# S Y N O P S I S

1. Statement of the Problem.

The problem was to evolve a simplified theory to predict the behaviour of high speed flow of gas-liquid mixture encountered in aerothermopressor - a device in which the hot exhaust gases of gas turbine are cooled by directly spraying water, the accompanying rise in total pressure improving the performance of the gas turbine. The following areas were to be covered in detail; (a) a continuum model for the two-phase flow system, (b) the evaporation characteristics, (c) the wall-friction factor for the two-phase flow and (d) analytical solution in a closed form suited for optimisation schemes.

An experimental verification of the theoretical analysis was sought as also informations on the performance of the aerothermopressor when coupled to the gas turbine, the two-dimensional flow patterns, and evaporation characteristics. A device for measuring the gas-phase total temperature was to be developed.

2. Summary.

A theoretical model that considers the mixture as a dispersion of particulate phase in a continuous fluid phase has been developed, and expressions for the bulk properties of this heterogeneous continuum derived. The general equations of motion of the two-phase mixture have been derived and simplified

for the case of flows.with small slip velocity between the constituent phases. Analytical solutions have been obtained for the one-dimensional case by the method of small perturbations. Solutions were also obtained numerically.

An experimental investigation has been carried out on a constant area aerothermopressor coupled to a 60 horse-power experimental gas turbine unit, with a view to studying (i) the behaviour of the device in conjunction with the turbine, (ii) the nature of the flow pattern of such type of flows and (iii) to substantiate the theoretical predictions. Also an accelerating nozzle to convert the annular flow from turbine outlet to a duct flow and to produce a high speed two-phase flow has been built and tested. The difficulties encountered in accelerating an annular flow into a duct flow, and in starting, have been outlined. The flow properties have been measured with the following specially constructed probes and instruments :

(a) Probe for measuring the gas-phase stagnation pressure of the two-phase mixture,

(b) Pitot probe for measuring the total pressure of the mixture,

(c) Static pressure probe and wall static taps,

(d) High recovery factor total temperature probe and

(e) Gas-phase humidity measuring unit.

The last mentioned probe was specially developed to measure the humidity and total temperature of the gas-phase in the two-phase mixture. The conclusions were based on results obtained from a

total of 35 runs taken for the range of liquid concentrations from 0.05 through 0.20, and four (out of six proposed) different spray configurations. There were 18 observation locations in the 110 cms long evaporation section. Observations of total pressure, static pressure, gas-phase stagnation pressure, humidity and gas-phase total temperature were made at 3 to 6 radial positions at every section. In all 450 data were read off for each run.

3. Conclusion.

It is found that the evaporation rates in the constant area evaporation section, are higher when operated in conjunction with a turbine. It is concluded that the simplified theory developed, predicts successfully the behaviour of the two-phase flows in constant area duct. It is an extension of the theory proposed by Shapiro et.al (in Trans.ASME, 78, 1956) and improvement in the following areas :
(a) the wall friction factor is permitted to vary, (b) greatly simplified and (c) better agreement between the experimental results and the predicted values. Also the design of the accelerating nozzle, sprayer and its location are satisfactory as also the design and performance of the gas-phase total temperature and humidity sampling probe.

It is proposed to extend the analysis to the case of varying area duct -(of the pressure - area power family)- with a view to

optimising the duct shape for best performance. A further improvement of the gas-phase total temperature and humidity sampling probe is under study.