EFFECTS OF THE THERMAL EXPANSION DISPLACEMENT OF COMBUSTOR TRANSITION NOZZLE ON THE ENDWALL THREE-DIMENSIONAL FLOW REGIO

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ABSTRACT

THE REASON FOR SIMULTANEOUS CRACKING AT THE LEADING EDGE AND ANNULAR CASING ENDWALL OF THE FIRST STAGE GUIDE VANES IS NOT FULLY UNDERSTOOD IN THE INDUSTRY NOWADAYS. ALTHOUGH THIS MIGHT BE DUE TO DRAWBACKS IN THE DESIGN OF THE INTERNAL COOLING AND FILM COOLING SYSTEMS, IT MIGHT POSSIBLY BE THAT THE EXTERNAL HEAT TRANSFER WAS UNDERESTIMATED. THE OBJECTIVE OF HIS STUDY IS TO DISCUSS A FACTOR WHICH IS FREQUENTLY IGNORED IN THE ESTIMATE OF EXTERNAL HEAT TRANSFER FOR A GUIDE VANE, NAMELY, THE EFFECT OF THERMAL EXPANSION DISPLACEMENT OF THE COMBUSTOR TRANSITION NOZZLE ON THE FLOW FIELD AND THE HEAT TRANSFER COEFFICIENT DISTRIBUTION AROUND THE FIRST STAGE GUIDE VANES. 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 ANNUAL CASING ENDWALL, TO STUDY THE EXTERNAL HEAT TRANSFER, IT IS QUITE NECESSARY TO FULLY UNDERSTAND THE FLOW FIELD AROUND THESE AREAS. MANY RESEARCHES HAVE POINTED OUT THAT THE FLOW NEAR THE ENDWALL OF A VANE IS THREE-DIMENSIONAL AND COMPLICATED, INCLUDING SECONDARY FLOWS SUCH AS HORSESHOE VORTEX, PASSAGE VORTEX, AND CORNER VORTEX, AND THE INTERACTION OF THESE VORTICES. THE FORMATION OF THESE VORTICES, HOWEVER, IS INTIMATELY TIED TO THE DEVELOPMENT OF THE UPSTREAM BOUNDARY LAYER ALONG THE ENDWALL. THE MATCHING OF THE EXIT OF THE TRANSITION NOZZLE AND THE ANNULAR CASING ENDWALL OF THE GUIDE VANES WILL OBVIOUSLY AFFECT THE BOUNDARY LAYER ALONG THE ENDWALL. IT SEEMS QUESTIONABLE TO FULLY IGNORE THE FACT OF THE EXPANSION DISPLACEMENT OF THE TRANSITION NOZZLE IN THE ESTIMATE OF THE HEAT TRANSFER DISTRIBUTION AROUND THE ENDWALL OF A VANE. EXPERIMENTS WERE CONDUCTED IN THIS WORK TO INVESTIGATE THE EFFECTS OF THE DISPLACEMENT OF TRANSITION NOZZLE ON THE HEAT TRANSFER COEFFICIENT DISTRIBUTION NEAR ENDWALL REGION OF A FIRST STAGE TURBINE GUIDE VANE. TWO-HALF-VANE MODEL WAS USED IN THE TEST. THE SIZES OF THE SIDE BLEED SLOTS OF THE TEST MODEL WERE DETERMINED USING A CFD PACKAGE TO SIMULATE THE FLOW SITUATION BETWEEN THE TWO-HALF-VANE MODEL AND A CORRESPONDING CASCADE. THE DISPLACEMENT OF TRANSITION NOZZLE RELATIVE TO THE ANNULAR CASING WALL DUE TO THERMAL EXPANSION WAS REPRESENTED BY A FINITE STEP IN THE TEST. THE DISTRIBUTION OF THE HEAT TRANSFER COEFFICIENT WAS DETERMINED BY TRANSIENT HEAT TRANSFER EXPERIMENT WITH LIQUID CRYSTAL THERMOGRAPHY. RESULTS OF THE EXPERIMENTS SHOW THAT, WHEN SUCH A DISPLACEMENT OCCURS, THE HEAT TRANSFER COEFFICIENTS AT THE ENDWALL AND ON THE SUCTION WALL NEAR THE BASE OF THE VANE ARE ENHANCED. ON THE OTHER HAND ,THE HEAT TRANSFER COEFFICIENT ON THE PRESSURE WALL SEEMS DECREASED SLIGHTLY. THE SIZE OF THE 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, TRANSITION NOZZLE, ENDWALL, HEAT TRANSFER COEFFICIENTS, TRANSIENT HEAT TRANSFER, LIQUID CRYSTAL THERMOGRAPHY

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