form of an inspector that is present at the tool, comparing the location of the ply, or exposed plies, with the pattern created by the projector.

This inspection may also be accomplished remotely by mounting a remote controlled video camera in the projector. This makes many workstations immediately accessible to one inspector. The video images which the inspector sees are also easily recorded and cataloged for documentation of proper assembly.

Fully automated inspection is not in operation at this time. This would require a method of determining the location of a ply. A report on the accuracy of placement of the ply could be made by comparing this ply placement data with the easily recognized layup guidance pattern. It is conceivable that video analysis could yield edge-of-ply data for this purpose. The hardware which would already be in place (remote controlled camera and computer) is likely to be able to support this function with additional software.

Assembly performance data can be reported from the assembly guidance computer to a data base for management or engineering. Information such as date and time of assembly, ambient temperature and humidity, amount of time spent on each step in the process, etc. can easily be tracked with this system. The formatting, storage, and reporting of this data is programed when the assembly process is being created or edited.

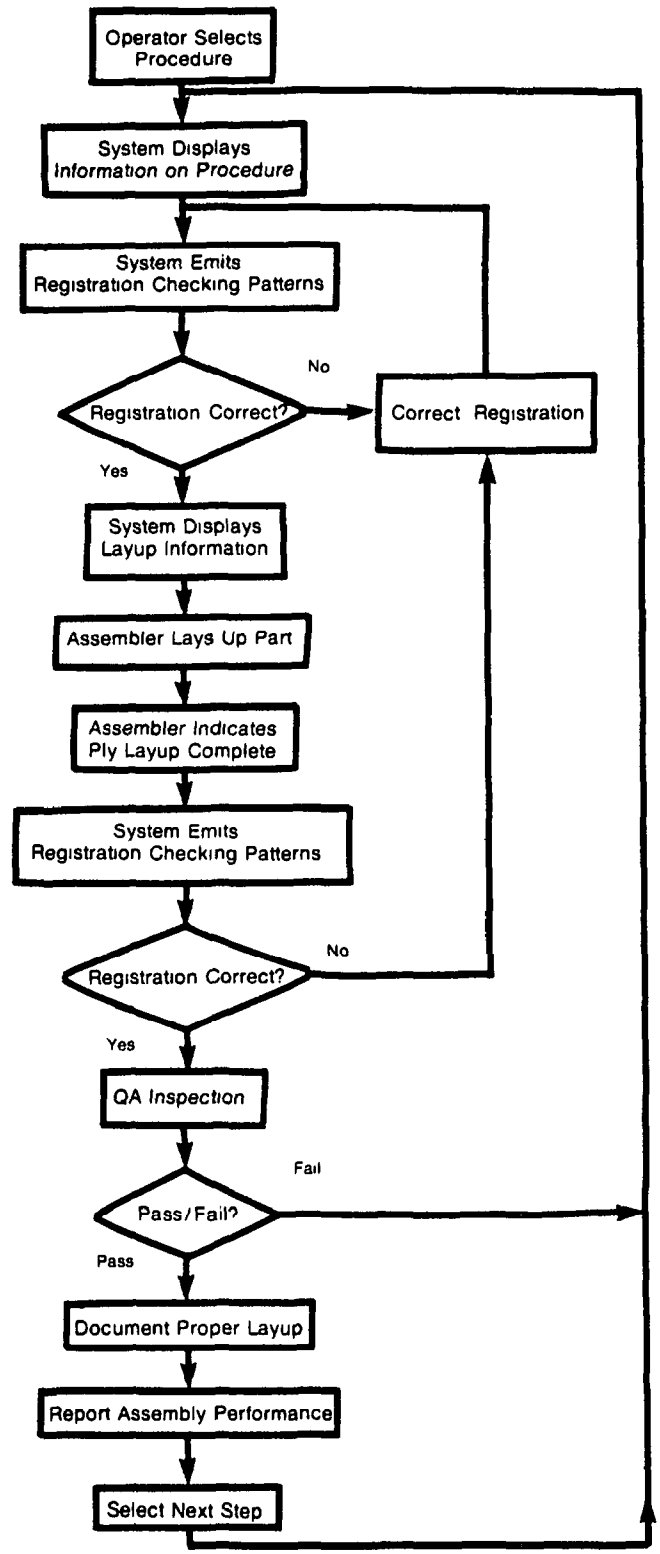


Figure 5.

System functions during layup.

SAFETY

The system described here presents no eye or burn hazard to operators or the surrounding environment. Exposure to laser light, even in very small amounts, is highly regulated by the Federal Center For Devices and Radiological Health (CDRH). The static beam emission levels from the projector are less than 30 mw. This is not even warm to the touch. The system is redundantly interlocked so that static beams cannot be emitted under normal operating conditions. The scanned output exposure levels to operators are less than 1 mw when measured by CDRH criteria. This level is considered "eyesafe" by the CDRH. The lines are of an intensity comparable to the brightness level of the dot produced by a laser pointer, often used by speakers at technical presentations. The CDRH has approved visible light beams up to 60 watts for display purposes. (The 60 watt beam was used for the rededication ceremonies for the Statue of Liberty in July of 1986. The light sequence was initiated by the president's pressing a button on Governor's Island, creating a highly visible, mile long beam of light to the statue which appeared trigger a reveal of the statue with conventional lighting.)

SUMMARY

The laser guided assembly system described here offers many advantages over current methods of aiding and documenting hand laid parts. Application of this electronic CAM system should increase assembly speed while reducing errors. ECOs should be easier to implement and a great, if not complete, reduction of paperwork can be accomplished. A more efficient use of inspectors and production space can be achieved through a conversion to this process.

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