Minutes of November 20, 1964 Meeting With AiResearch Manufacturing Company to Discuss Turboalternator Design Concepts

This memorandum is a summary of the meeting held at CANEL on November 20, 1964 with representatives of AiResearch and AEC-CANEL to discuss SNAP-50/SPUR turboalternator design. The minutes of a meeting between representatives of AiResearch and PWA held the same day to discuss work responsibilities and schedules have been reported previously.

Personnel present at the meeting:

**AiResearch**
- L. Chadborne
- J. S. Murphy
- D. G. Randall

**AEC-CANEL Project Office**
- C. R. McFarland

**Pratt & Whitney Aircraft-CANEL**
- H. C. Gray
- C. C. Bigelow
- E. Bernstein
- E. C. Hill
- A. H. McKibbin
- M. Prendergast

The discussion centered on the turboalternator design concepts that are being considered by AiResearch. The concept of a split case design (AiResearch print SKP-7121) was reviewed. The advantage of this approach is ease of assembly and bearing alignment. PWA feels that difficulty will be experienced in maintaining the roundness of the case and that this type of construction presents a difficult flange seal welding problem. There would be a tendency for the seal weld to crack, a problem with bolt sealing tube redundancy and large amounts of welding are required. It is believed possible to design a full round case with circular bolted flanges at essential break points with more reliable seal welds. There is a basic question with the use of seal welds in this type of construction which relates to whether the seal welds do or do not also act as structural welds. A general discussion of turbine case welding problems ensued. In general, PWA experience with Cb-1 Zr welding indicates that weld design be considered for the following features:

1. All welds must be capable of being inspected by X-ray and other techniques.
2. All welds must be carefully annealed for proper weld conditioning, strength, and dimensional stability of the case.
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3. Butt welds should be used wherever possible, with care to keep comparable section thickness. Considerable difficulty has been encountered at CANEL with right angle welds, circular welds in the center of a sheet, etc. and butt welds with all possible freedom for unrestrained shrinkage have proven most satisfactory.

A list of CANEL specifications which are applicable to the welding problems is appended to these minutes.

A turboalternator design concept which uses a two bearing approach was discussed (AiResearch print SKP-T136). This concept uses a six stage turbine with the alternator between the bearings and three stages of the turbine overhung from each bearing. The advantages of this approach include reduced alignment problems, a lighter more compact unit, fewer bearings, and no flexible coupling required. This approach permits reheating of the vapor between the third and fourth stages should it be necessary due to condensate erosion. One problem with this approach is the connection of the turbine wheels to the generator rotor. One approach is to attach the turbine wheels to a single generator rotor-shaft forging. One disadvantage of this approach is that it requires a heat barrier between the turbine wheels and shaft coolant which flows through the shaft in this design in order to prevent excessive heat flow to the coolant system. It has been estimated that reheating may improve the turbine efficiency five percent over that which could be experienced if no moisture separation was used. AiResearch is conducting a study of the effects of reheating on turbine performance and is to advise P&W of the results of the study. Split case construction is not a feature of this design.

A discussion of bearing and seal concepts was held. It was felt that the final bearing configurations may be a hybrid bearing and not hydrodynamic or hydrostatic per se. Estimates of the two bearing machine bearing and seal power consumptions are tabulated below.

<table>
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<tr>
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<th>Power, Kw</th>
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<tbody>
<tr>
<td>Turbine Seals</td>
<td>1.0 Kw/seal</td>
</tr>
<tr>
<td>Generator Seals</td>
<td>1.5 Kw/seal</td>
</tr>
<tr>
<td>Journal Bearings</td>
<td>0.1 Kw/bearing</td>
</tr>
<tr>
<td>Thrust Bearing</td>
<td>3.0 Kw/bearing</td>
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</tbody>
</table>

The orientation of the turboalternator on a flight vehicle and for a ground test was briefly discussed. AiResearch felt that a vertical orientation would probably be preferred for a flight test inasmuch as the thrust bearing provides a larger bearing surface for the launch load than does the journal bearings. For ground testing, a horizontal orientation is preferred in order to reduce the thrust bearing load.
The pressures to be sealed in the turboalternator at off-design were reviewed. A study at P&WA indicates that the pressure leaving the turboalternator at the idle condition can be reduced from 75 psia (CNIM-4400, Supplement 6) to 31 psia. This can be accomplished by operating the condensate and jet pump somewhat off the optimum point at the full power condition, thus flattening the performance curves of the pumps. P&WA will supply AiResearch with the revised conditions.

P&WA requested AiResearch provide the following data on the turboalternator for use in control studies.

1. Polar moment of inertia.
2. Transfer function of generator field current to field voltage.
3. Transfer function of generator output voltage to field current.
4. Transfer function of the voltage regulator, field voltage to input error voltage.

P&WA requested that AiResearch perform certain experiments during the operation of the 400 Kw heat transfer loop at Phoenix in order to provide guidance for P&WA in the design of the Boiler Test Facility and the Non-nuclear Power-plant Test Facility. The experiments are listed below.

1. Determine the effect of a heating loop temperature perturbation on the two phase loop. The magnitude, duration, and associated time constants are also needed.
2. Determine the effect of an air flow rate perturbation on the two phase loop. The magnitude and duration of this perturbation and associated time constants are also needed.
3. Establish the upper limit of the $\Delta P_{\text{vapor}}/\Delta P_{\text{liquid}}$ ratio while maintaining stable operation.
4. Establish degree of liquid superheat required to initiate boiling and establish if it changes with time.
5. Establish effect of the presence of non-condensibles on loop stability.
6. Determine effect of condenser heat flux on stability of the two phase loop.
7. Establish effects of loop "hardness" on stability.
8. Establish the minimum amount of liquid throttling needed at the inlet to the three preheaters in order to maintain stable flow.
It was agreed that this subject would be discussed further at a forthcoming meeting in Phoenix in December with the personnel involved in the operation of the loops.

cc: Colonel E. M. Douthett-AEC
    C. H. Armbruster-USAf
    W. H. Pennington-AEC
    J. H. Dannon-AiResearch
    L. Chadborne-AiResearch
    W. Doll
    R. I. Strough
    R. M. Meyer
    H. C. Gray
    J. S. Murphy
    D. G. Randall
    E. Bernstein
    R. W. Kelly
    H. E. Means
CANEL Specifications - Welding

CS-105  Inspection - Special Policy
CS-110  Welding - Columbium Alloy - General Procedure
CS-111  Welding - Inert Gas Chambers - General Procedure
CS-120  Welding - Shielded Arc, Tungsten Arc - General Procedures for
CS-130  Welds - Fusion - Dimensions and Tolerances
CS-140  Inspection of Welds - Procedure for
CS-200  Leak Detection by Mass Spectrometer - Procedure for
CS-309  Cleanliness of Parts and Assemblies - Semi-Finished and Finished
CS-400  Annealing Columbium-1% Zirconium Alloy