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An analysis of heat transfer systems fitted with various rib geometries in elliptical passages

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ABSTRACT

This paper presents a test examination for heat move upgrade and liquid stream in elliptic al sections fitted with various rib geomettries. Limit conditions are: bay coo lant air temperature is 300 K and stream Reeynolds number range (11000, 13500 and 16000). The encompassing steady tourist temperatures was (673 K).Results present the impact of utilizing diverse rib geometries in various circular entry perspective r atio on the liquid stream and warmth move charracteristics. The cooling air temperature appropriation at the section centerline, inward divider surface temperature of the channel, normal Nusselt number, contact factor rattio, and warm execution factor are p disdained in this paper. I was indicated that normal Nusselt number expanded with in wrinkling Reynolds number, and the most elevated worth was found for utilizing rib 1 and chann el perspective (2).Increasing coolant wind current vellocity diminishes the coolant air temperatur e at channel centerline, so diminishes the inward divider channel temperature. Utilizing ribs d ecreases the inward divider channel temperature and expands the coolant air temperature at channel centerline. Erosion factor ratiio increment with increment Reynolds numberr and the lower pressure drop (lower contact factor proportion) is found for rib 1 at all aspecct proportion.

Keywords: *Gas Turbine, Heat Transfer Enhancement, Internal Cooling, Rib Turbulator.*

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Nomenclature

Symbol	Description	Units
A	Surface area	m^2
C_p	Air Heat Capacity	J/kg.K
D_h	Hydraulic Diameter	m
e	Rib Height	m
f	Friction Factor	[-]
g	Acceleration of gravity	m/s^2
H	Height of Channel	m
h	Heat Transfer Coefficient	$W/m^2.K$
k	Thermal Conductivity	W/m.K
L_c	Characteristic Length	m
$\dot{m}$	Mass Flow Rate	kg/s
Nu	Nusselt Number	[-]
μ	Air Dynamic Viscosity	$N\ s/\ m^2$
P	Rib Spacing(Pitch)	m
Q	Rate of Heat Transfer	W
pw	circumference	m
Re	Reynolds Number=ρuD/μ	[-]
T	Temperature	K
u	Flow Velocity	m/s

INTRODUCTION

Transferring of thermal energy from the outerturbine blade surfaces to the inner regionsvia conduction and then this heat will removed by internal cooling. The passages of internal cooling are modeled as rectangular or square ducts with different aspect ratios[1].

The aim of presenting the ribs at regular spaces is to improve the heat transfer averages. Ribs are manmade protrusions that are sited in a controlled technique along the walls. The rib prompts a separation through flow and hence causes an increase in the friction loss. The improvement of the heat transfer has a drawback in the rising pressure drop, which sometimes be able to several times larger than for the smooth passage[2,3].

The heat transfer and pressure drop are strongly associated to the height of the rib. Though the ribs can be placed at different orientation, almost studies focus on the ribs placed orthogonally (at 90 degrees) to the mainstream flow. The rib size and the space between the two following ribs, the pitch has great importance [4,5].

The performance of heat transfer in the ribbed passage depends on Reynolds number on the cool air, rib shape, the passage aspect ratio. When the coolant passes over the ribs, the flow separates and reattaches.

J.C.Han [6] studied the compounding effect of using different attack angles of rib and channel aspect ratio on heat transfer coefficient distribution in a rectangular channel. Where the ribs fixed on the upper and lower side of the channel, air flowed with $Re=10*10^3$ to $60*10^3$, attack angle of the rib was varying from 30 to 90, and the aspect ratio was raging from 1 to 4. Result found that the effect of varying attack angle was slightly in the channel with aspect ratio (2).Thermal performance was changing from 1.05 to 1.85 depending on the attack angle and channel aspect ratio. Semi-empirical friction heat transfer and heat transfer correlations had been obtained for an account for rib spacing, rib angle, channel aspect ratio, Reynolds number, and rib height. The results could be utilized in the designing channel of the blade of the gas turbine.

M. Amro[7] performed an experimental investigation of the heat transfers in a triangular channel having rounded edge which roughened with ribs as a model that simulates the passage in the blade of gas Turbine. To measure the heat transfer, it was used the method of A transient liquid crystal. Reynolds numbers vary between5 × 10□5 × 10□ and. it had been found from results that the ribs of 60^o were better than the ribs of 45^o in heat transfer and with this ribs of 60o were had high friction factors. The enhancements of overall heat transfer depend on the rib and also structure rib angle.

SachinBaraskar et al.[8] presented an experiment research of friction factor properties and heat transfer of fixing ribs on one wall of the rectangular channel, the aspect ratio of channel equal to 8, the ribs were with and without gap, ribs spacing to height (p/e) =10,heat transfer and friction properties of this ribbed channel have been compared to the smooth channel with similar condition. The influence of rib has been studied for a range of Reynolds numbers from 5 × 10□ to 14 × 10□. The best enhancement in friction factor and the Nusselt number was perceived to be 2.85 and 2.57 times of that of the smooth channel, respectively.

UmeshPotdar et al. [9] presented an experimental work in the stationary square channel with V-shaped and 45°inclined arc of circle rib turbulators to find the thermal and hydraulic performance. Channel aspect ratio of (W/H=1) was considered in the analysis. Square ribs (w/e = 1) were considered as the baseline configuration. The heat transfer performance for the channel was calculated with range of Reynolds numbers from 45x10□ to 75x10□. The results obtained for the channel with different ribs configuration proved that the increase in rib width increases the thermal performance of the channels.

Shailesh et al.[10] performed an experimental investigation for ribs which have no gaps and ribs having gaps with (p/e) =10, (e/Dh) =0.06 and two attacking angles (60^o and 90^o), $Re= 5x10^3$ to $40x10^3$. The thermal heat transfer performance of continues and discontinuous ribs with (d/w) =0.2 and g/e=1 was investigated under the same conditions, the results of friction factor ratio and heat transfer were obtained from the ribbed channel were compared with the channel without ribs. From the results it was found that the performance of inclined ribs is best than the transverse ribs with and without gaps. The best case of thermo hydraulic performance was found to be the case of inclined ribs with gaps at Re=5000 and it was about (2.03).

channel aspect ratio from 1 to 4.The researcher used three channel having the same hydraulic diameter (□ =40mm) but different in channel aspect ratio (AR=1,2, and 4) . The Reynold number range from 10000 to 20000 In a rib-roughened channel with angled ribs, the results show that intersecting rib raised the thermal efficiency for every case, despite the channel aspect ratios and Reynolds numbers and the effect of the intersecting rib was strongest for AR = 2.0.

Effect of rib geometry on the thermal performance factor

By the averaged Nusselt number ratios and friction factor ratios, the thermal performance factor for each channel can be evaluated. Figure (13) shows the variation of the thermal performance factor for the ribbed channel with AR=2. The thermal enhancement factor varies between 0.53 and 2.12 depending on the rib configuration and Reynolds number. The maximum value of thermal enhancement factor was found at channel with AR=2 fitted with rib 1 at Re=16000.

CONCLUSIONS

- Average Nusselt number increased with increasing Reynolds number, and the highest value was found for using rib 1 and channel aspect (2).
- Increasing coolant air flow velocity decreases the coolant air temperature at channel centerline, so decreases the inner wall channel temperature.
- Using ribs decreases the inner wall channel temperature and increases the coolant air temperature at channel centerline.
- Increase the aspect ratio of elliptical channel decreases the inner wall channel temperature and increases the coolant air temperature at channel centerline.
- Friction factor ratio increase with increase Reynolds number and the lower pressure drop (lower friction factor ratio) is found for rib 1 at all aspect ratio.

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