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NUCLEAR MATERIALS and PROPULSION OPERATION

APEX 725

FLIGHT PROPULSION LABORATORY DEPARTMENT

FORMERLY

MASTER

**AIRCRAFT
NUCLEAR
PROPULSION
DEPARTMENT**

Final Status of General Engineering Laboratory
Air Flow and Dust Test Program

Part I-Walter F.Venneman

Part II- R. L. Lawrence and P.T. Ryan

SPECIAL REREVIEW FINAL DETERMINATION	Reviewers	Class.	Date
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APEX-725
(Informal)

C-44C Nuclear Technology -
Reactor Engineering and
Technology

M-3679 (25th Ed.)

**FINAL STATUS OF GENERAL ENGINEERING
LABORATORY AIR FLOW AND DUST TEST PROGRAM**

General Engineering Laboratory, Schenectady, N.Y.
Part I - Walter F. Venneman
Part II - R.L. Lawrence and P. T. Ryan

May 25, 1961

UNITED STATES AIR FORCE

CONTRACT NO. AF 33(600)-38062

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(FORMERLY AIRCRAFT NUCLEAR PROPULSION DEPARTMENT)**

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ABSTRACT - PART I

A full scale 15° sector of the P122 reactor configuration was constructed. The model was complete with respect to all internal cooling air passages, and reflectors, thermal shielding, and island reflector. The contract was terminated before any test data could be obtained. This report was prepared under Interdepartment requisition No. 04734 by W.F. Venneman, General Engineering Laboratory, Schenectady, N.Y.

ABSTRACT - PART II

Investigation of the effect of atmospheric dust on performance of reactor systems using wire screen matrix fuel elements is reported. Interim conclusion: Dust would not limit aircraft performance or life. Work proposed but not completed is outlined. Appendices contain previously unpublished reports.

Appendix II was prepared under Interdepartment requisition No. 05987 by R. L. Lawrence, General Engineering Laboratory, Schenectady, N.Y.

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Introduction

The testing of the Air Flow Model of the P122C reactor described herein was planned as the culmination of a series of previous air flow investigations of both two and three dimensional nature, and encompassing analytical and experimental programs. References to these programs will be found in the appropriate section of this **report**.

It was envisioned that the results of the experimental program would provide assurances that the air design presented a system which would meet the requirements and specifications of the nuclear reactor. The P122C model incorporated simulations of all of the components which would be required in the actual reactor pressure vessel with the exception of the mechanical control bar operating linkage and control sensing devices. In addition it was complete with respect to all air flow passages for cooling front and rear reflector, island cooling and fuel cartridge side plate cooling.

All work was terminated on April 21, 1961, upon receipt of orders from the Aircraft Nuclear Propulsion Department to the General Engineering Laboratory of the General Electric Company.

The status of the test program on April 21, 1961, was as follows:

- 1) Manufacture of all components of the model was 100% complete.
- 2) Trial assembly was 95% complete.
- 3) Internal instrumentation was 100% complete.

Immediately upon receipt of the termination order a concentrated effort during the next eight hours resulted in the complete assembly of all model components and hardware so that a complete "package" could be shipped upon request. This is the status then at this time - a completed assembly, less externally accessible instrumentation and without air seal (gasket) joints. The model is not ready to be air tested.

Contributing Factors to Current P122C Reactor Design

With the exception of the initial experimental study undertaken in 1959 by this author¹ which was a one dimensional folded flow experiment, all the remaining experiments have been either two dimensional full scale or three dimensional full scale.

The initial experiment was conducted with a scale factor at approximately full scale but was defined in terms of the L/D ratio of the folded passage; the actual value being $L/D = 15$ and simulating a Reynolds number of 1.3×10^5 and $M = .125$. This initial experiment provided the impetus to take a further look at the "Folded Flow Concept" of compacting a heat exchanger. Among other conclusions the following were pertinent and a result of the initial test.

1. The overall pressure loss experienced in folding the air through 180° is less than 15% of the absolute inlet pressure.
2. The flow distribution is influenced by the inlet and outlet passage geometry.
3. A uniform flow distribution can be achieved or a predetermined distribution achieved by "shaping" or "tailoring" the boundary walls.

A further outcome of this program was the impetus it provided for other investigators (Dr. C.D. Fulton, Dr. J.F. Heyda and J.A. Delaney)^{2,3} to contribute to the solution of the phenomena of this concept of duct design.

Feasibility of the air flow system having been determined the next step was to take a look at the three dimensional aspects. The size of the reactor was not finalized at this time, January 1, 1959, and as a result the model which was built represented a compromise and its size and number of sectors reflected the concepts of a composite of a group of alternate designs. With respect to dimensional similarity, the hot exhaust duct regions were scaled to a reduced size (area) to simulate the discharge Mach number if there had been internal heat generation.

Reference 4 documents in detail this air test program. Some of the conclusions itemized in this report are herewith repeated to provide continuity.

1. The folded flow core and duct system with its four 90° turns has been proven to be aerodynamically feasible.

2. The core radial air flow distribution is fairly flat and can be controlled by adjustments in core and reflector geometry.
3. The core axial air flow distribution is flat.
4. The core pressure drop is about 13% for the design air flow conditions.
5. The reactor shield assembly pressure drop is about 22%.

Some metallurgical problems were being encountered at about this time with the manufacture of thin moderator material. Incorporated in the model of reference 4 were foil shaped sections of this material. In addition, experiments conducted at the ANP Department on reactor criticality showed that the core and reflector lumped air voids are more harmful than the calculations indicated and that the jacket reflector design needs close attention⁶. For these and other reasons further two dimensional studies and air flow experiments were made.

The results of these studies are documented in this author's report of reference 5. Again, for continuity and to assemble in a concise manner the results of a considerable amount of engineering effort, the salient conclusions drawn are herewith repeated.

1. Overall pressure loss coefficients in the order of 12% have been demonstrated feasible. (This does not include inlet or outlet turn.)
2. The overall pressure loss coefficient is a function of the maximum Mach Number in the inlet slot at the outermost radius of the active core region.
3. A venturi in the outlet slot increases the air swallowing capacity without increasing the pressure loss coefficient.
4. Conformity to inlet and outlet slot ratios established by J. F. Heyda (Reference 2) tend to maintain uniform specific weight flow distributions through the fuel matrices..

5. The effect on performance in terms of pressure loss and fuel matrix air flow maldistribution is not measurable when the control blade is beyond 0.50 inches above the outermost radius of the active core region.
6. Introduction of cooling air from the island region into the active core does not affect the fuel matrix air flow distribution. With constant total air flow the pressure loss coefficient is reduced when 10% of the total flow is introduced in the active core region from the island region.
7. Perforated moderators act similar to fuel matrices with high resistance coefficients with respect to specific weight flow distribution.

As a result of the successful completion of this two dimensional study, Dr. C.D. Fulton in his document of Reference 7 proposed the construction of a full size 15° sector of the Pl22C reactor with the following objective:

" - - to determine the air flow distribution and pressure distribution throughout all essential parts of the Pl22C reactor. The results will indicate whether the cooling of each part is insufficient, adequate, or excessive, and whether the pressure drop is equitably distributed and the overall pressure ratio requirement is met" - -
"further reasons for making the investigation are to determine and demonstrate feasibility, uncover problems, and find improvements."

Description of Model of Pl22C (Designed to conform to Iteration 2)

Figure 1 is an end view layout drawing showing a complete assembly and including all parts. Figure 2 is a side view of the model. The model constructed was a full scale 15° sector of the full annulus. The sector chosen was one full inlet sector and two, half outlet sectors. Full scale was chosen because (1) the Mach number, which is the

similarity parameter, could be conveniently obtained with an available air supply - 2.3 lb/sec. @ 19 psia and 640°R, (2) the eighteen fuel matrices to be incorporated into 9 fuel cartridges were under development by the ANP Department in full scale size (4" x 6") only; and (3) a full scale model provides a true perspective upon which to evaluate the mechanical complexities in which one must become involved when the prototype unit is constructed.

The series of photographs in Figures 3 through 8 is explained by the titling. It is unfortunate that the contract was terminated at the time it was, since a complete stepwise photograph-assembly series was planned for the final assembly of the model.

An outstanding feature of the reactor core assembly is the manner in which the side reflectors, perforated moderators and fuel matrices are assembled into an integrated unit denoted as a fuel cartridge. An assembly drawing, Figure 9, of a fuel cartridge shows the details of the fabrication. The perforated moderator slabs were drilled by an automatic tape controlled electro-hydraulic machine. Each 4" x 6" slab contains 1040 holes of 0.040" dia. on a 0.200" square pitch. The material was aluminum and only simulated the actual hydrided material which would have been used in the prototype reactor. It is interesting to note that if the actual material to be used is machinable, this type of operation is relatively inexpensive.

The air discharge ducts were fabricated of hard wood, laminated and shaped. The wall thickness was increased to shrink the internal area, thus adjusting the air Mach number to that which would have existed if internal heating of the air had been affected.

The end reflectors each had cooling air passages leading to a common island cooling region. Rather than drilling long radial holes through the island reflector two perforated sheets provided the pressure drop, while the honeycomb material sandwiched between the sheets maintained the axial location of the entering cooling air while directing this air into the island end of the fuel cartridges.

In a similar manner the cartridge end plate cooling air was directed radially toward the island to a plenum and thence through the slots in the island end of the fuel cartridges. The fuel cartridge support beam from which the cartridges are hung in the prototype design was simulated, although not used as part of the structure. Rather, the cartridge alignment was maintained by slotting the sides which form the pressure retaining walls of the 15° sector.

The wavy-wall inlet was duplicated with turned wood inserts forming the inner and outer boundaries of the channel. Similarly the discharge duct extensions (turbine inlet transitions) were hard wood, laminated and shaped to actual full scale dimensions on the external surfaces, and the wall thickened to effect a 33% reduction in discharge area necessary to maintain the design discharge Mach number.

Instrumentation

Particular emphasis was placed on this phase of the design program so that it could be assured that both the quality and quantity of the data to be recorded later was sufficient. Quantitatively speaking, some pressure level measuring stations had to be sacrificed for lack of recording equipment since it was judged impractical to try to rerun a "set" data point and record a different group of pressures. A list of instrumentation provided follows, categorized into the region in which it is located and the type (total or static) of pressure level it was intended to transmit.

A. Core Region

- (1) Fuel matrix gross flow distribution; radial and axial.
Located at seven radial stations in mid-plane, on left and right side of fuel cartridges 1, 5 and 9. Four additional axial stations of three taps along edges of fuel matrices in fuel cartridge #5. Total of 56 static pressure taps on air inlet side of fuel matrices.
- (2) Square edge needle probes in locations of radial and axial symmetry, compatible with static taps of A (1), Total 56 stations. With difference in pressure between each pair of A (1) and A (2) the static pressure drop

through the fuel matrix can be measured. Then

$$G(x) = K \left(\frac{P_n \Delta P_n}{T} \right)^{\frac{1}{m}} \quad (\text{See Reference 1})$$

- (3) Total pressure probes protruding 5 instrument tube diameters upstream of control blade and mounted in leading edge of control blade at 9 axial stations (center of each fuel cartridge with respect to axial direction.)
- (4) Axial static pressure distribution in cartridge inlet slot. Nine static pressures flush with inner wall of cartridge beam.

B. Wavy Wall Inlet Channel

- (1) Provision for radial traverse with pitot-static probe at inlet. A 10:1 area ratio in inlet transition assures uniform flow eliminating need for rake probe.

C. Discharge Duct Exit

- (1) Total pressure traverse of this area. No static pressure required since discharge is to atmosphere.

D. Reflector Cooling Passages

- (1) Each passage, in each of nine plates in front reflector (and similarly in rear reflector) has a pair of static wall taps approximately 10 inches distant from each other. There are two distinct cooling passage shapes in the nine plates. The procedure is to calibrate each of the two different cooling passages obtaining a curve of flow quantity as a function of the pressure drop between the wall static taps with pressure level as a parameter. Total 36 static pressure taps for front and rear reflector.

E. Core Entering Total Pressure

- (1) A kiel probe at the station (3.3) dividing the reflector and the first fuel cartridge.

F. Fuel Cartridge End Plate Cooling Passage

- (1) A pair of static pressure taps located approximately 11 inches distant from each other is provided. Since the L/D of the channel is greater than 20 the flow can be accurately calculated from the classical friction pressure drop equation. Taps are located in passage between fuel cartridge 4 and 5.

G. Island Cooling Passage

- (1) A static pressure tap is provided at the forward and aft entrances to this passage. Comparison of either of these pressures with downstream tap in reflector cooling passage gives the loss in the turn from the radial to the axial direction.

H. Front Reflector Inlet

- (1) Kiel probe to be installed upstream of scoop (not installed) which directs and recovers total pressure for pumping air through reflector cooling passages. This dynamic pressure when used in conjunction with upper cooling passage static pressure tap will yield value of scoop flow coefficient.

I. Rear Reflector Inlet Static Pressure

- (1) This static pressure tap is not installed. A judicious choice of location must be made to measure this pressure. It looks quite impossible to locate, with any certainty, a total pressure probe since flow directions in this region are not known.

J. Provision for inlet and exit air temperature must be made at time of installation of the model in the air handling facility.

Note: Under the top cover plate in the assembled model is an instrumentation code drawing giving exact location of static pressure taps described in A (1) and A (2). This should be retained with the model.

Recommendations for Future Conduct of Tests

Without question, all air flow tests that have been conducted in the past have verified the feasibility of the "Folded-Flow" concept of compacting a heat exchanger. There are undoubtedly difficult design problems with the nuclear **power** and with control systems, but not unsurmountable ones. This author makes this statement only to point out that if the overall program is reinstated the continuation of the development of this particular reactor configuration should be given prime consideration.

More specifically, if this particular component test were to be reinstated the following items would necessarily have to be accomplished.

1. Complete disassembly of model and thorough cleaning of parts and instrumentation holes.
2. Calibrate forward and aft end-reflector flow passages.
3. Install front reflector scoop.
4. Reassemble model, sealing all joints as assembly progresses.
5. Install 9 static pressure pickup tubes in cartridge beam support.
6. Locate and install aft reflector inlet pressure pickup (See Instrumentation I (1)).
7. Drill hole for wavy wall inlet total pressure.
8. Install externally accessible instrumentation.

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References and Related Reports on Folded Flow Experiments

1. Venneman, W. F., "Folded Flow Through Sphere Type Matrix", XDC-59-11-77(U).
2. Heyda, J. F., "An Analytical Study of a Balanced Reverse Folded Flow", XDC-60-1-158(U).
3. Heyda, J. F. and Delaney, J. A., "A Flow Sensitivity Study of a Balanced Reverse Folded Flow", XDC-60-8-16(U).
4. Venneman, W. F., "Folded Flow Reactor Experimental Pressure Losses and Air Flow Distribution", XDC-59-12-50(C).
5. Venneman, W. F., "Pl22C Folded-Flow Cold Air Tests on Single Cell Model", XDC-61-2-117(SRD).
6. Thomson, W. B., "The Pl22B Folded Flow Reactor and Power Plant as of April 1, 1960, DC-60-8-83(SRD), page 77.
7. Fulton, Dr. C. D., "Plans for Pl22C Air Flow Tests at GEL", DC-60-8-163(SRD).
8. Fried, E., "Three Dimensional Cascade Turn", GV-58-27-39(U).
9. Hardy, Lynn, "Flow Distribution in Reverse Folded Flow", DC-60-2-146(SRD).

Fig. 1 - End view of P122C air flow model (544E352)

Fig. 2 - Side view of P122C air flow model (7044F72)

Figure 3 AIR FLOW INVESTIGATION MODEL OF P122C REACTOR SECTOR.
View shows air discharge end and control blade adjusting rods
protruding through simulated pressure shell. Castors are for
mobility during assembly.

Figure 4 AIR FLOW INVESTIGATION MODEL OF P122C REACTOR SECTOR.
Removal of cover exposes simulated thermal shielding (top center)
Instrument tubing through control bar adjustment rods record total
pressure level at inlet to each of nine fuel cartridges.

Figure 5 AIR FLOW INVESTIGATION MODEL OF P122C REACTOR SECTOR. View looking with inlet air flow direction. External shape of discharge air ducts is shown. Central inlet air slot to each of nine fuel cartridges is visible. Random appearance of instrument tubing due to lack of time to route tubing through thermal shield.

Figure 6 AIR FLOW INVESTIGATION MODEL OF P122C REACTOR SECTOR.
View looking opposite to inlet air flow. Top background shows end
reflector. Central inlet gap is flanked by left and right discharge ducts.

Figure 7 AIR FLOW INVESTIGATION MODEL OF P122C REACTOR SECTOR.
View looking with air flow through discharge duct extensions.
(Discharge duct removed).

Figure 8 AIR FLOW INVESTIGATION MODEL OF P122C REACTOR SECTOR.
Overhead view showing, left to right aft end reflectors, nine fuel
cartridges, and front end reflectors.

421D144		CARTRIDGE	
QTY	PART NO.	NAME	DWG NO. DESCR. MATL. WT.
1	ASM	END	453 C 419-P1
2	BLOCK	539 B 940-P1	
2	PLATE	453 C 420-P1	
2	SCREEN	539 B 939-P1	
6			
7			
8	INSERT	*4-40 SCR X 1/4 LG (FURNISHED)	
16	SCR, MCH	*4-40X 1/4 LG FL HD BRASS CAD PL	
10			
11			
12			

Fig. 9 - P122C air flow model fuel cartridge assembly (421D144)

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PART II - DUST TEST PROGRAM

Purpose of the Investigation

Proponents as well as critics of the folded flow reactor system using wire screen matrix fuel elements have noticed the similarity between these fuel elements and some types of air filters. The thought naturally occurs, "Won't these clog with dust and debris from the engine air flow?"

The purpose of the series of investigations whose status is summarized here was to answer the related questions below.

1. How much dust occurs in the atmosphere at various times and altitudes in various parts of the world?
2. What are the constituents of this dust?
3. How much dust would be swallowed by a power plant during the operational life of its reactor core?
4. What percentages are retained in various parts of the power plant airflow system?
5. What effect will this accumulation have on life or performance? If dust accumulation is a serious problem, what remedies are available?

ResultsGeneral

Appendix I gives an engineering appraisal of the problem based on tests equivalent to ingestion of 50 pounds of dust by a full scale power plant. Reference 1 describes these tests. Briefly stated, reasonably expected dust conditions would not cause replacement of a reactor core before its design life was reached.

Temperature Dependence of Collection Rate

GEL observed that in the temperature range 1800-2100°, dust collection reached a maximum rate. This is thought to be due to semi melting of the particles. Reference 2 reports these results.

Work in Progress at Cancellation

At the Evendale ANPD Gas Dynamics Laboratory tests were begun by Lynn Hardy (Reference 3) to determine the effect of dust ingestion on a fuel element with internal electric heating. No serious dust collection nor measurable change in heat transfer coefficient was observed. It may be that the increased roughness and surface area of the collected dust counterbalanced its insulating effect. The planned series of tests was

not completed.

At GEL a physical comparison of dust from Idaho Test Station with Arizona Road Dust was underway. Appendix II describes results.

Preparations were made to subject a separable layer matrix to air flow containing a measured amount of dust to observe the variation in the pattern of collection from layer to layer. Figure 1 shows the matrix layers which were being constructed. The apparatus for this test was completed, but no tests were run.

References

1. GEL 97 The Clogging of Folded Flow Wire Fuel Elements by Atmospheric Dust, June 14, 1960, T. A. Rich and R. L. Lawrence
No. 60GL36
2. GEL 101 Interim Report - Dust Collection by Wires, November 17, 1960,
No. 60GL209 R. L. Lawrence and T. A. Rich
3. APEX 724 Heat Transfer Characteristics of Crossed Rod Matrices,
June, 1961, L. Hardy and R. Noyes

PT.	A	MAT'L
1	4.125	NI-CH
2	3.125	
3	3.610	
4	2.610

3. 42 WIRES IN G2
2. 59 WIRES IN G1
1. TO BE FLAT WITHIN .010 T.I.R.
- NOTES:

Screen Assembly (977C747)

APPENDIX IDust Ingestion By Nuclear Power Plants

I. Background Information

About 40% of the land area in the world is arid or semi-arid or desert. Thus dust storms may occur over about 6% of the earth's surface. The remaining areas are either vegetated, water or ice cap.

As an indication of the variation possible, the following list gives some typical concentrations of dust and the weight of dust which would be ingested by a 510 pound-per-second engine in a 1 hour period.

<u>Condition</u>	<u>Dust Concentration Mg/M³</u>	<u>Dust in 510 lbs/sec for 1 hour, lbs.</u>
Average ITS condition	.07	.0989
Worst ITS conditions	.8	1.13
Moderate sand storm	15	21.2
Australian Dust storm - 1000' altitude	17.4	24.5
MIL-STD-210 dust storm	60	84.8
Aircraft on dirt field	100	141
Severe Sahara dust storm	1000	1410

II. Power Plant Mission Cycle

For the purpose of evaluating the exposure to dust in the atmosphere the following cycle is assumed for a power plant operating life.

8 missions composed as follows:

1 hour preflight runup and take off	8 hours
4.5 hour approach at Mach .6 and 1000' altitude (3000 miles per mission)	36 hours
120 hours cruise at 35,000 feet	960 hours

In addition 50 hours total ground runup for
check out and testing

Total

50 hours
1,054 hours

III. Operating Conditions Assumed

1. Aircraft will operate from paved runways.
2. Ground runup will not be done during an obvious dust storm except for take off on a mission.
3. Bases will not be located in the Sahara or other wide desert areas.
4. No more than 25% of take offs will occur during dust storms.

IV. Total Dust Ingested

A conservative estimate of the total dust ingested is outlined below:

<u>Operating time</u> <u>hours</u>	<u>Altitude,</u> <u>ft.</u>	<u>Mach</u> <u>No.</u>	<u>Air flow</u> <u>lb/sec</u>	<u>Total airflow</u> <u>cubic feet</u>	<u>Weight of dust</u> <u>lbs.</u>
960	35,000	.8	172	2.56×10^{10}	0 (a)
36	1,000	.6	510	8.88×10^8	12.7 (b)
8	0-1000	0	426	1.65×10^8	35.6 (c)
50	0	0	412	9.7×10^8	<u>3.9</u> (d)

Total ingested 52.2 lbs.

- (a) No significant amounts of dust occur above 15,000 ft.
- (b) 25% of time at .8 mgm/M³ (severest Idaho condition)
75% at .07 mgm/M³ (average Idaho condition)
- (c) 25% of time at 15 mgm/M³ (moderate dust storm)
75% at .07 mgm/M³
- (d) This checking will only be done under favorable conditions (.07 mgm/M³)

P. T. Ryan
March 6, 1961

APPENDIX IILetter Report - Clogging of Screens - May 1, 1961Abstract

Although tests are incomplete, we have some interesting results, particularly on the nature of the dust. There were two distinct dust types in the vicinity of the station; those normally associated with clay and those associated with sand. Both sand and clay had similar slag points; that is, similar to each other, and similar to Arizona Road Dust. Thus, regardless of whether the dust in the air at Idaho is what we took from the ground or Arizona Road Dust, the high temperature operation problem ought to be the same; that is, the region from 1800 to 2100°F should be a region where dust will positively stick to the wires, regardless of its origin.

Although we do not have full results of our testing, we ought to make our best guess as to the extent of the dust problem. It is our opinion that the nuclear aircraft could be operated successfully without having dust interfere with aerodynamics of the reactor. A probable exception to this would be flying in obvious dust storms.

Discussion of Those Tests Which Were Completed

We received 22 samples of dirt from Idaho Falls; Sample No. 1 was taken from the floor inside the hangar, Sample No. 2 was taken immediately outside of the hangar, Samples No. 3 through 22 were taken from a point starting ten miles upwind of the hangar to the vicinity of the hangar, at approximately even intervals. The first thing we noticed about these samples was the character of the samples, that is the physical nature. Those samples in the vicinity of the station were in general clay like in appearance, while those further away from the station were more sand like in appearance. Thus it was decided to select a representative clay sample, a representative sand sample, and a combined sample of the two.

The first series of tests we wished to run were sieve tests. In this manner we hoped to sieve out the various sizes and deposit that portion of the sample below 43 microns in a pan at the bottom. The screens we used were standard screens, the smallest being approximately 43 microns in size. It was a rather difficult job to get material below 43 microns from the samples we had. Prior to running the samples we had dried them overnight in ovens at 100°F to dry off excess moisture. This did not help us, because the samples tended to form little balls or agglomerates of smaller particles all through the various size baskets in the sieving device. Thus we were unable to get good representative sizing from these samples above 43 microns, and indeed it was quite difficult to get anything to finally go through the 43 micron screen.

After sieving, the fine dust (43 microns in size or less) was taken and put in a light scattering particle counter. Mr. Rich says he was unable to get satisfactory and consistently meaningful results from the particle counter and was unable to give a particle size distribution for the samples

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IN THE 43 MICRON RANGE AND LOWER. HOWEVER, IF MORE TIME PERMITTED I THINK HE WOULD HAVE BEEN SUCCESSFUL IN TROUBLESHOOTING THE DEVICE TO OBTAIN BETTER RESULTS.

IN ADDITION TO THE ABOVE TESTS WE RAN SOME SLAG TESTS ON THE VARIOUS SAMPLES. IN GENERAL, THOSE TEMPERATURES AT WHICH PRONOUNCED SLAGGING OCCURRED WERE PHOTOGRAPHED, AND IN EVERY CASE THIS TURNED OUT TO BE ABOUT 2,000°F. IN ADDITION, SOME MICROSCOPIC PHOTOGRAPHS WERE TAKEN OF THE SANDY AND CLAYEY SAMPLES, EACH AT THE SAME MAGNIFICATION. IT IS QUITE NOTICEABLE THAT THE STRUCTURE OF THE CLAY MATERIALS IS MUCH MORE AGGLOMERATED THAN THAT OF THE SAND. IN ADDITION, WE HAVE SOME MISCELLANEOUS PHOTOGRAPHS OF OUR SIEVE SHAKER AND DUST GENERATOR, AND SOME SIEVED SAMPLES WHICH ARE REPRESENTATIVE OF THE TESTS MADE.

ADDITIONAL COMMENTS CONCERNING PARTICLE DEPOSITION

IT IS INTERESTING TO SPECULATE ON THE ABILITY OF COMPRESSORS AND OTHER COMPONENTS TO FILTER OUT SOME OF THE DUST BEFORE IT REACHES THE REACTOR. THE GAS TURBINE DEPARTMENT HAS USED FILTERS ON THEIR LINES FOR GAS TURBINE INSTALLATIONS IN DESERT AREAS. GENERALLY THEY USE AN OIL BATH FILTER AND FIND THAT THIS IS QUITE SATISFACTORY TO PREVENT COMPRESSOR WEAR. OCCASIONALLY SOME OIL WILL SPILL OUT OF THE FILTERS AND LODGE ON THE COMPRESSOR BLADES. IN THESE INSTANCES THE OIL COATING TENDS TO COLLECT DUST PARTICLES ON THE BLADES.

ANOTHER INTERESTING EXPERIENCE HAD OCCURRED ON GAS TURBINES AS APPLIED TO LOCOMOTIVES. THE ROAD BED DUST ENCOUNTERED BY LOCOMOTIVES INDICATES LARGE QUANTITIES OF DUST ARE STIRRED UP AS THE ENGINE PROCEEDS DOWN THE TRACK. HOWEVER THERE IS NO EROSION IN THE WINTER TIME, INDICATING THAT SNOW COVER OR FROZEN GROUND WILL PROHIBIT THE DUST FROM BECOMING AIRBORNE.

GAS TURBINE DEPARTMENT HAS ALSO FOUND THAT QUIESCENT AREAS OR COMPONENTS WILL COLLECT DUST. SUCH THINGS AS CRACKS, ELBOWS, HOLES AND SEALS (PARTICULARLY TURBINE SEALS) WILL ACT AS DUST COLLECTORS.

THEY HAVE FOUND OUT THAT FINE DUST WILL CONTINUE TO COLLECT ON HIGH VELOCITY REGIONS, BUT THAT COARSE DUST WILL TEND TO SCRUB OFF COLLECTED DUST IN HIGH VELOCITY REGIONS. COMPLEMENTING THIS FACT IS THE OBSERVATION THAT FINE DUST TENDS TO STICK MUCH MORE READILY UNDER MOST CONDITIONS. FINE DUST IN THIS CASE IS DEFINED AS DUST SMALLER THAN ABOUT 5 MICRONS. THEY HAVE OBSERVED THAT MOST COMPRESSORS DO NOT COLLECT MUCH DUST WHEN OPERATED ABOUT 200 FT/SEC., BUT THAT IF THE DUST IS MOIST IT WILL SOMETIMES DEPOSIT.

I MENTION ALL OF THESE INCIDENTAL FACTS WITH A THOUGHT IN MIND THAT CERTAIN SIMPLE MEASURES CAN BE TAKEN TO INCREASE THE LIKELIHOOD THAT PORTIONS OF THE DUST WILL BE REMOVED RELATIVELY EASILY BY COMPONENTS UPSTREAM OF THE REACTOR, PROVIDED CERTAIN PORTIONS OF THE DESIGN TAKE ADVANTAGE OF THE OBSERVED FACTS ON DUST DEPOSITION.

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(THIS IS A COPY)

UNCLASSIFIEDSome Personnel of GE Who May Be of Help in any Future Dust Investigations

1. Mr. R. P. Ordway of SAED
2. Mr. Al Bell of FPLD Flight Test at the Schenectady Airport
3. Mr. R. Junge of Gas Turbine Department, Schenectady
4. Mr. T. A. Rich, General Engineering Laboratory

How Much Dust is in the Air?

There still looms the very large question of how much dust will actually be encountered by an aircraft flying through the air close to the ground or taxiing on the ground. At the time these tests were cancelled Mr. Ted Rich was contacted by people at Idaho Falls and they were to run some investigations on this question. We had anxiously awaited results from these tests, but we do not have them because of the nuclear aircraft project cancellation.

There is a classified report which may be of interest on this question. I was unable to get this report before the cancellation. The report is as follows: Helicopter Model K-10 Twin Turbine Reports, September, 1956, prepared under Navy Bureau of Aeronautics contract NOa(S) 53-1102C, report No. R-169, part 2 of 2, Kaman Aircraft Corp.

Other Sources

For other information on this problem see the previous reports, TIS 60GL36 and TIS 60GL209.

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