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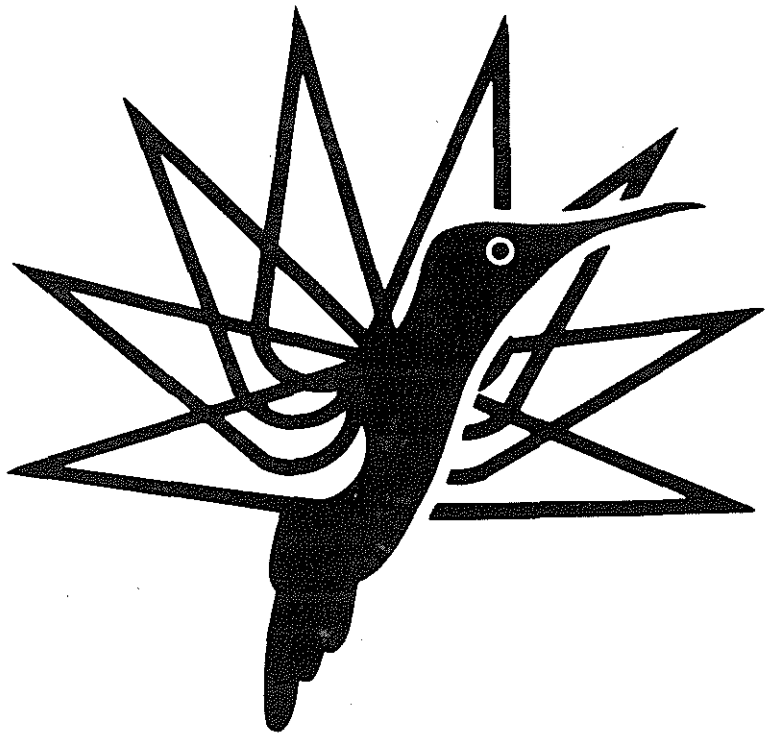

COMPOSITES IN THE DEVELOPMENT OF AGUSTA HELICOPTE

BY

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COMPOSITES IN THE DEVELOPMENT OF AGUSTA HELICOPTERS

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Abstract

Elicotteri Meridionali - Agusta Group - manufacturers composites blades and composite primary structures of different types of helicopters such as Agusta helicopters and licenced helicopters. Advanced composite parts are constructed for military helicopters such as anti-tanks and ant-submarines.

This paper describes the new composite factory applied to primary structures, main rotor blades, hubs, tail rotor blades, etc. The technology used will be illustrated as well as the machines, tool and materials employed in the production of the above applications.

The composite plant has been in production since the end of 1982, at the moment the goal is to improve the composite applications, so that to increase the volume of production. In addition Agusta Company is currently under contract with the Italian Government to develop the A129"MONGOOSE" and EH101 ASW in which high percentage in surface, volume, weight is made in composite material.

1. INTRODUCTION

ELICOTTERI MERIDIONALI - AGUSTA GROUP - started in the year of 1982, the development and the employ of the COMPOSITE MATERIALS in production of helicopters parts.

For this reason a new plant has been established in ANAGNI (ITALY) at 60Km south from ROME.

Advanced composite materials such as Kevlar epoxy and Graphite epoxy were introduced in the manufacturing of dynamic parts: main rotor blades, tail rotor blades, hubs and primary air frames structures - tail units - panels etc.

Methods of manufacturing were developed and at the same time, tools machines etc., according to AGUSTA engineering's design.

2. ANAGNI PLANT

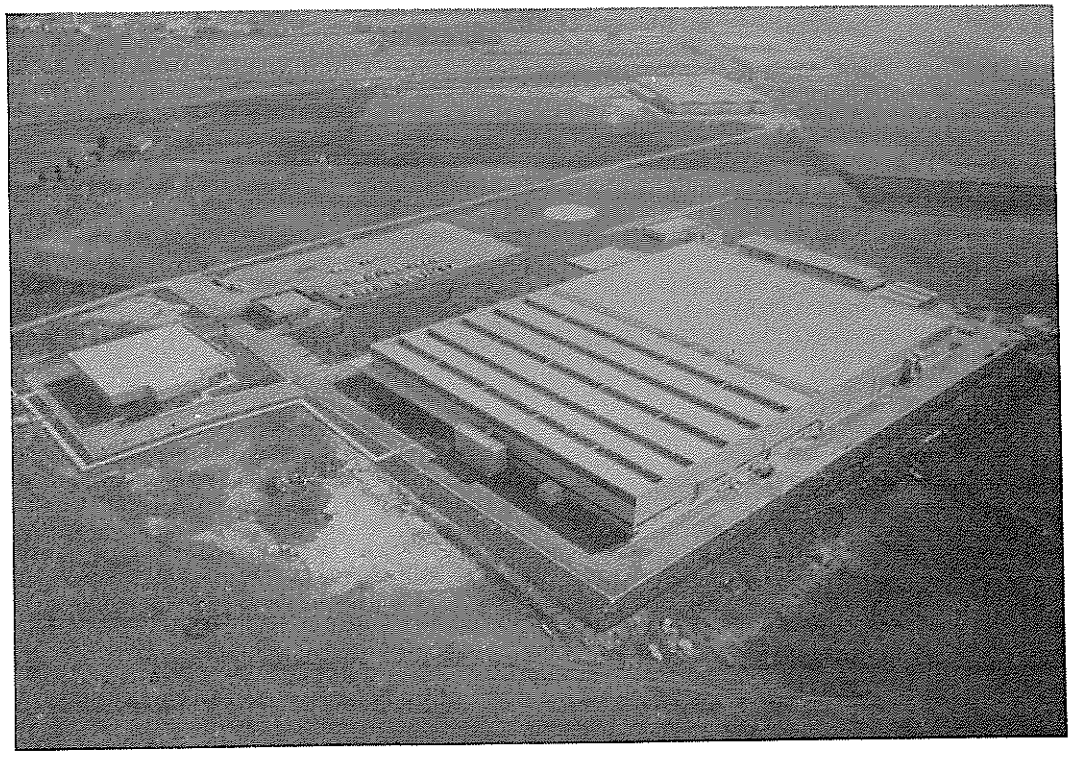
The ANAGNI PLANT has available an area of 200,000 sq.mt. of which 18,700 sq.mt. are covered by structures and edifices.

The working force consists of 200 dependents, but as work increase an additional amount of dependents will be needed.

The PLANT has in the total working area many departments furnished and equipped with the latest and up-date machinery and equipment.

The Departments are:

- WAREHOUSES
- METAL CHEMICAL TREATMENT DEPT.
- CLEAN ROOM
- FINISH DEPT.
- THERMAL POWER DEPT.
- TECHNICAL OFFICES
- EXPERIMENTAL PILOT CENTRE



View of Anagni Plant

3. MANUFACTURING MACHINERY AND EQUIPMENT

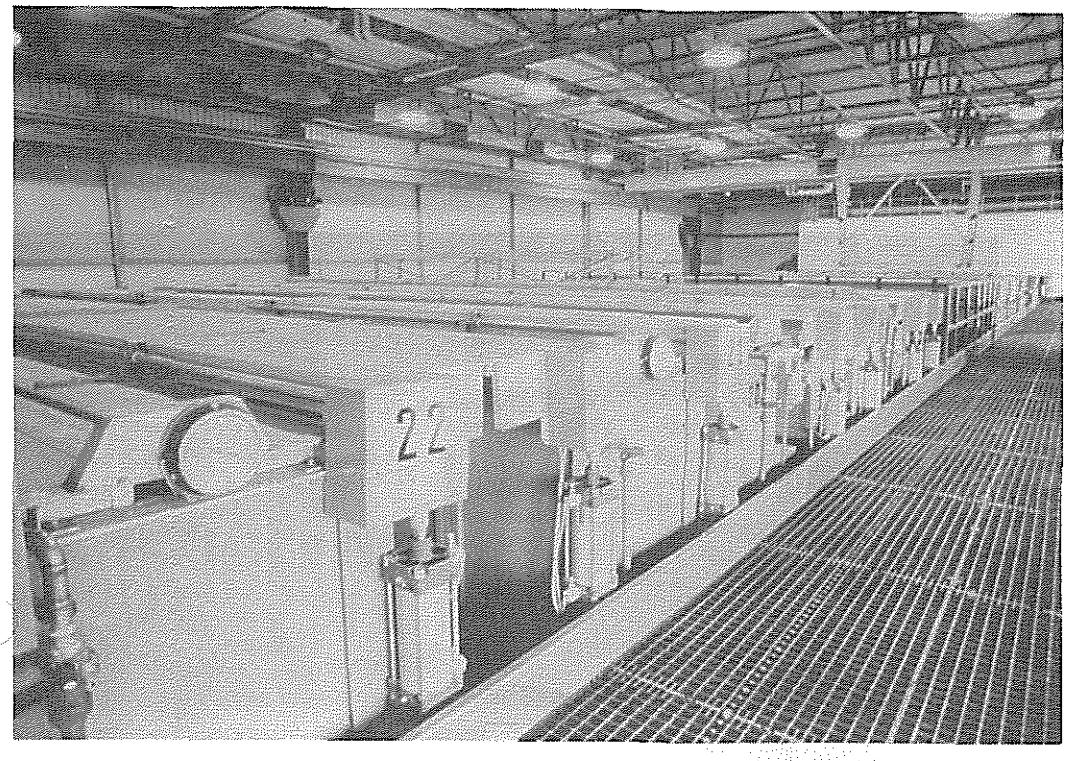
3.1 Warehouses

To store the Composite Materials which have a "LIFE TIME" durability, the warehouse is equipped with two refrigerators of 750 cb meters each, kept at a temperature level of -20°C.

3.2 METAL CHEMICAL TREATMENT DEPARTMENT

All work treatments are done by automatic machines.

Antipollution equipment also is included providing to eliminate from exaust waters all substances which cause pollution, and this is done by neutrolization and sedimentation (ex. Cr).



3.3 CLEAN ROOM

The CLEAN ROOM is equipped with AUTOCLAVE, HOT PRESSES and it covers an area of 4000 sq.mt. by 24,000 cb.mt. at a temperature level of 21°C, 50% R.H., Filtering 99,9 D.O.P.

The pressure in the CLEAN ROOM is much higher than the pressure outside the Room, this impedes dust contamination.

3.3.1 AUTOCLAVE

The maximum load is 7000 Kg.

It's dimensions are: L = 10 meters
Ø = 3 meters

The maximum values of T & P usable: 260°C and 12 ATE

The temperature tollerance is of $\pm$ 2°C, and the maximus ramp is 8°C/min.

The pressure tollerance is $\pm$ 0,01 Kg/cm^2

3.3.2 HOT PRESSES

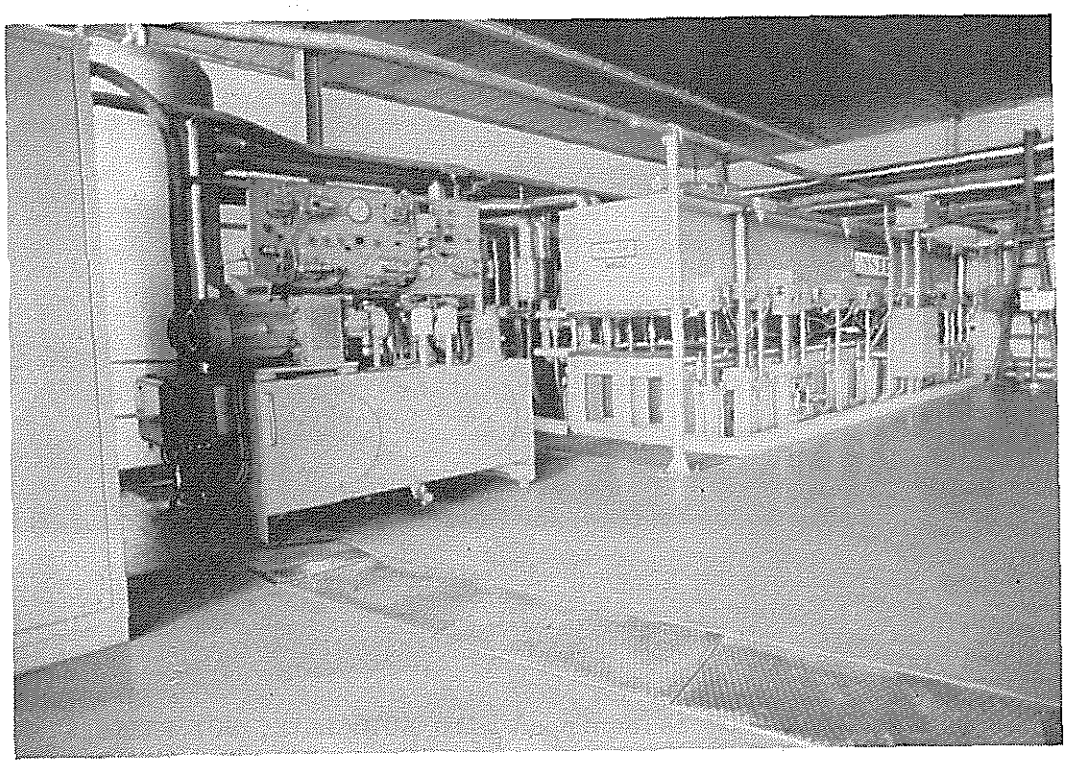
The presses dimensions are: Lenght = 9 meters
Width = 1,3 meters
Height = 0,4 meters

The main feature of this press is that the platform is made of one piece, divided in six sectors and each individual sector is separa tely controlled. It is heated by oil.

The maximum value usable is T = 260°C
P = 7 ATE (850 tonn)

The temperature tollerance is $\pm$ 2°C

The maximum Ramp is 5°C/min.



3.3.3 MACHINERY

a) FILAMENT POLAR WINDING MACHINE

Parts mady by roving are produced and manufactured by the FILA MENT POLAR MACHINE,which can utilize 16 Spools or less. It takes an area of 9,6 mt long, 0,6 mt wide and 0,3 mt high.

This machine manufactures parts of main rotor hubs, for EH 101 and main rotor grip for helicopters A129 etc.

b) TAPE LAYUP MACHINE

The dimensions of the coils used are 500mm diam. and 200mm wide. This machine manufactures Spars Assy for helicopters models A129,

3.3.4 C.C.S. RESEARCH & DEVELOPMENT AREA

Of the 4000 sq.mt. occupied by the CLEAN ROOM, an area of 1000 sq.mt. is available for Research on the appling composite materials.

Engineers, technicians and specialists work closely toghether on Samples and Prototypes for experimental studies in order to develop and industrialyze projects, providing:

- Raw Materials features and related Specifications
- Tooling Development and Set-up
- Development and Qualification Specifications
- Manufacturing Work (Planning)
- Control Specifications

These activities are closely correlated with Agusta's engineering, who has the responsability for design and qualification.

3.3.5 FINISH DEPARTMENT

a) NOMEX CONTOUR MACHINE, this machine is made of 2 spindles, each spindle has five axis movements.

The features of this machine are:
Production work maximum speed 10 meters/minute
Spindle speed 7000 to 24000 RPM

b) WATER-JET MACHINE is used to cut the Laminated composite material, and operates by Water-Jet pressure (4000 ATE max pressure).

c) ELECTRO-HYDRO MOULD MACHINE, is used especially to mould Metal Tip Caps of blades.

3.3.6 VARNISH DEPARTMENT

This department is for varnish blades and panels.
The work is done by automatic electric machinery, (conveyor belts movements). Only in a break down of the equipment a person or more have to continue for the production work.

4. TOOLS

The main tools used can be divided in two groups.

1) Layup and Compact Tools
2) Polymerization Tools

4.1 The Layup and Compact Tools are designed and constructed to obtain the final shape of each part.

The Tools have been constructed and designed so that they can be used on available machinery.

The Tools are made of aluminium or stainless steel.

4.2 The Polymerization Tool is made up of a one piece mould or of two pieces mould. (Male and Female).

The one piece mould is used by the autoclave, the two pieces mould are used by the press.

The moulds are made of Aluminium, Stainless steel, Nickel Electro - Depositated, Resin and Fiber.

5. QUALITY AND CONTROL DEPARTMENT

EQUIPMENT AND TESTING

The Quality Control Dept. is responsable for the quality of all the parts and pieces manufactured, it also garantees that all STANDARDS, MANUALS, SPECIFICS and DRAWINGS are observed.

At the present time one of the major task to be achieved is the development of personalized Non Destructive Test capable to garantee the constant quanlity of the products; in fact our experience, at this time says that each piece manufactured requires a particular methodology.

The Quality Control main activities are:

- Manufacturing Tests
- Non Destructive Tests
- Planning Control
- Acceptance Tests
- Laboratory Analysis

5.1 The equipment used by the Quality Control Department are:

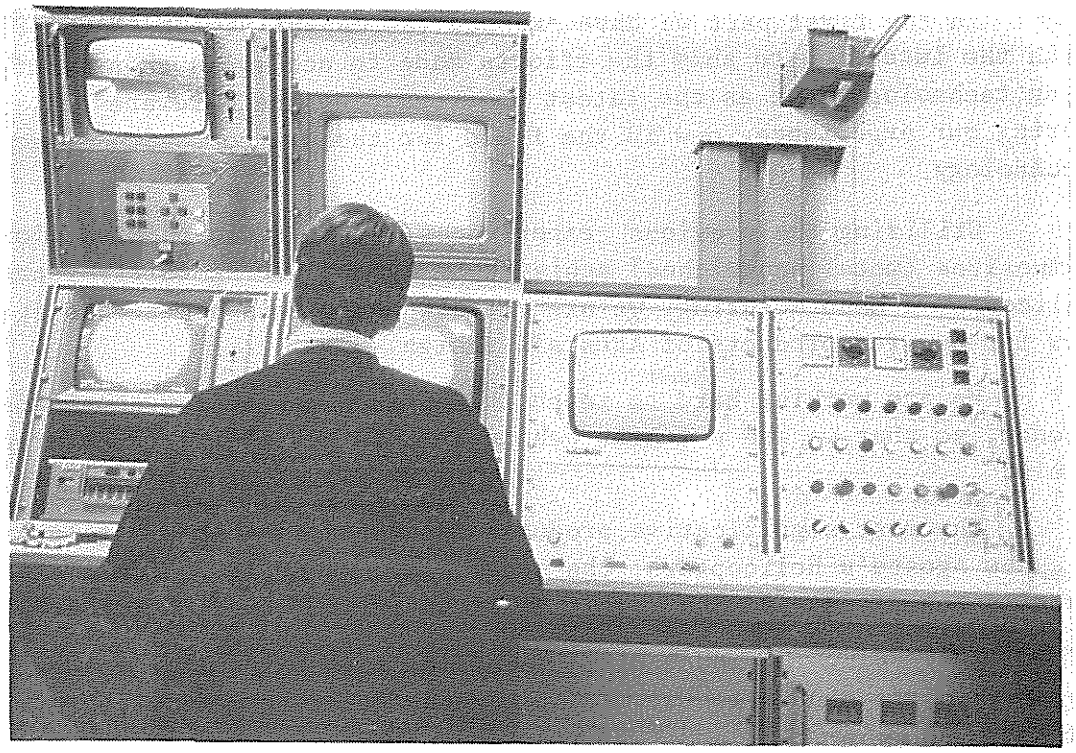
- NON DESTRUCTIVE TEST (the main equipment)

a) X-RAY MACHINE, capable of a scanning of 10 mt by 1 mt and by 2,2 mt.

A radiography and floroscopic system shows images in color, black and white and 3D. Also a tape register is installed that records all the data and can be seen at any time.

b) ULTRASONIC MACHINE, has installed a water container, its dimensions are 15 mt by 1,8 mt and by 1,8 mt.

The work is done by imersions or by Water-Spray System.



X-Ray Control Panel

5.2 CHEMICAL-TECHNOLOGY LABORATORY

The Chemical-Technology Laboratory is furnished with the following instruments:

a) Equipment for Chemical and Physical Tests on Prepregs and Laminates

b) Physico-Chemical Tests on Prepregs and Laminates

- HPLC (High Pressure Liquid Chromotography)
- DSC (Differential Scanning Calorimetry)
- TMA (Thermo Mechanical Analysis)
- DMA (Dynamic Mechanical Analysis)
- IR (Spectrophotometry)

c) Mechanical Tests on Composites

- Tensile
- Flexure
- ILSS
- Compression

d) Adhesives

Various types of shear and peeling Tests on Adhesives utilizing a Universal Testing Machine.

6. PRODUCTS

In the first part we have exposed the capability of ANAGNI PLANT with the intention to show the efforts made to achieve such a manufacturing technology, not as the latest one regarding the hardware but, considering our experience, new in the field for the new composite materials technology.

Utilizing the previous experiences in the field of traditional composites (metal sandwiches) achieved by Agusta during thirty years of helicopter's manufacturing, we are consolidating this new technologies, new for us, for products of Agusta's design.

We are working hard to reach the up-date technology experiences needed, so that we are not left behind in this new Composite Materials field.

The most significative products manufactured now, are related to the new Agusta's Helicopters; the model A129 "MONGOOSE" which the prototype is now flying and the model EH 101 is in full development stage.

Regarding the model A129, in addition to parts like covers and panels, we are manufacturing the main rotor grips (commonly called "HORSE SHOE"), the main rotor and tail rotor blades.

Agusta Model A129 "MONGOOSE"

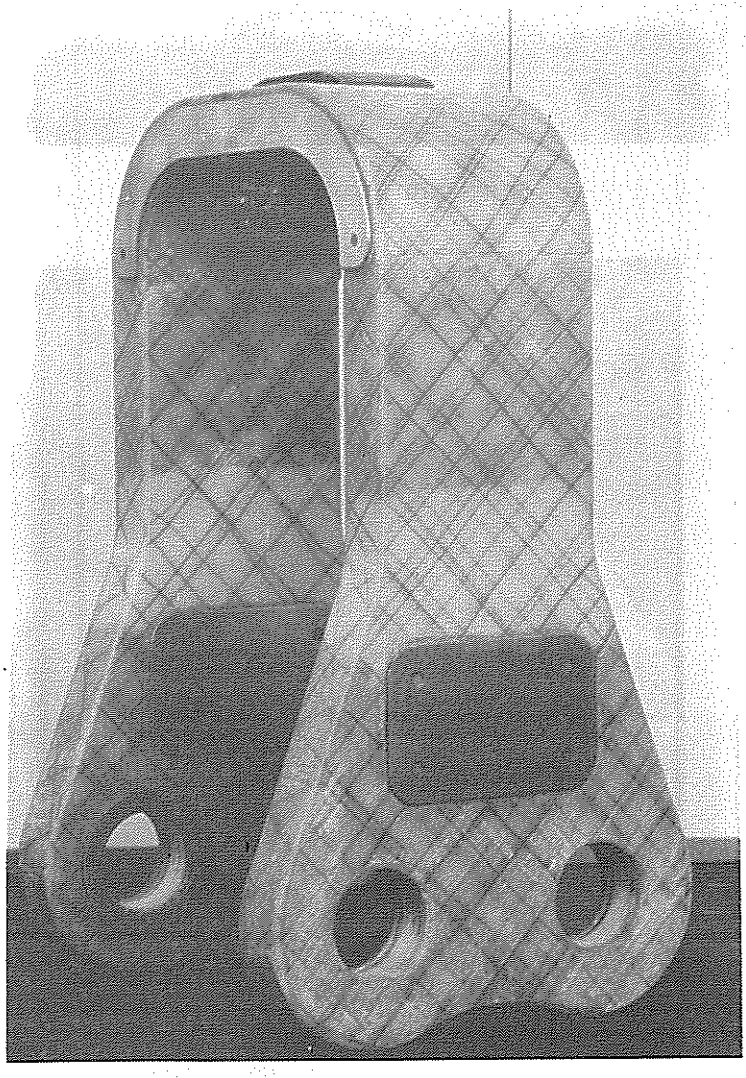
Regarding the model EH 101 we are manufacturing the main rotor hub and the one piece tail cone and vertical fin.

6.1 Grip Assy, - Helicopter model A129

The Grip Assy, (horse-shoe shape), has the inner part made of glass roving and the outside cover made of glass, cross-ply; in the contact area with other main rotor hub components, the Grip Assy is protected by metal plate or bushing.

The proper fiber's alignment is garanteed utilizing the winding machine and a special tool; the polymerization process is obtained with the hot press in two stages, one for the roving assy and the second for the Grip Assy, completed of covers and metal parts.

After the first stage of polymerization the part is put through radiographic and ultrasonic test to check the proper alignment of rovings and the void's absence, the result of this test is comparing proper acceptance standard obtained from the previous activities of experimental tests.

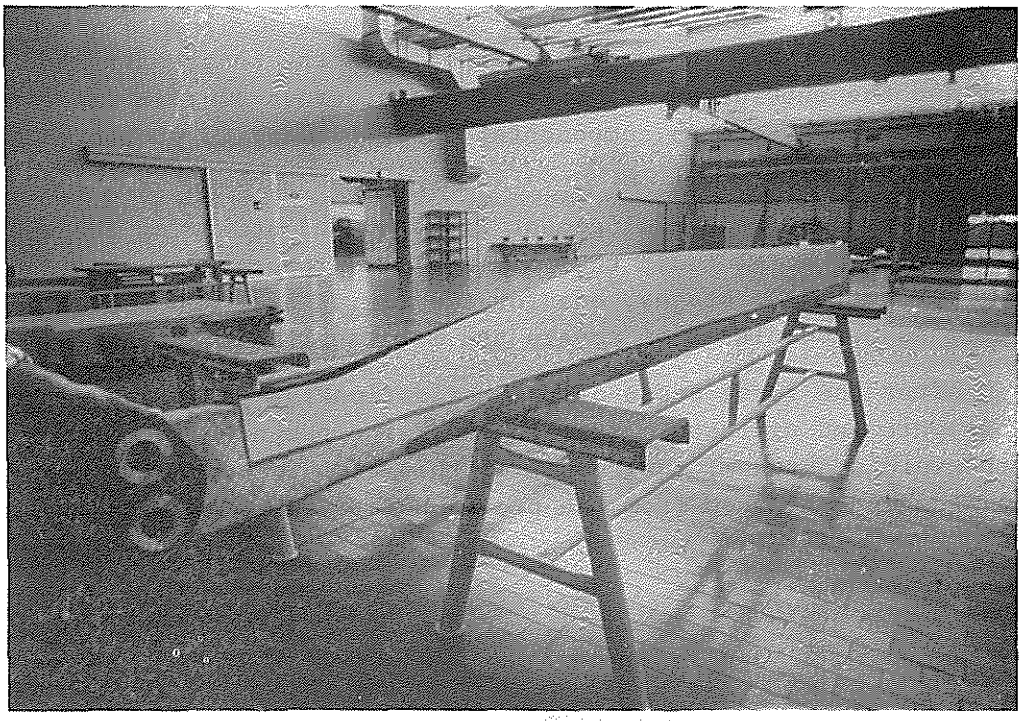


A129 Main Rotor Hub - Grip Assy

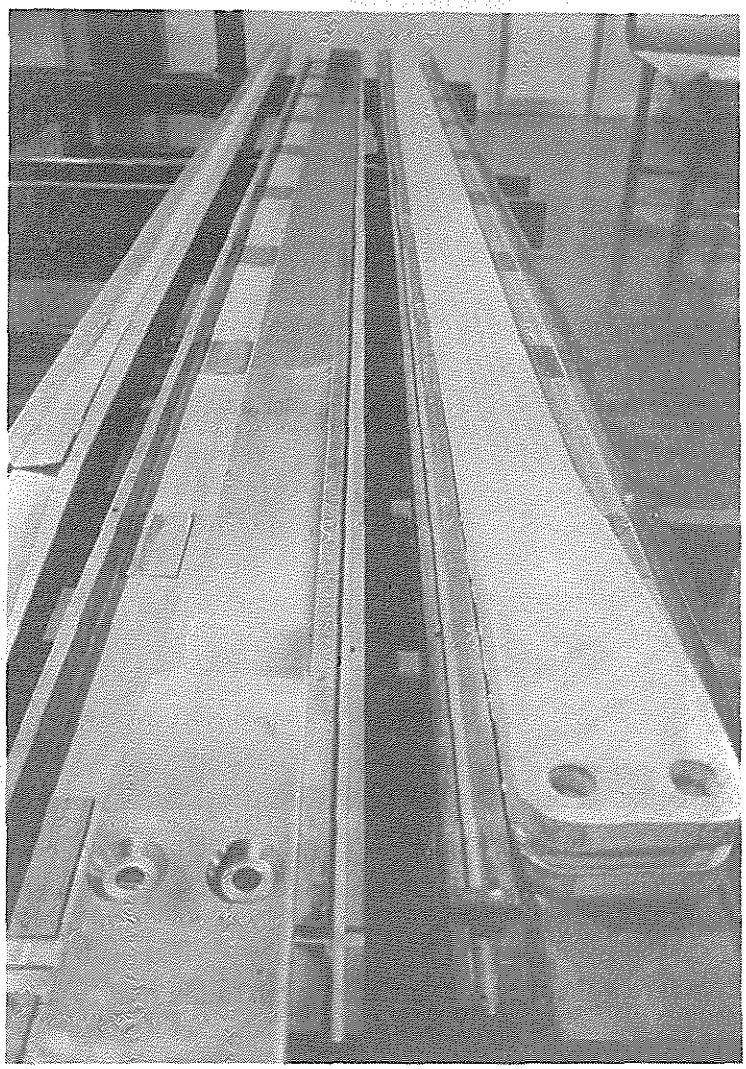
6.2 Main Rotor Blade - Helicopter model A129

This blade is installed on a four-blades fully articulated main rotor hub.

The blade thickness is constant from the root to a certain point and then the thickness decreases to the tip, with a linear-ratio; the twist has a non linear ratio.



A129 Main Rotor Blade Assy



A129 Main Rotor Blade - Spar Assy

The spar assy is manufactured separately, utilizing unidirectional glass, glass cross-ply and with a stainless steel anti abrasion strip, utilizing the hop press. After that, the entire blade assy is polymerized in the hot press, adding nomex core and glass skins to the previous polymerized spar assy; the nomex core is bonded to the prepolymerized lower skin.

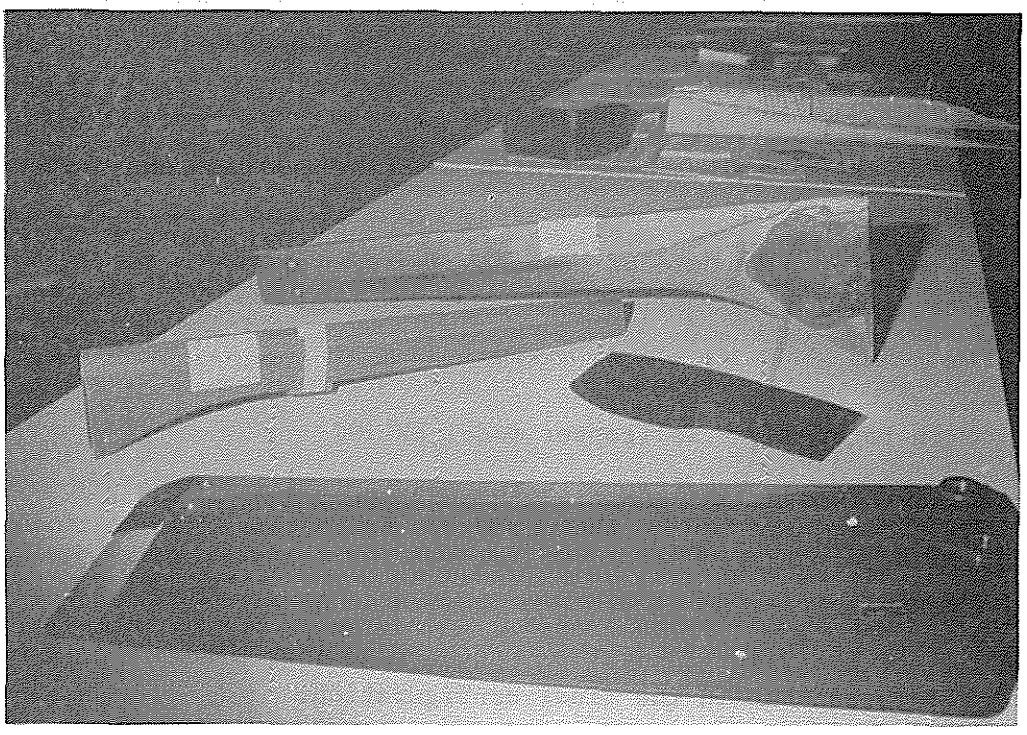
The manufacturing process than continues with the final machining of the root; from the tips are obtained the samples to check the entire process of polymerization; the blade is also tested with radioscopic and ultrasonic test.

After being varnished the blade is statically balanced utilizing a weight located at the root and at the tip; the dynamic balance is made directly on the helicopter.

6.3 Tail rotor blade - Helicopter model A129

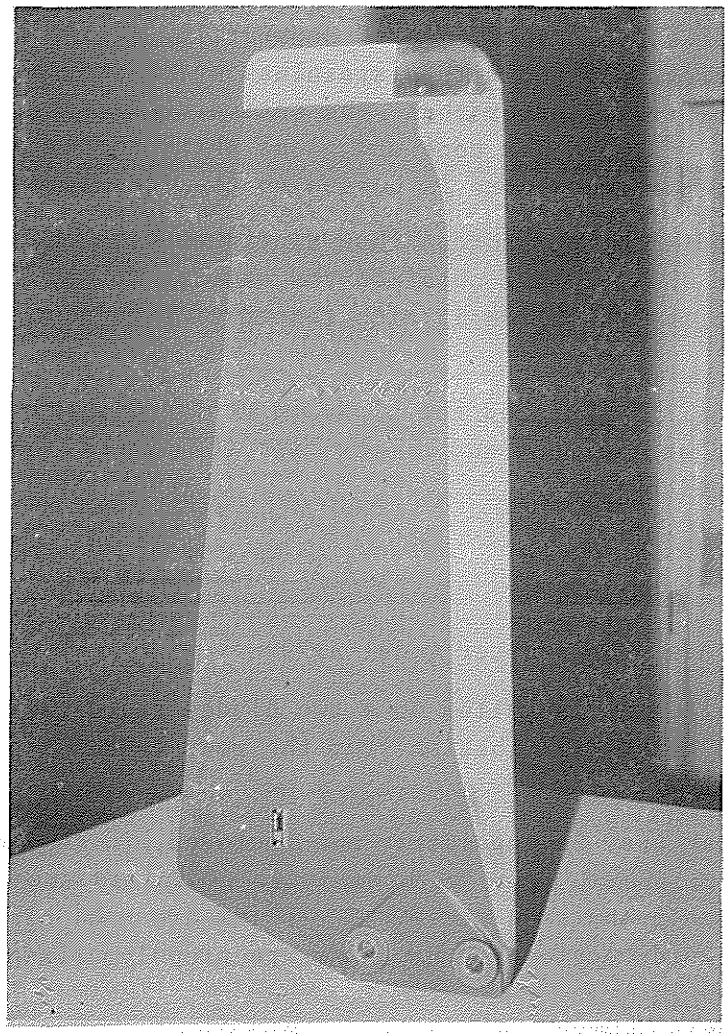
This blade is installed on a two blades rigid tail rotor hub; thickness and twist distribution from the root to the tip has a linear ratio.

The spar assy is separately manufactured, in the hot press, polymerizing undirectional glass with an outer stainless steel skin, utilizing also as anti abrision strip. The skins are made of Kevlar cross-ply and graphite unidirectional, the skins are prepolymerized.



A129 Tail Rotor Blade and Components

The entire blade assy is polymerized in the hot press, bonded together the spar assy, the skins, nomex core, a root frame of compression moulding and two external doublers made of al-alloy.



A129 Tail Rotor Blade Assy

After the machine finish and final varnish, the blades are statically balanced.

The procedure of acceptance are the same as per main rotor blade.

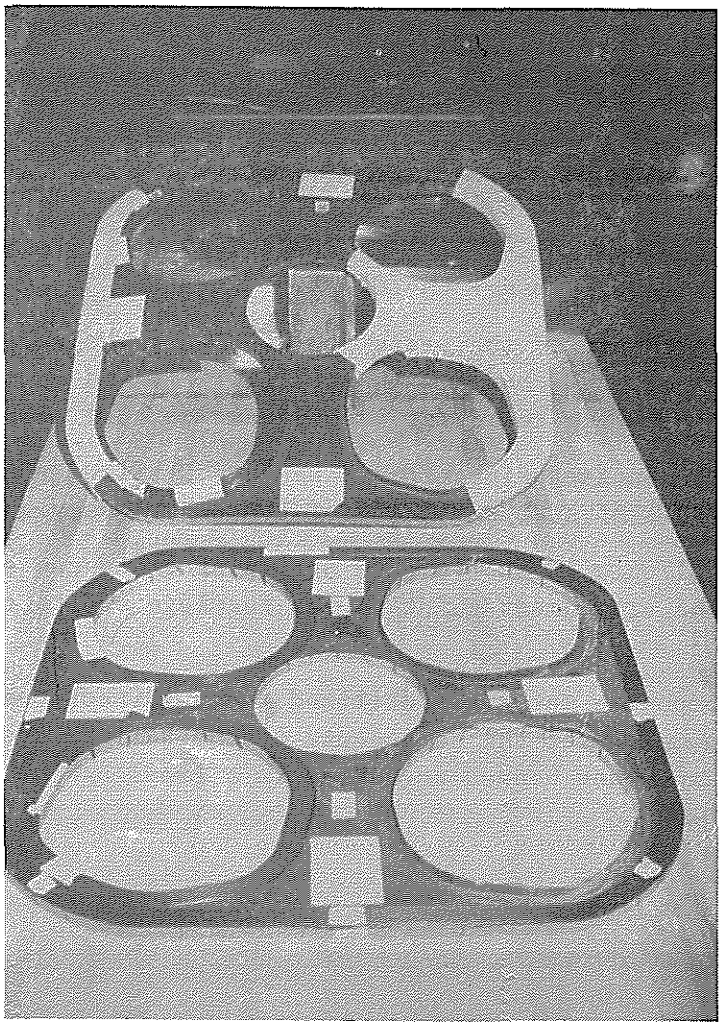
6.4 Main rotor hub - Helicopter model EH 101

We are starting with the manufacturing of the pre-production series after the completion of the prototype series in order to check, with Agusta's engineering design requirements and the manufacturing and quality control technology.

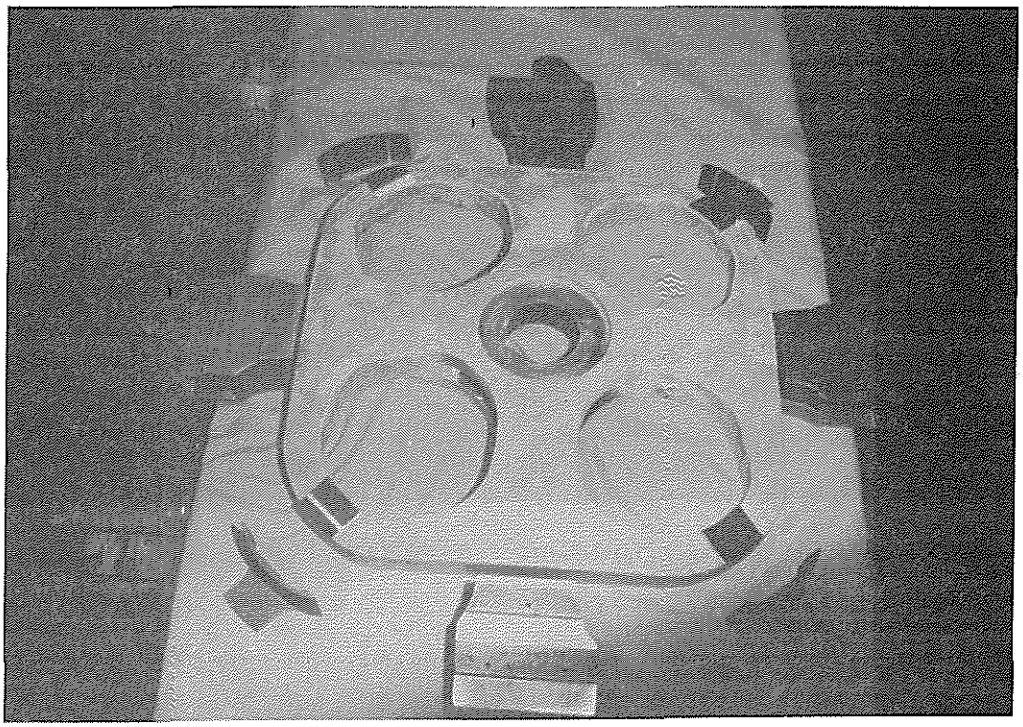
The Test-proposal prototype is a four-blades hub, instead of the five-blade hub in the final configuration.

The hub assy, has a metallic central element to which are attached four upper rings and four lower rings, manufactured separately utilizing graphite roving on a special tool with the winding machine.

On the outside are two other rings, upper and lower, manufactured as the inside ones; all these rings are prepolymenrized with the hot press.



EH101 Main Rotor Hub's Components



EH101 Main Rotor Hub Assy

The entire hub has a glass cross-ply cover that is also prepolymerized and consists of three parts.

The hub is assembled and bonded toghether with the necessary metal parts utilizing the autoclave, meantime, we are developing a complete hot press process to the pre-production series.

6.5 Tail Unit - Helicopter model EH 101

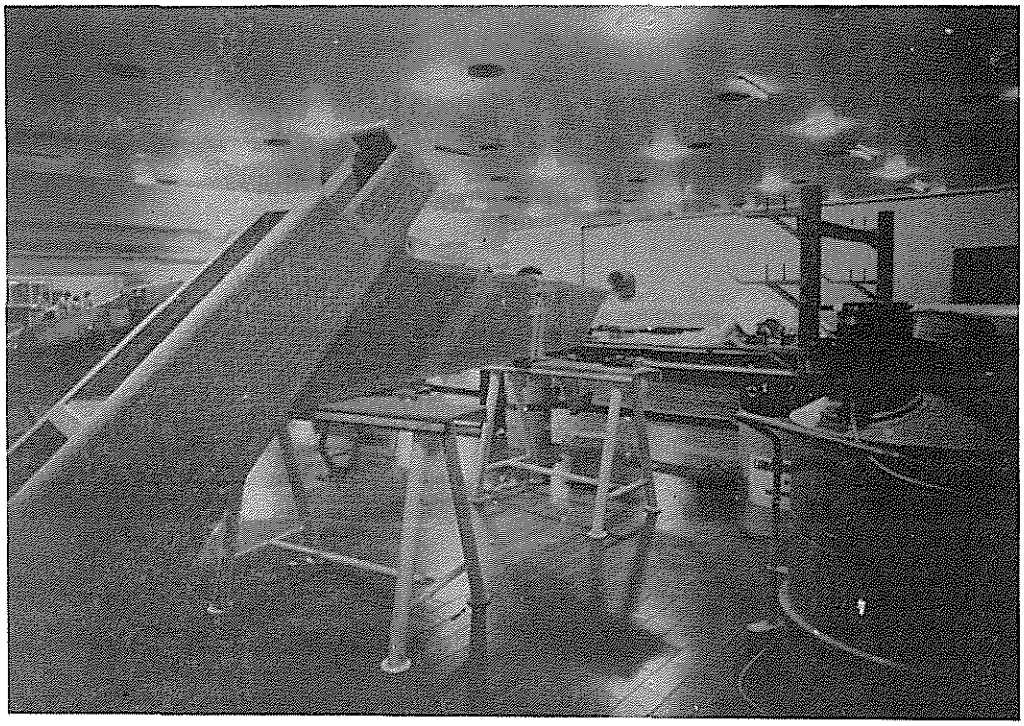
We have completed the prototype series of the entire Tail Unit, consisting of the tail cone and the vertical fin and we are now about to start manufacturing the first pre-production tail unit.

In this manufacturing process we have utilized the autoclave, due to the dimensions of some parts and of the entire assy.

The tail unit is a structure utilizing frame and skins with metal doublers at the attachment point to the fuselage and to the tail rotor gear-box.

The composite materials utilized are unidirectional praphite and Kevlar with nomex core; the components of the tail unit are singularly manufactured and then bonded toghether in a final assembly tool.

EH101 Tail Unit - Assembly Tool



EH101 - Tail Unit Assy

7. CONCLUSION

In the following years of 1985 and 1986, a larger scale production activity is expected.

The experiences and labour done in the past years, can help us to get the best and higher quality potential's value from all the machinery and equipment that the PLANT has.

At the present time an important view to keep in mind is the development of Non Destructive Tests capable to garantee a high quality of all our products.

It is very important thatall management and coordination is kept in order to have better results in planning between the QUALITY CONTROL DEPT., TECHNICAL ENGINEERING DEPT. and PRODUCTION DEPT.

The most important task for us is to have the capability to garantee the products and production program schedules, especially in the manufacturing of helicopters on Agusta's design.

I N D E X