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EFFORTS RELATED TO MANUFACTURING TECHNOLOGY
(NASA) 10 p HC A02/MF A01 CSCL 13H

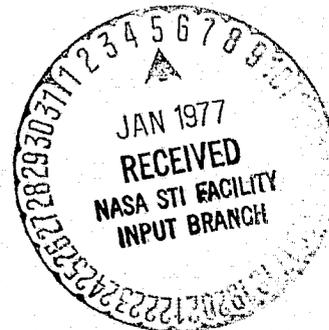
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**OVERVIEW OF NASA/OAST EFFORTS
RELATED TO MANUFACTURING TECHNOLOGY**

by Neal T. Saunders
Lewis Research Center
Cleveland, Ohio 44135

Presented at the MTAG-76 DOD Tri-service
Conference on Manufacturing Technology
Arlington, Texas, November 8-11, 1976



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Neal T. Saunders
NASA-Lewis Research Center
Cleveland, Ohio

E-9047

We welcome this opportunity for NASA's initial participation in the MTAG Conferences. These coordination activities are particularly useful to us at this time because we are in the early stages of trying to formulate an expanded manufacturing technology effort as part of the NASA program supported by the Office of Aeronautics and Space Technology (OAST).

What I intend to do in this presentation is to give an overview of some of NASA's current efforts related to manufacturing technology and some possible directions for the future. The topics that I will be discussing are primarily those supported by OAST -- the advanced research and technology arm of NASA. Since OAST has prime responsibility for the first 'A' in NASA, about 3/4 of OAST's budget is directed at aeronautics technology. So the prime emphasis of this presentation is on manufacturing technology for aeronautic applications.

Historically, OAST activities relating to manufacturing technology have emphasized materials and processing development. But a question that often arises in our planning concerns how far we should proceed into the application-development phase to encourage use of new technologies. Currently, we are reassessing the most appropriate role for NASA in the manufacturing technology field. This is a subject that draws a wide range of opinions. NASA's role in aeronautics is that of a technology-generator, rather than as a technology-user as in the space-related part of NASA's activities or in the DOD activities. Thus, the question becomes -- should we focus our efforts at the near-term applications end of the technology-generation spectrum? Or should we give greater emphasis to the more exploratory and longer-term end of the spectrum? Obviously, some balance between these extremes will be needed, but the nature of that balance is difficult to define.

The current OAST aeronautics program has some major activities that involve significant efforts related to manufacturing technology. Three of these activities are indicated below and will be discussed in this presentation:

- Computer-aided design
- Composite structures
- Turbine engine components

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Computer-Aided Design

In the computer-aided design (CAD) area, there are several different base-technology efforts which have been underway for several years, plus one recently-started specific program, termed IPAD (Integrated Program for Aerospace-Vehicle Design). The base-technology efforts involve a wide range of CAD approaches which are primarily directed at improved means for designing specific classes of components or structural subsystems. These involve both airframe and engine components, and they are primarily conducted through Langley, Lewis, and Ames Research Centers. The prime emphasis of these efforts has been on improved performance of selected components, but the pressures of rapidly escalating costs of aircraft are focusing greater concern for the inclusion of trade-off factors for lower-cost manufacturing requirements.

IPAD is a specific CAD-type program aimed at developing a generalized approach for design of a complete aerospace vehicle. The emphasis in this program is on automating the entire vehicle design process and improving the integration of individual subsystem designs. IPAD is intended to establish a common base for design procedures that should be applicable to a wide variety of vehicle configurations. These efforts should provide the ability to generate more useful information on the trade-offs between vehicle performance, cost, and reliability. As such, the design programs will incorporate pertinent information on manufacturing limitations and costs. Furthermore, key data to be used later in computer-aided manufacturing processes will be generated in the IPAD Program.

The IPAD Program is planned as a 5-year contractual effort starting during FY76 with a contract award to Boeing. This effort is being managed at the Langley Research Center. Since the resulting CAD software are intended to be general in nature, the contractual efforts are closely monitored by an advisory group consisting of both government and industrial representatives. This group periodically reviews the efforts and makes recommendations to assure the broadest possible applicability of the results.

Composite Structures

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technology that will lead to truly cost-competitive composites. The efforts include synthesis of new composite materials, property testing and analysis, component design and fabrication, and eventual testing of components under simulated operating conditions. The results of these efforts are continually fed into system design and cost studies to aid decisions on the most cost-effective use of composites. As a result of these base technology efforts, composite structures are now being incorporated in a wide variety of aerospace systems such as those illustrated at the bottom of the figure. These efforts on composites are closely coordinated with similar efforts supported by the Air Force with the interest of developing interdependent programs.

The applications of composites is pursued through some of OAST's focused systems programs. An example of one of these is the ACEE (Aircraft Energy Efficiency) Program. ACEE is aimed at generating and demonstrating technology for more energy efficient future commercial transport aircraft. The prime goal of this effort is to provide technology for a 50% reduction in fuel consumption for aircraft to be introduced into flight service in the early 1990's. At least 10% of this goal should be achieved through structural weight savings. Thus, heavy emphasis is being directed toward the use of composite airframe structures.

The nature of the composite structures portion of ACEE is illustrated in figure 2. These efforts involve design, manufacture, and certification of several major composite components and their subsequent incorporation in flight service aircraft to gain long-term durability experience. The planned components include:

- Three secondary structural components -- such as the DC-10 rudder section which is currently beginning flight service;
- Three medium-size primary structural components -- such as the L-1011 vertical fin which should be certificated in about 2 years; and
- At least one large primary structural component -- such as a transport wing which should be certificated about 3-4 years from now.

These efforts are being managed at the Langley Research Center and will be accomplished through long-term contracts with the three major domestic manufacturers of commercial aircraft -- Boeing, Lockheed, and McDonnell-Douglas. A major portion of

these efforts will involve development of the manufacturing technology required to produce the components and to generate the cost data needed for economic acceptance of composite structures.

Turbine Engine Components

A third major area of NASA efforts involving manufacturing technology is directed at turbine engine components. These efforts are managed at the Lewis Research Center. They include:

- A wide variety of base-technology efforts to develop advanced materials and processing technology;
- A materials-technology applications program that we call MATE (Materials for Advanced Turbine Engines); and
- An ERDA-sponsored effort for automotive turbine components.

The scope of the base-technology efforts is indicated in figure 3. Most of these involve exploratory research efforts aimed at components for either the fan or turbine sections of engines. In most cases, these exploratory efforts are carried only to the point of demonstrating laboratory-feasibility. But in a few cases, we have extended the efforts to an engine test to demonstrate technology-feasibility.

An example of the latter is illustrated in figure 4. This involves the use of advanced oxide-dispersion-strengthened (ODS) alloys in turbine vanes. This effort was an off-shoot of earlier alloy-development efforts for the Space Shuttle thermal protection system. These efforts resulted in a series of ODS-NiCrAl alloys that had both good strength and excellent oxidation resistance at elevated temperatures (e.g. - above 1000°C). Thus, efforts were subsequently directed toward application of these alloys in turbine vanes. Through a series of contractual efforts, primarily with General Electric, the feasibility and potential advantages of using these alloys in turbines has been clearly demonstrated. The prime advantage of these ODS-NiCrAl alloys over more conventional ODS-NiCr alloys is that the ODS-NiCrAl's can be used without an oxidation-resistant coating. Also, the feasibility of using near-net-shape fabrication methods for turbine vanes has been demonstrated for these alloys.

Our other efforts on aircraft turbine manufacturing technology are accomplished through the MATE Program, which is depicted in figure 5. MATE is a technology-applications program which is intended to bridge the gap between laboratory-feasibility and technology-demonstration in engine tests. It involves advanced materials technologies that have successfully passed critical laboratory-feasibility tests. MATE supports development of any necessary manufacturing technology for a specific component, the generation of initial design-allowable properties, and extensive evaluation of the components in rig tests which simulate the engine environment. When these steps are successfully completed, the components are run in a ground-based test engine for at least 150 hours to demonstrate the performance advantages of the advanced technology. This demonstration test is primarily intended as a confidence-builder for engine program managers so that they will seriously consider incorporating the advanced technology in new engine designs.

MATE is planned as a 5-year program which started early in CY 1976. It is being accomplished through contracts with three domestic aircraft engine manufacturers: Pratt & Whitney, General Electric, and Garrett-AiResearch. These contracts involve a series of individual projects, each involving a separate materials technology. The four projects currently included in the program are summarized in figure 6. Additional projects will be added to these during the next three years.

Two of the current projects involve development of powder metallurgy (PM) and hot-isostatic-pressing (HIP) fabrication processes to produce near-net-shape turbine disks and/or shafts. These are Pratt & Whitney's project on PM-Astroloy and General Electric's project on PM-Rene'95. In both of these projects, the prime emphasis is on reducing manufacturing cost and increasing materials utilization. The other two projects, being conducted by AiResearch, are primarily directed at reducing fuel consumption in smaller aircraft engines. One of these projects involves the application of abradable coatings to the outer shrouds of compressor and turbine sections to reduce gas-path leakage. The other project involves the use of an exothermic casting process to produce directionally-solidified (DS) turbine blades. The latter permits higher turbine blade temperatures and thus reduces the need for turbine cooling air. These four projects are all in the early stages of their planned development and are progressing as scheduled. A detailed public review of the progress on these projects is planned for February, 1977.

The other part of our manufacturing technology efforts for turbine engine components involves components for automotive gas turbines. ERDA has the government responsibility for supporting the automotive industry in developing gas turbine engines to help achieve the national goals for fuel conservation. Their long-term goal is to reduce automotive fuel usage by at least 50% by 1990, and the turbine engine offers one of the prime hopes of achieving this goal. ERDA has recently assigned management responsibility for some of the technology-development portions of their program to the Lewis Research Center (through NASA's Office of Energy Programs). So we are currently developing program plans and will soon be initiating contractual efforts for this purpose.

The prime thrusts of these efforts will be on ceramics for both turbine-section components (turbine wheels and stator vanes) and heat exchangers (recuperators and regenerators). Portions of this effort will be extensions of the ceramics technology efforts that ARPA has been supporting for the past several years.

Summary

I have attempted to summarize three of NASA/OAST's current program areas that involve activities which are closely related to the DOD's manufacturing technology efforts. These involve computer-aided design, composite structures, and turbine engine components. In addition to these current efforts, we are considering adding a more generalized manufacturing technology program some time in the future. Therefore, we welcome your comments and suggestions on what generic areas of manufacturing technology would best assist the aerospace manufacturing industry in the future.

**NASA COMPOSITES PROGRAM
TECHNOLOGY**

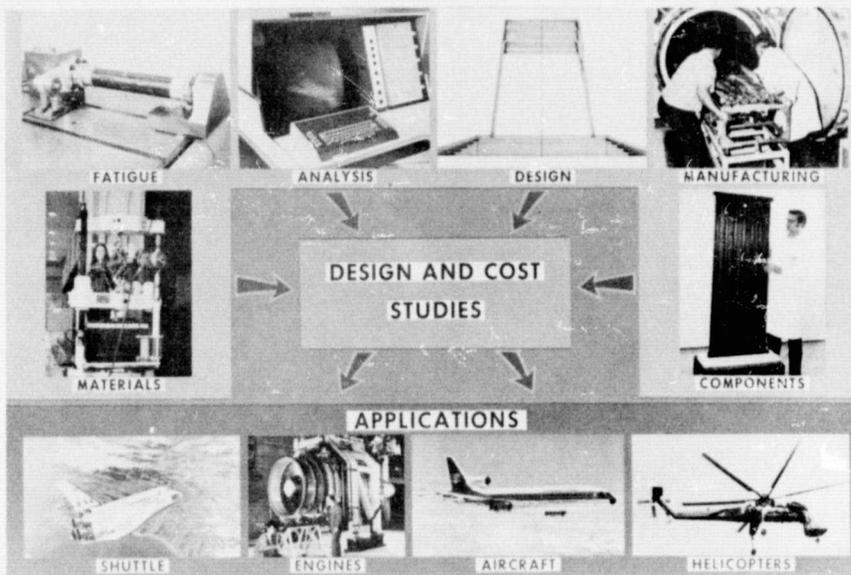


Figure 1

ACEE COMPOSITE PRIMARY AIRCRAFT STRUCTURES

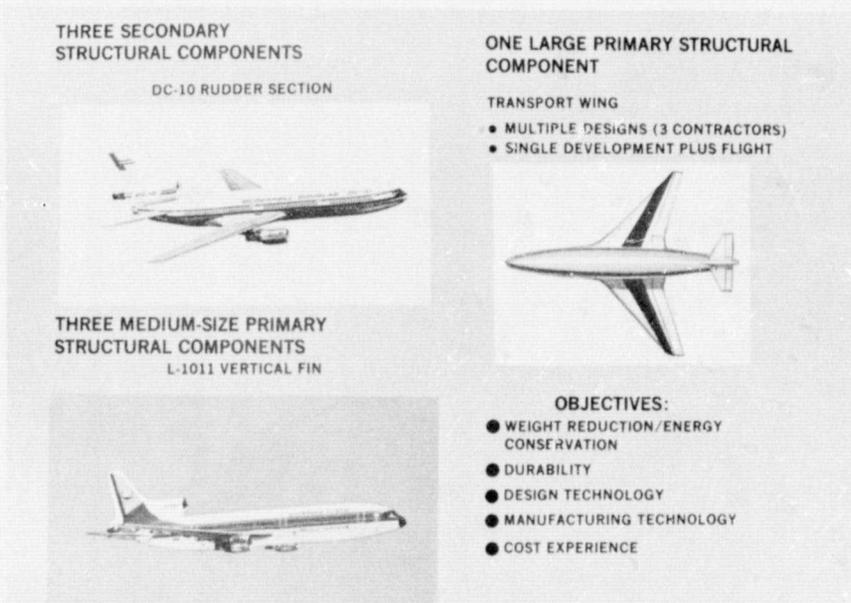


Figure 2

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BASE-TECHNOLOGY EFFORTS FOR TURBINE ENGINES

- COMPOSITES DEVELOPMENT/FABRICATION
- SUPERALLOY DEVELOPMENT/FABRICATION
- CERAMICS DEVELOPMENT/FABRICATION
- COATINGS DEVELOPMENT/APPLICATION
- METALWORKING & JOINING TECHNOLOGY
- INSPECTION (NDE) TECHNOLOGY

Figure 3

OXIDE DISPERSION STRENGTHENED (ODS) VANES

PAYOFFS

- GREATER HIGH TEMPERATURE STRENGTH
- HIGHER BURNOUT CAPABILITY
- IMPROVED THERMAL FATIGUE RESISTANCE
- IMPROVED MICROSTRUCTURAL STABILITY
- ELIMINATE NEED FOR COOLING AIR (LPT VANE)

APPLICATIONS

- HPT VANES
- LPT VANES

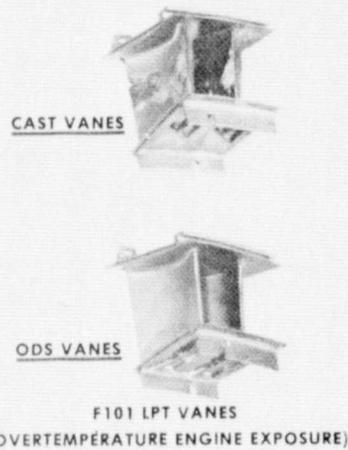


Figure 4

MATE

(MATERIALS FOR ADVANCED TURBINE ENGINES)

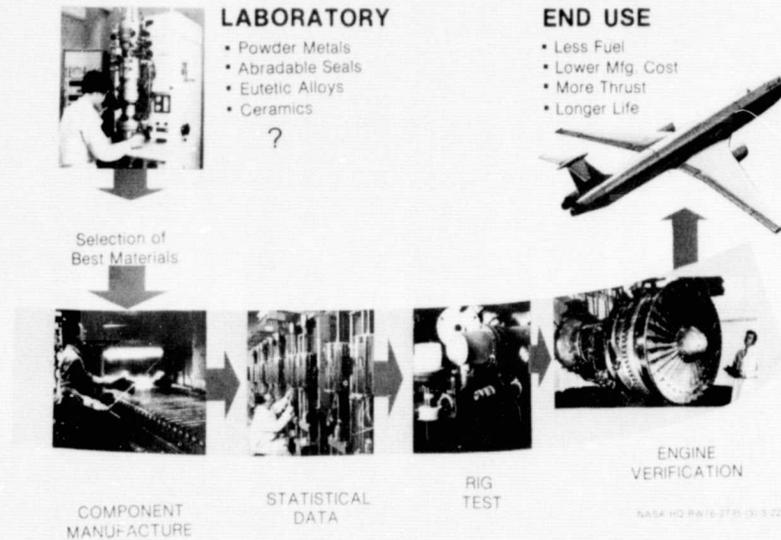


Figure 5

MATERIALS FOR ADVANCED TURBINE ENGINES (MATE)

Initial Projects

<u>MATERIAL</u>	<u>APPLICATION</u>	<u>BENEFIT</u>	<u>ENGINE</u>
P.M. ASTROLOY	TURBINE DISK	MANUF. COST: -20%	JT8D
NiCrAl ABRADABLE COATINGS	COMPRESSOR/TURBINE SHROUD SEALS	SFC: -1.7%	TFE731
SUPERALLOYS EXOTHERMIC DS PROCESS	TURBINE BLADE	SFC: -1.5%	TFE731
P.M. RENE 95	TURBINE DISK/SHAFT	MANUF. COST 50%	F101, CF6

Figure 6

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