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CFD SIMULATION OF TRANSITIONAL FLOW ACROSS PAK B TURBINE BLADES

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Abstract- In most of the Gas Turbine Engine applications, the flow in the Low-Pressure Turbine stages are invariably transitional, and the behavior of the transitional flow is emphatically influenced by the free stream turbulence level and the pressure gradients along the flow. The phenomenon of laminar to turbulent transition in boundary layer is observed, specially in flow through an inter-blade passage of a turbomachine typically operating at Reynolds numbers where the laminar boundary layer on the blade surface may broaden significantly starting from the leading edge and further the boundary layer on the pressure side of the blade often remains fully laminar. The laminar to turbulent transition process can therefore have a very strong influence on the separation behavior of boundary layers on the suction surface and hence on the overall performance of a turbomachine. In order to predict this drop of total pressure along the blade surface and the associated heat transfer, one must have the capability to predict accurately the behavior of the flow in presence of laminar to turbulent transition covering the complete domain ranging from the laminar, the transition to turbulence and finally to the fully turbulent flow regimes. The present work attempts to analyse transitional flow past an isolated PAK-B aerofoil designed and tested by M/s Pratt and Whitney, for a wide range of angles of attack and for a chord-based Reynolds number of 50,000. The total head losses due to the sharp curvature of the blades and also due to the skin friction on the blade surface

Energy(k_l), ***Turbulent Kinetic Energy***(k_t) and ***Specific Dissipation (ω) of turbulence.*** The computations employing inhouse code RANS 3D are validated against corresponding measurement data on the PAK-B aerofoil on surface pressure and , in order to demonstrate the performance of the existing transition cum turbulence models for analyses of transitional flows past an isolated aerofoil .

Key Words: PAK-B, Gas turbine Blade, Transitional Flow, Boundary layer, RANS3D.

1. INTRODUCTION

Three major components of any CFD analysis are Grid Generation, Numerical Solution of Flow equations system and Turbulence Modeling. However for most of the engineering problems, the flows are turbulent and sometimes even more complex with laminar patches in the otherwise turbulent flow field. Unfortunately our understanding of the physics or dynamics of turbulent flow is not adequate for accurate modeling of flows with turbulence. Turbulence Modeling is often therefore the ***pacing item*** for the growth and development of CFD technology.

Most of the popular mathematical models of turbulence use a judicious combination of intuition, empiricism and the governing equations of the mean and fluctuating motion which are valid strictly for turbulent flows without any laminar region. In reality however any wall-shear or free shear flow consists of some laminar flow patches which eventually undergo transition over a finite length to fully turbulent flows. Various physical mechanisms are responsible for this inception of laminar to turbulent transition. Most of the turbulence models used in CFD analyses are unable to predict ***Transitional Flows*** which consist of laminar patches along with fully turbulent zones. Accurate prediction of transitional boundary layer flows is essential for correct computation of the losses and heat transfer in such systems. The phenomenon of laminar to turbulent transition, as understood from reliable measurement data and variety of theoretical analyses are discussed in brief in the following paragraphs.

1.1 Phenomenon of Laminar to Turbulent Transition

Reynolds first demonstrated that the injected dye filament remains thin but never mixing at low velocities, undulates at higher velocities finally becoming turbulent law of Poiseuille for laminar pipe flow is invalid. Finally the disturbances amplify to become 3-D mutually interacting forming local turbulent spots which transform the flow condition to turbulent downstream. The physical process of transition is commonly characterized by two factors *viz.,* (1) **Transition *Onset* /*Inception: at*** this point laminar comes to halt and growth of disturbance begins (2) transition length / the finite ***Extent***: this component provides the number of laminar patches in given length of flow in a domain as a function of ***Intermittency.*** Conditions which affect the above are: free-stream turbulence, pressure gradient, flow separation, flow Mach number, wall roughness and streamline curvature.

1.1.1 Importance of Prediction of Transition phenomenon

A linear Transition phenomenon plays a vital role in computational fluid dynamics analysis of all turbo machinery. Operation of turbo-machine blades happens at Reynolds numbers where in laminar boundary layer grows on the upper surface of the blade may extend to a significant length starting from the leading edge and boundary layers on pressure side remain laminar. Transition of laminar-to-turbulent thus affects the boundary layer separation. Example: Turbomachine performance seriously gets affected by "separation-induced transition" after laminar boundary separates and reattaches as fully turbulent downstream. ***Drag Crisis*** can be explained similarly for flow past a circular cylinder this was observed at critical Reynolds number. Wake induced transition is observed in Rotor-Stator interactions where in row of blades become unsteady at the passage of wakes. The wall shear stress and heat transfer distributions get over predicted by turbulent solutions in above kind of transitional flows, blockage and loss predictions go wrong in turbulent solutions. Eddy-viscosity based turbulence models coupled with the conventional RANS solvers, used by industries to predict fully turbulent flows can't solve the complex dynamics real Transition situations. Sincere efforts by different research groups led to a wide spectrum of so-called ***Turbulence Models*** making a compromise between accuracy required and the computational resources available to the user.

At very low free stream turbulence level, transition occurs due to flow instability (T-S Waves) that results in exponential growth of the 2-D disturbances eventually into a non-linear breakdown to turbulence. On the other hand, what happens in flow through inter-blade passages of turbomachines has been identified as ***bypass transition***. In another situation for example, in the case of simple 2D flow around a curved object, the transition may be induced by flow separation due to adverse pressure gradient that leads to acceleration of the fluid outside the separation bubble and eventually makes it turbulent even before the bubble reattaches to the body surface. In spite of such important effects of transition phenomenon on the mean flow pattern, no unique model has as yet been proposed which can accurately simulate the physical effects of transition on the behavior of the time-averaged flow- be it in a wall shear layer or a free shear layer flow.

Most of the commercial and user-friendly computer codes employed today for industrial design of equipments involving fluid flow and/or heat transfer use Unsteady Reynolds Averaged Navier Stokes (URANS) equations for conservation of mass, momentum and energy where this Reynolds Averaging process simply eliminates the important effects of linear disturbance growth happening during the laminar to turbulent transition. Further the empirical transition models based on the physics of simple flows involve many non-local operations The URANS framework used in General Purpose CFD codes is therefore strictly not suitable for prediction of transition phenomenon. However independent of the model embraced, a huge level of uncertainty is imminent in prediction of turbulent shear flows, even in an extremely basic setup. In the last few decades, critical measure of advance has been made in the improvement of turbulence models which can precisely model an extensive variety of turbulent flows. Endeavors by various researchers have brought about a range of models valid for wide range of applications, keeping up a harmony between the precision prerequisites and the computational assets accessible to a CFD client. The models developed on the basis of hydrodynamic stability theory and hence computing the amplification of disturbances are not quite compatible to the structure of RANS codes handling very large scale complex flows. However the essential understanding of the basic dynamics of laminar-turbulent transformation has led to the development of one or two other partial differential equations - one governing the initiation of the transition process – represented by the so-called ***Intermittency*** which starts growing from zero (laminar) to unity (turbulent) or the enhancement of the kinetic energy of fluctuation which, along with development of turbulence, gradually grows from a low value at laminar state to a high value at the fully turbulent state. Depending on the transition models developed, the progress of the generation of turbulence is represented either by the *Intermittency* or by the level of kinetic energy of fluctuation which is zero at the purely laminar state. The other transport equation indicating the transition process in terms of growth of this fluctuating energy may be represented by the instantaneous *Momentum Thickness* only. Five distinct methods of transition and the essential flow parameters which decide the initiation and progress of the turbulent fluctuation are further discussed in the following paragraphs.

1.1.2 Low Pressure Turbine Blades

Unlike other turbomachinery like compressors or high pressure turbines, the low-pressure turbines are by and large not subjected to outrageous ecological conditions that require careful steps like active cooling for safe operations. However, in the design of low pressure turbines, care needs to be taken mainly for the aerodynamic characteristics of the blades in order to expand the loading capabilities and efficiency. Low-pressure turbines dependably work in a precarious situation. The turbine blades shed periodic wakes leading to high local free stream turbulence as the wakes travel further downstream. During these periods of high turbulence, the boundary layer for the most part does not separate from the blade. However once a wake has passed and the turbulence level is reduced, the flow again becomes laminar and eventually separates from the blade surface.

Newly launched analysis software makes it possible to get the solution for the nonlinear analysis easily. However, one should know the tools in the analysis software for getting the nonlinear analysis results easily. Nonlinearity is due to the geometric nonlinearity, material nonlinearity and constraint and contact nonlinearity.

1.2 Problem Definition

Present work is computational analysis carried out on incompressible 2-D flow with laminar to turbulent transition for flow over an isolated PAK-B Aerofoil for an angle of attack of 25^0 at chord-based Reynolds number of 50,000 (transitional flow regime) for given free stream turbulence level. The measurement data, specially the coefficient of static pressure (C_p) and the skin friction coefficient (C_f) variation along the blade surface for the same cascade has also been reported by Langtry, R.B., and Sjolander, S.A (2002). All the computations use a pressure based finite volume RANS algorithm as included in in house code RANS 3D. This code is provided with two different eddy viscosity based turbulence models - each coupled to two different transition models either to the three-equation transition model based on the concept of Laminar Kinetic Energy, proposed by Walters et al [2002] or the four equation model of Langtry et al [2002] coupled to the SST Model of Menter [2002].

1.3 Aim

To understand the effects of transitional flow across low pressure turbine blades and capture the boundary layer phenomenon across the PAK B blade under study.

2. OBJECTIVE AND METHODOLOGY

To analyze the transitional flow in two specific test cases: (a) flow past an isolated PAK-B aerofoil designed and tested by M/s Pratt and Whitney, for a wide range of angles of attack a chord-based Reynolds number of 50,000. The total head losses due to the sharp curvature of the blades and also due to the skin friction on the blade surface, have been computed in terms of the loss coefficient. In order to predict this drop of total pressure along the blade and skin friction coefficients, two different transition cum turbulence models have been attempted in the present work. The first one uses the transition model of Langtry *et al* (1974) solving for the four additional equations . General methodology used in inhouse code RANS 3D has been utilized to carry out the above mentioned work which is briefly explained in following paragraphs.

2.1 Methodology

Generation of smooth body fitted grid with approximate orthogonality at the boundaries is practically the first step towards accurate numerical solution of fluid flow equations for arbitrary configurations, using finite volume, finite element and similar methods. Once the suitable grid is generated we move onto the next step is fixing of suitable and accurate boundary conditions. Finally the solver equations are provided according to the given problem running the solution till the required convergence is met and outputs are obtained for presenting the results using software TECPLOT. The desirable features of a good grid generation procedure are smoothness and the boundary-orthogonality of grid generated, an easy and direct control of grid-spacing and grid skewness at any desired location and finally an efficient and fast numerical algorithm. In the present work, a 2D curvilinear grid is generated on X-Y plane for the components of the configuration considered, conveniently divided further into multiple blocks spanning corresponding segment accordingly. Finally the results are compared with the standards.

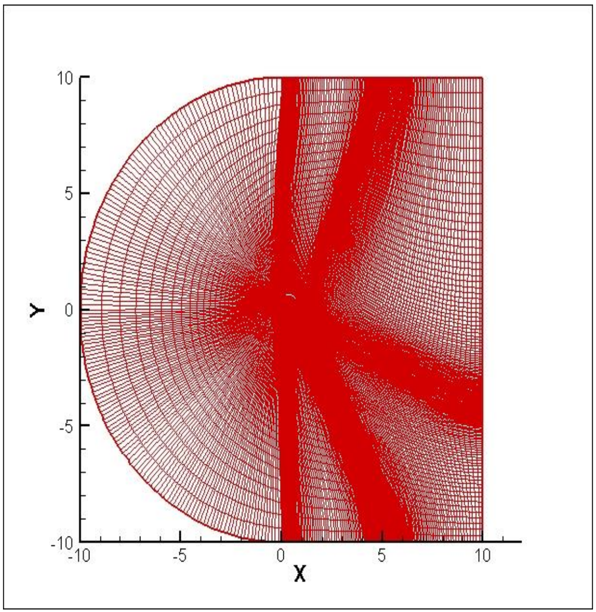

Fig1. C-grid used to study the PAK B aerofoil

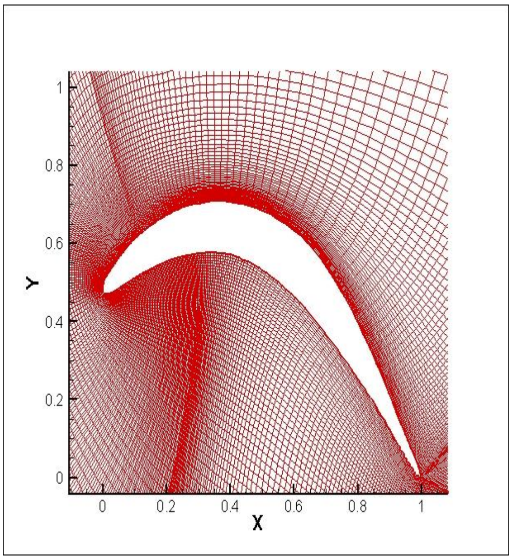

Fig2. Zoomed view of the aerofoil PAK B

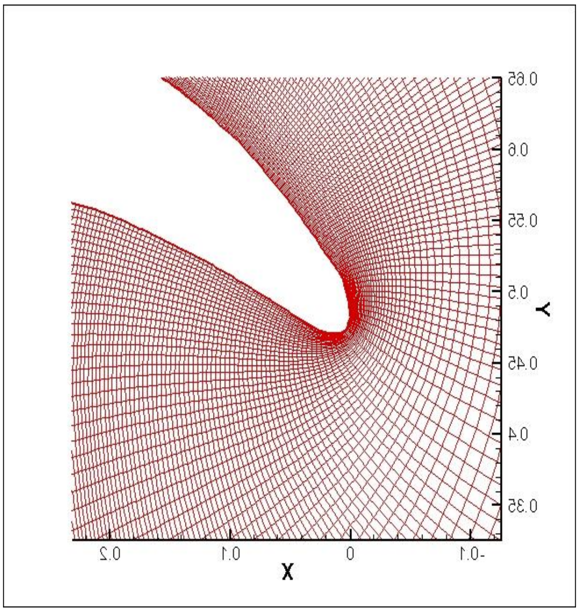

Fig3. Zoomed in view at the leading edge of PAK B blade grid.

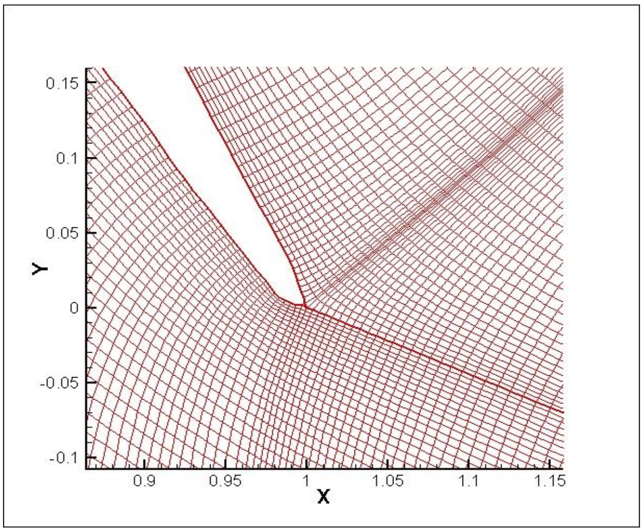

Fig 4. Zoomed in view of the trailing edge of PAK B arofoil

2.2 Sequence of the RANS3D Algorithm

The RANS3D code is capable of handling multiblock structured grid where the block dependent data are to be provided for each block separately.

The main control of code is divided into 3 DO loops-outermost on given timestep followed by the loop for iterative sweep of flow domain and innermost loop is on block structure.

The task of sequential solution of each equation of flow system is divide into 3 sub stacks, coefficient generation, computation of linearized source terms, finally the iterative solution of equivalent linear equation system for each variable like velocity component , pressure and two turbulence scalars for evaluation of eddy viscosity each having a sparse sept diagonal coefficient matrix.

Location and the kind of boundary conditions are provide in **(BLKREAD)** .All the block-independent control indices like convergence criteria etc in **(CONREAD).**

2.3 Mathematical Modeling

2.3.1 Turbulence Models for Fully Turbulent Flow

Standard *k-ω* turbulence model proposed by Wilcox *et al* (1987) expresses the eddy viscosity ϑ_t in terms of the turbulence kinetic energy *k*. *S* is the mean strain rate and *P* is the production of turbulence energy and the flow conditions are assumed to be fully turbulent. The model is expressed by the following two coupled pde's.

$$D_t k = P_k - \beta^* k\omega + \nabla\cdot\left(\left(\nu + \frac{\nu_{eff}}{\sigma_k}\right)\nabla k\right)$$

$$D_t \omega = \alpha P_k \frac{\omega}{k} - \beta\omega^2 + \nabla\cdot\left(\left(\nu + \frac{\nu_{eff}}{\sigma_\omega}\right)\nabla \omega\right)$$

For transitional flows: $\nu_{eff} = \gamma\nu_t + (1-\gamma)^*\nu_l$ where γ is the Intermittency

Where, turbulent velocity scale is $\sqrt{k}$ & turbulent length scale is $l = \frac{k^{1/2}}{\omega}$ and hence

Following the definition of eddy viscosity, $\nu_t = \frac{k^{1/2}}{\omega}$

The model constants are α = 5/9, β = 3/40, β* = 0.09, $\sigma_\omega = \sigma_k = 2$. However in case of a transitional stream, the updation of the compelling vortex consistency under the above conditions is likened to a direct blend of the laminar consistency and the vortex thickness. The irregularity obtained from the progress display, portrayed in the following area, is utilized as the weighting capacity for the successful swirl thickness. Eddy Viscosity (μ_t) field is obtained from the solution of additional transport equations for turbulence scalars. Transition is taken care by evaluation of Intermittency Factor γ derived from Experimental Correlation.

Spallart - Allmaras Model One Equation only for Eddy Viscosity $\tilde{\upsilon}_t$:

Equation for Eddy Viscosity based on Intuition, Empiricism and Pool of Measurement Data

k-ω SST (Shear Stress Transport Model)

The SST model is a combination of the k-epsilon in the free stream and the k-omega models near the walls. Wall functions aren't used and most accurate when solving the flow near the wall. The SST model doesn't quickly converge, so the k-epsilon or k-omega models are often solved first to give good initial conditions the results are shown to compare well with experimental data.

For turbulent kinetic energy k,

$$\frac{\partial(\rho k)}{\partial t}+\frac{\partial(\rho u_j k)}{\partial x_j}=P-\beta^*\rho\omega k+\frac{\partial}{\partial x_j}\left[(\mu+\sigma_k\mu_t)\frac{\partial k}{\partial x_j}\right]$$

For dissipation,

$$\frac{\partial(\rho\omega)}{\partial t}+\frac{\partial(\rho u_j\omega)}{\partial x_j}=\frac{\gamma}{\nu_t}P-\beta\rho\omega^2+\frac{\partial}{\partial x_j}\left[(\mu+\sigma_\omega\mu_t)\frac{\partial\omega}{\partial x_j}\right]+2(1-F_1)\frac{\rho\sigma_{\omega 2}}{\omega}\frac{\partial k}{\partial x_j}\frac{\partial\omega}{\partial x_j}$$

2.3.2 Correlation Based Model

This observational model proposed by Abu Ghannam is construct for the most part in light of transverse speed profiles at various longitudinal stations estimated utilizing hot wire anemometers and furthermore the divider static weight along the stream heading utilizing appropriate divider tappings, for stream over a smooth level plate set in test area of low speed wind tunnel. Another critical conclusion from these itemized estimations is recognizing the areas of begin and end of transition process on plate. Anytime on plate the non- dimensional change length parameter $\boldsymbol{\eta}$

$$\eta=\frac{\mathrm{Re}_X-\mathrm{Re}_{X_s}}{\mathrm{Re}_{\theta_s}-\mathrm{Re}_{X_s}}$$

$$\text{where}\quad \mathrm{Re}_X=\frac{\rho x U}{\mu}$$

where, Re_x is the local Reynolds number based on the length x along the flat plate and free stream velocity U; Re_{xs} is the Reynolds number based on ,the length at the start (onset) of transition, exceeds $\mathrm{Re}_{\boldsymbol{\theta}}$ which is once again decided by γ_θ the pressure gradient parameter as defined by the following empirical equation derived from measurement data .

$$\mathrm{Re}_{\theta s}=163+\exp\left\{F(\lambda_\theta)-\frac{F(\lambda_\theta)}{6.91}Tu\right\}$$

$$F(\lambda_\theta)=6.91+12.75\lambda_\theta+63.64\lambda_\theta^2\quad \text{when}\,\lambda_\theta\langle 0$$

$$F(\lambda_\theta)=6.91+12.75\lambda_\theta-12.27\lambda_\theta^2\quad \text{when}\,\lambda_\theta\rangle 0$$

2.3.3 Three Equation Eddy Viscosity Model

TurbulentKineticEnergy:

$$D_t k_T=P_{kT}+R_{BP}+R_{NAT}-\omega k_T-D_T+\nabla\cdot\left(\left(\nu+\frac{\nu_T}{\sigma_k}\right)\nabla k_T\right)$$

LaminaKineticEnergy:

$$D_t k_L=P_{kL}-R_{BP}-R_{NAT}-D_L+\nabla\cdot(\nu\nabla k_L)$$

Specific Turbulence Energy Dissipation:

$$D_t\omega=C_{\omega 1}\frac{\omega}{k_T}P_{kT}-C_{\omega 2}\omega^2+C_{\omega 3}f_\omega\alpha_T f_w^2\frac{\sqrt{k_T}}{d^3}+\nabla\cdot\left(\left(\nu+\frac{\nu_T}{\sigma_\omega}\right)\nabla\omega\right)$$

$$P_{k_T}=\nu_{T,l}S^2;\quad P_{k_L}=\nu_{T,s}S^2\quad \mathrm{S:Mean\ Strain\ rate}$$

2.3.4 Correlation-based Transition Model of Menter et *al* (2006)

This model has been recommended to cover Standard Bypass Transition as well as Natural Transition for flows with Low Free Stream Turbulence.

Intermittency (γ) :

$$\frac{\partial}{\partial t}(\rho\gamma)+\frac{\partial}{\partial x_j}(\rho\overline{U}_j\gamma)=\frac{\partial}{\partial x_j}\left\{(\mu+\mu_t/\sigma_\gamma)\frac{\partial\gamma}{\partial x_j}\right\}+P_{\gamma 1}-E_{\gamma 1}+P_{\gamma 2}-E_{\gamma 2}\quad(3.25)$$

Transition Momentum Thickness Reynolds number:

$$\frac{\partial}{\partial t}(\rho\,\mathrm{Re}_{\theta t})+\frac{\partial}{\partial x_j}(\rho\overline{U}_j\mathrm{Re}_{\theta t})=\frac{\partial}{\partial x_j}\left\{(\mu+\mu_t)\frac{\partial\,\mathrm{Re}_{\theta t}}{\partial x_j}\right\}+P_{\theta t}$$

$$\mathrm{Re}_{\varpi}=\frac{\rho\varpi y^2}{\mu}\quad\text{and}\quad \mathrm{F}_{\mathrm{wake}}=e^{-\left(\frac{\mathrm{Re}_{\varpi}}{1.E+5}\right)^2}$$

The model constants for the $\mathrm{Re}_{\theta t}$ equation are:

$$c_{\theta t}=0.03\quad\text{and}\quad\sigma_{\theta t}=2.0$$

The limit condition for $\mathrm{Re}_{\theta t}$ at a divider is zero transition.

The limit condition for $\mathrm{Re}_{\theta t}$ at a

c bay ought to be Figd from the exact connection in light of the gulf turbulence force.

The model constants for the $\mathrm{Re}_{\theta t}$ equation are:

$$c_{\theta t} = 0.03 \text{ and } \sigma_{\theta t} = 2.0$$

It is utilized as a part of Equation is the length of the change zone and is substituted in Equation is where the model is initiated keeping in mind the end goal to coordinate both F_{Length} and $Re_{\theta c}$ is utilized as a part of Equation. At introduce, these observational relationships are restrictive and are not given in this manual.

The first empirical correlation is a function of λ_θ the local turbulence intensity, Tu, and the Thwaites' pressure gradient coefficient is defined as

Where $\frac{dU}{ds}$ is the acceleration in the streamwise direction.

These equations however are not arrived at through any rigorous mathematical derivation, but based mostly on intuition, experience, experimental information and dimension analyses-based decisions. Like every other transport equation solved in CFD, these transport equations also consist of three kind of processes – convection, diffusion and source terms

But unlike experimental correlations which express this quantity as function of free stream turbulence level or mean flow pressure gradient *etc.*, this quantity is needed by the Intermittency equation inside the boundary layer to transmit the information about the free-stream into the boundary layer.

2.3.5 k-k_l-ω model of Walters *et al* (2008)

This equation involves the below explanation of various terms of transition and turbulence

$$\frac{Dk}{Dt} = P_{kT} + R_{BP} + R_{NAT} - \omega k \; - D_T + \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\alpha_T}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right]$$

$$\frac{Dk_L}{Dt} = P_{kL} - R_{BP} - R_{NAT} - D_L + \frac{\partial}{\partial x_j}\left[\mu \frac{\partial k_L}{\partial x_j}\right]$$

In order to improve the predictions of separated flow transition. The main difference is that the constant that controls the relation between $R_{\theta v}$ and $R_{\theta c}$ was changed from 2.193, its incentive for a Blasius limit layer, to 3.235, the incentive at a detachment point where the shape factor is 3.5.

Coupling the Transition Model and SST Transport Equations

The transition model interacts with the SST turbulence model, as follows:

$$\frac{Dk}{Dt} = \tilde{P}_k - \tilde{D}_k + \frac{\partial}{\partial x_j}\left[(\mu + \sigma_k \mu_t)\frac{\partial k}{\partial x_j}\right]$$

where $\tilde{P}_k = \gamma_{eff} P_k$ and

$$\tilde{D}_k = \min(\max(\gamma_{eff}, 0.1), 1.0) D_k \qquad R_y = \frac{\rho y \sqrt{k}}{\mu}$$

$$F_3 = \exp - \left(\frac{R_y}{120}\right)^3 \text{ and } F_t = \max(F_{1orig}, F_3)$$

Where P_k and D_k are the original production and destruction terms for the SST model and F_{1orig} is the original SST blending function. Note that the generation term in the Eq. isn't altered. The method of reasoning behind the above model definition is given in details in Menter *et al* .

With a specific end goal to capture both the laminar and transitional limit layers accurately, the the order of magnitude of y^+ should be around one. On the off chance that the y^+ is too expansive (i.e. > 5), at that point the progress beginning area moves upstream with expanding y^+. It is recommended to use the bounded second order upwind based discretization for the mean flow, turbulence and transition equations.

3. RESULTS AND DISCUSSION

This section presents the computational and experimental results for transitional flow past an isolated PAK-B aerofoil ., have also been computed in terms of the loss coefficient. Validation of the computational result against the corresponding measurement data [6] for flow past an isolated PAK-B aerofoil .

3.1 6 Pressure field around an isolated PAK-B aerofoil and PAK-B Cascade

Following figures represent pressure distribution along the boundary layer and around the domain of blade and cascade has been clearly captured. The variation in the pressure at the pressure side is positive displacement and negative displacement at suction side.

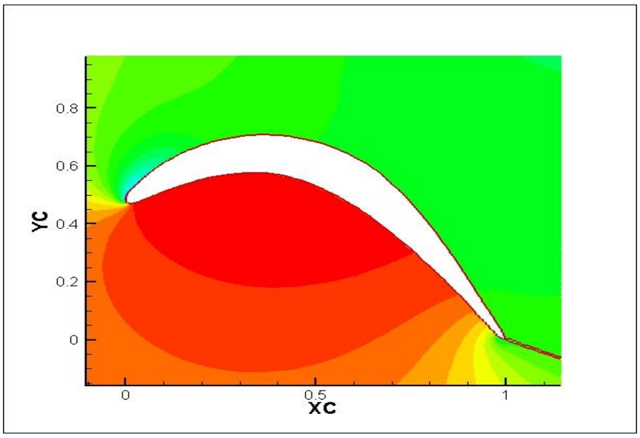

Fig 5. Pressure distribution for PAK B aerofoil

3.2 Validation for Aerodynamic Coefficients

Shows the variation of C_l and C_d with angle of attack (the variation which represents the aerodynamic performance of the aerofoil. The maximum value of Cl is around 4.02E-01 at an angle of attack of 25.6 where the value of Cd is around 5.63E-01 possibly due to the large contribution of the pressure drag and Cd reaches the minimum (=2.45E-01) at zero degree angle of attack.

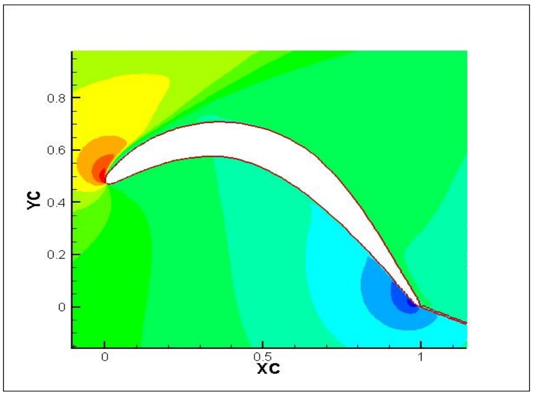

Fig 6. V-velocity distribution for PAK b aerofoil

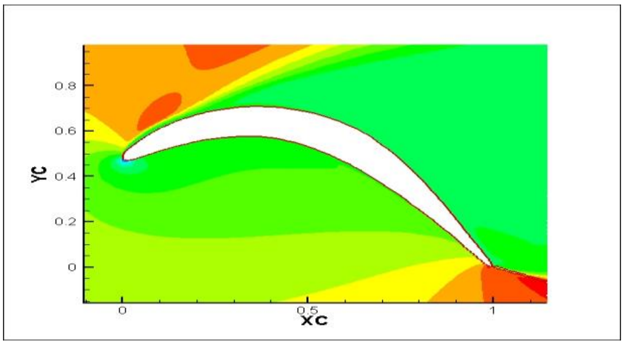

Fig 7. U-velocity distribution for PAK B aerofoil

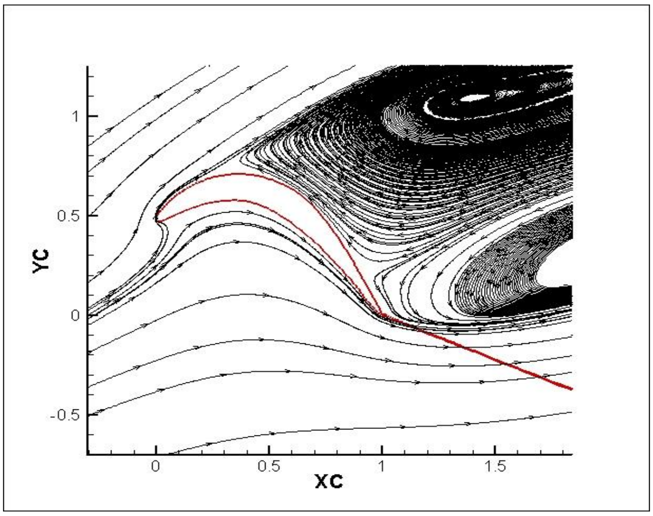

Fig 8. Streamline distribution for PAK B aerofoil

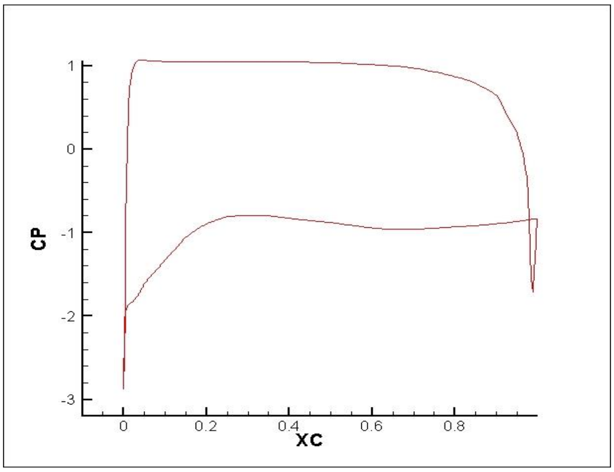

Fig 9. Surface Pressure Coefficient v/s Chord Length for PAK B aerofoil

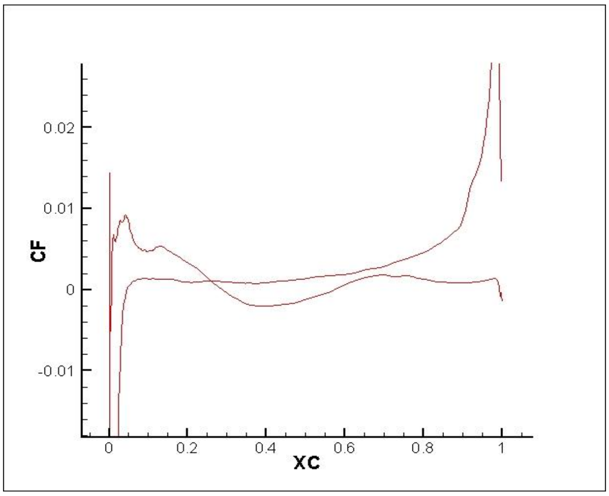

Fig 10. Skin Friction Coefficient v/s Chord Length for PAK B aerofoil

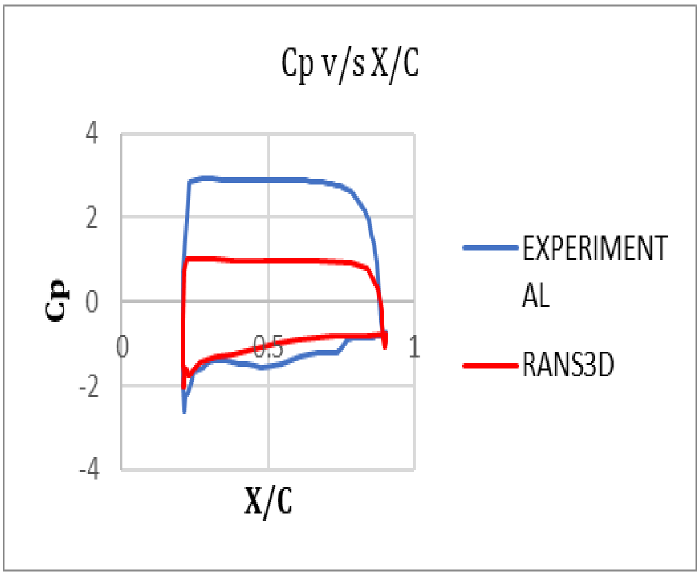

Fig 10. Experimental and RANS3D Comparison of Surface Pressure Coefficient v/s Chord Length for PAK B aerofoil

4. CONCLUSIONS

- The grid generation code **MESHGEN** developed at NAL, based on Elliptical Poisson Solver has been thoroughly understood and successfully used to generate single block structured grid with near orthogonality at boundaries for PAK B aerofoil where C-grid topology has been used.
- In case of flow solution code **RANS3D** , the mathematical modeling , discretization schemes, eddy viscosity based models for turbulent have been understood before implementing transition models in present work.
- An eddy viscosity based three equation model (Walters et al) for transition solving laminar and turbulent kinetic energy and specific turbulence dissipation is studied and incorporated into code this pde based model is tested for flow past PAK B aerofoil.
- The aerodynamic performance of PAK B aerofoil section is assessed by the chordwise variation of surface pressure, skin friction coefficients. RANS3D code has been used to predict flow characteristics of PAK B aerofoil, operating at low Reynolds number of 50,000 when transitional flow is expected and eddy viscosity based transitional model is used to predict transition of flow from laminar to turbulent.
- The present simulation successfully captures the transition flow and well known phenomenon of growth of Laminar Separation Bubble (LSB).reported I experiments followed by turbulent reattachment on the foil surface is clearly observed in the velocity based particle traces.

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