

THE EFFECTS OF A FORWARD-FACING ENTRANCE STEP ON FILM COOLING PERFORMANCE NEAR THE ENDWALL REGION OF A GUIDE VANE

林廷祐、吳佩學

E-mail: 9126600@mail.dyu.edu.tw

ABSTRACT

THE REASON FOR SIMULTANEOUS CRACKING AT THE LEADING EDGE AND ANNULAR CASING ENDWALL OF THE FIRST STAGE GUIDE VANES IS NOWADAYS NOT FULLY UNDERSTOOD IN INDUSTRY. SINCE THE CRACKING OF THE FIRST STAGE GUIDE VANES IS USUALLY FOUND TO OCCUR AT THE LEADING EDGE, THE TRAILING EDGE NEAR THE ENDWALL, AND AT THE ANNULAR CASING ENDWALL, HENCE IT IS NECESSARY TO FULLY UNDERSTAND THE FLOW FIELD AROUND THESE AREAS. MANY RESEARCH RESULTS HAVE POINTED OUT THAT THE FLOW NEAR THE ENDWALL OF A VANE IS THREE-DIMENSIONAL AND COMPLICATED, INCLUDING SECONDARY FLOWS SUCH AS HORSESHOE VORTICES, PASSAGE VORTEX, AND CORNER VORTICES, AND THE INTERACTION OF THESE VORTICES. THE FORMATION OF THESE VORTICES IS INTIMATELY TIED TO THE DEVELOPMENT OF THE UPSTREAM BOUNDARY LAYER ALONG THE ENDWALL. THERE WOULD BE A DISPLACEMENT BETWEEN THE COMBUSTOR TRANSITION NOZZLE AND THE FIRST STAGE GUIDE VANE DUE TO THERMAL EXPANSION, CONSEQUENTLY THE DIFFERENT ENTRANCE FLOW EXISTS OBVIOUSLY. THE MATCH CONDITION DUE TO THE EXISTENCE OF DISPLACEMENT IN THE TRANSITION NOZZLE AND THE ANNULAR CASING ENDWALL OF THE GUIDE VANES WILL MARKEDLY AFFECT THE BOUNDARY LAYER ALONG THE ENDWALL. SO IT SEEMS QUESTIONABLE TO FULLY IGNORE THE FACT OF THE EXPANSION DISPLACEMENT OF THE TRANSITION NOZZLE IN THE ESTIMATE OF THE FILM COOLING DISTRIBUTION AROUND THE ENDWALL OF A VANE. EXPERIMENTS WERE CONDUCTED IN THIS WORK TO INVESTIGATE THE EFFECTS OF THE DISPLACEMENT OF A TRANSITION NOZZLE ON THE FLOW FIELD AND FILM COOLING EFFECTIVENESS DISTRIBUTION NEAR THE ENDWALL REGION OF A FIRST STAGE TURBINE GUIDE VANE. A TWO-HALF-VANE MODEL WAS USED IN THE TEST. THE DISPLACEMENT OF A TRANSITION NOZZLE RELATIVE TO THE ANNULAR CASING WALL DUE TO THERMAL EXPANSION WAS REPRESENTED BY A FORWARD-FACING ENTRANCE STEP IN THE TEST. THE DISTRIBUTION OF THE FILM COOLING EFFECTIVENESS WAS DETERMINED THROUGH THE WAY OF STEADY-STATE HEAT TRANSFER EXPERIMENT WITH LIQUID CRYSTAL THERMOGRAPHY. RESULTS OF THE EXPERIMENTS SHOW THAT, WHEN SUCH A DISPLACEMENT OCCURS, THE FILM COOLING EFFECTIVENESS AT THE ENDWALL IS DECREASED AROUND THE LEADING EDGE OF TEST VANE. THE LOW FILM COOLING EFFECTIVENESS (TRIANGULAR) REGION ON THE SUCTION SIDE SURFACE DUE TO THE THREE-DIMENSIONAL FLOW PATTERN NEAR THE ENDWALL IS ENLARGED. THESE RESULTS INDICATE THAT THE THREE-DIMENSIONAL FLOW PATTERN HAS BEEN CHANGED AND THAT THE POSSIBILITY OF DAMAGE TO A VANE IS INCREASED.

Keywords : GUIDE VANE, FORWARD-FACING ENTRANCE STEP, FILM COOLING EFFECTIVENESS, STEADY-STATE HEAT TRANSFER, LIQUID CRYSTAL THERMOGRAPHY

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