Lethal Effect of Salts on the Terrestrial Snail *Monacha Cantiana*

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Abstract: The lethal effect of ten salts,on the terrestrial snail *Monacha cantiana*, was examined in laboratory. Tested salts were: sodium chloride, potassium sulphate, ferrous sulphate hepta hydrate, magnesium sulphate hepta hydrate manganese sulphate tetra hydrate, zinc sulphate hepta hydrate, ammonium sulphate, calcium nitrate, di ammonium phosphate and ammonium nitrate.

LC_{50} values of the previous salts after 72 hours were; 2.09 %, 3.70 %, 0.27 %, 11.65 %, 3.38 %, 0.13%,1.36 %, 1.85 %, 0.90 % and 0.20 %, respectively.

LC_{90} values of the previous salts after 72 hours were ; 10.27 %, 4.82 %, 0.67 %, 25.45 %, 5.00 %, 0.18 %, 5.87%, 7.59 % , 4.68 % and 0.83 %, respectively.

Each of Lc_{50} and Lc_{90} values correlated negatively with E.C. values of 1 % solutions of the tested salts but correlated positively with pH values of 50 % solutions of the examined salts. In other words each of Lc_{50} and Lc_{90} values correlates negatively with each of salinity and acidity of salts.

Each of Lc_{50} and Lc_{90} values were found to be correlated positively with the molecular weights of the examined salts.

Key words: Lethal salts terrestrial snail *Monacha cantiana*

Introduction

Slugs are a serious pest in floriculture, horticulture and agriculture in many parts of the world. *Deroceras reticulatum* is generally the most destructive species (Grewal *et al.*, 2001).

Different investigators examined different agents to be used to control snails; Bullock *et al.*(1992) found that control of terrestrial slugs and snails can be achieved by some common metals as contact-action poisons acquired passively by crawling animals and they were acting more efficiently than the currently used bait-delivery method.

Trent *et al.* (1997) tested thirteen molluscicides containing metaldehyde, three molluscicides containing metaldehyde plus carbaryl, one molluscicide containing metaldehyde plus methiocarb and one molluscicide containing methiocarb alone for their efficacy against the brown slug, *Vaginula plebeia* Fischer, and the two-striped slug, *Veronicella cubensis* (Pfeiffer). With the exception of corry's liquid slug, snail and Insect killer against *V. plebeia*, all the tested molluscicides caused significant mortalities against both species. In a separate study, physical barriers composed of copper or fiberglass screens repelled both slug species.

David *et al*. (2001) stated that feeding inhibition by diluted tuber peel extracts of the variety Homeguard was greater than that elicited by comparable authentic glycoalkaloid solutions suggesting additional inhibitory compound(s) in the peel of this variety.

Grewal *et al.* (2001) found that the beneficial nematode, *Phasmarhabditis hermaphrodita*, has potential for the biological control of slugs and application rates of 3.0×10^9 infective juveniles (IJs)/ha are usually required for effective plant protection.

Schuder *et al.* (2003) tested certain products that have irritant, antifeedant, physical barrier, chemical repellent, or molluscicidal effects or a combination of more than one effect against slugs. Garlic, ureaformaldehyde and cinnamamide were the three best products for controlling snails. In 7 day bioassay trials, these products had mortality rates between 20% and 95% which was significantly higher than the untreated.

Shmuel *et al.*(2004) tested two formulations of water dispersible granules contained 61.4% and 53.8% of copper hydroxide. The 0.1% concentration of either formulation was sufficient for the management of the land snails *Monacha syriaca* and *Theba pisana* populations.

Der *et, al.* (2005) stated that morpholine which is a solvent of apple wax was very effective in suppressing hatching of the snail *Pomacea canaliculata* eggs at a concentration of 60%.

Ravindra *et al.* (2008) proofed that saponin concentration in rice water at 9 and 11 ppm gave seedling protection of 93% and 95%, respectively after 48 h against different sizes of the snail *Pomacea canaliculata*.

Youssef (2011) tested four plant species used as a dry powder of their leaves against *Biomphalaria alexandrina* snails. The bioassay tests revealed that the plants *Datura stramonium* and *Sesbania sesban* were more toxic to the snails than the other two tested ones.

Snails are found tremendously beside irrigation or drainage canals where moisture is abundant .They are more active after irrigation. Snails destroy the vegetative parts of plants therefore, the aim of the present study is to determine the most suitable substance to ban snails from passing through. These substances may be useful and can be used to surround fields to protect them from snails for their molluscicidal effects as contact-action poisons.

Modeling of Residual Stresses in TBC Coated Gas Turbine Blades

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Abstract: Ceramic thermal barrier coatings have been developed for advanced gas turbine and diesel engine applications to improve engine reliability and fuel efficiency. Blades and vanes of the high-pressure turbine stages of aero-engines are the most highly stressed parts in engineering components. The blade geometry was objected to airflow at the temperatures about 800°C. These high gas turbine temperatures can only be maintained through advanced cooling techniques like electro-beam physical vapor deposition (EB-PVD) and thermal barrier coatings (TBCs). Such TBCs consist of thin ceramic layers of low thermal conductivity, yttrium stabilized zirconia (YSZ) which are applied on the blade surface. The coating imparts good adhesion of the ceramic to the substrate.

In this study, 3-D finite element structural and thermal analyses were carried out on both uncoated (without coating) and ceramic-coated turbine blade using ANSYS code. A 150 micron super alloy bond coating (NiCrAlY) was first applied to the turbine blade. Then, the blade was covered by 350 micron thickness of Mullit ($3Al_2O_3.2SiO_2$) as a top coating. These analysis were performed for detecting the possible thermally problem spots. Finally, the blade's thermal stressed problematic areas were determined by the finite element simulations which were important for the improving blade and TBC.

Key words: TBC, Turbine Blade, Finite Element Analysis, Residual Stresses, Modeling

Introduction

For the protection of the blade in hot working conditions by thermal stresses and other effects, TBC was applied on to the geometry. Different types of coating technologies widely used on the turbine blades. Thermal barrier coating (TBC) systems, consisting of yttria partially stabilized zirconia (YSZ), thermally grown oxide (TGO) and a metallic bond coat are used in applications for thermal protection of hot-section parts in gas turbine engines. (R.A. Miller 1987, D.J. Wortman at all 1989, S.M. Meier at all 1991, R.T. Jones at all 1996, R.D. Jr. Sisson at all 1995, Y.H. Sohn at all 2001)

When the turbine blades are considered, some affects are more important than the others. The important research areas related to heat transfer of a gas turbine blade include external and internal heat transfer coefficient predictions, metal temperature distributions, blade cooling methods, rotation effects, and ceramic coatings amongst others. External convection depends upon the development of the boundary layer on the blade surface, which is a complex phenomenon, and there is considerable uncertainty associated with both numerical predictions and experimental measurements (] N. Asok Kumar , S.R. Kale 2001).

The thermal barrier coating provides a temperature drop of up to 200°C, due to its low thermal conductivity, which is enhanced further by the intentionally porous microstructure (Marcin Białas 2008).

Although the composition of the TBC was created many protective abilities for the blades, some insufficient and troubled behaviors are still alive. A major weakness of TBC systems is the interface between the metallic bond coat and the ceramic TBC. At this interface an in-service degradation is observed often leading to a macroscopic spallation of the ceramic layer (R.A. Miller, C.E. Lowell 1982). The interface regions undergo high stresses due to the mismatch of thermal expansion between BC and TBC. Additionally, growth stresses due to the development of thermally grown oxide (TGO) at the interface and stresses due to interface roughness are superimposed. Stress relaxation leads generally to reduce stress levels at high temperature, but can give rise to enhanced stress accumulation after thermal cycling resulting in early crack initiation at the bond coat/alumina interface and spallation failure afterwards (A.G. Evans at all 2001, G. Fleury at all 1997, F. Schubert at all 2000)

In this study, finite element simulations of uncoated turbine blade model and also thermal barrier coated turbine blade geometry were performed with the ANSYS code. For the TBC used geometry, the turbine blade was covered with a super alloy bond coating (NiCrAlY). Over the bond coating layer, Mullit ($3Al_2O_3.2SiO_2$) was used as a top coating. For the coated turbine blade; hot air flow was applied to the all top coating layer surfaces and for the uncoated geometry; hot air flow was applied to the turbine blade surfaces. The results of the thermal simulations were compared, initially with the temperature distribution of the coated and uncoated turbine blades. Then the equivalent stress profiles of coated and uncoated turbine blade were matched and evaluated. As a final decision, TBC for the blade geometry is a supporting material for reducing the blade's temperature and equivalent stress value.

Materials

For the base blade material, steel substrate was used. As a bond coating material NiCrAlY was preferred. Mullit was selected for the top coating layer. See table 1 for materials' details. Up to the selected materials, thermal and structural properties affect the turbine blades behaviors. For an appropriate protection; which was originated from the selected materials, chemical and structural behaviors, coating material types and usage will differ.

For the TBC used geometry, the turbine blade was covered with a 150 micron thickness of a super alloy bond coating (NiCrAlY). For over the bond coating layer, 350 micron thickness of Mullit ($3Al_2O_3.2SiO_2$) was used as a top coating.

Table 1. Material properties of substrate, bond coat and top coating

Material	Thermal conductivity [W/m°C]	Thermal expansion 10^{-6} [1/°C]	Density [kg/m^3]	Specific heat [J/kg°C]	Poisson's ratio	Young's modulus [GPa]
Steel Substrate	16,2	17,2	7850	434	0,3	200
NiCrAlY	16	15	7710	520	0,25	16,8
Mullit	1,2	5,2	2608	760	0,25	21

Modeling and Analysis

For the thermal and structural simulations of the turbine blades, solid CAD models were used. Solid models of the two different finite element models of the uncoated and coated turbine blades were modeled in Pro_Engineer CAD program. Simplified solid models of the turbine blades were sent to ANSYS code directly, for easy control of finite element model. To prepare the fine meshed and simple based finite element models, unchanging one section area was applied to the turbine blades.

Two types of solid elements were used for the thermal and structural analysis in ANSYS code. Each solid element has 20 nodes. "*Solid 90"* element for the thermal analysis and "*Solid 186"* element was applied for the structural analysis. In figure 1, the meshed model of the coated turbine blade can be observed. For the uncoated turbine blade 2900 elements and 13428 nodes; for the coated model 1100 elements and 5959 nodes were used.

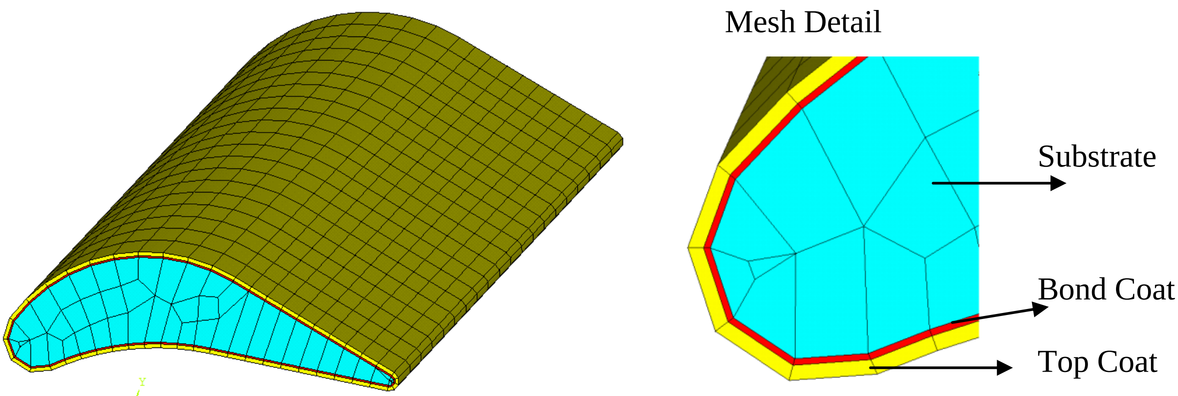

Figure 1. Meshed model of the coated blade

Initially, thermal analysis was processed for each turbine blade. During the thermal analysis, 800°C air flow was applied to the top coating surface for a while. For comparing the blades, in the uncoated model, same 800°C air flow was applied on to the turbine blade surfaces. The simulations were solved under these circumstances. The results of the thermal simulations were imported into the structural analysis set up data of the turbine blades.

During the structural analysis preparation process, transferred data of all the thermal simulation results was adapted to the structural finite element models. The thermal element "solid 90" was switched in to the structural element "solid 186" in ANSYS; but the mesh structure and distribution were not changed. Not changed mesh structure gives valuable advantage for the comparison between coated and uncoated turbine blades. All the comparisons were made from the same attitude of the elements and nodes of the mesh structure. The results of the analysis can be matched between the same node and the same element numbers for the base turbine blade geometry.

In the structural analysis, thermally simulated models were hold in All DOF from one flat side surface of the turbine blade geometry. The imported temperature distributions in the turbine blades and the coatings were reflected to the material behavior to find the stresses of the thermal simulation results. For the imported thermal simulation data, of the coated and the uncoated turbine blades, were solved. Finally, stress results for the thermally originated structural analysis can be determined for each turbine blade.

Results and Discussion

After the analysis, results are satisfactory for the evaluation and comparison for the uncoated and coated turbine blades. The thermal simulation results for the models can be determined from the figure 2. Evaluation of the figure 2 is showed that coating material was decreased the turbine blade surface temperature from 440°C to 360°C during the process of 800°C air flow. For the last steps of the analysis of, about 80°C profit was held. Using Mullit as a top coating material, 18% thermal protection was received for the turbine blade.

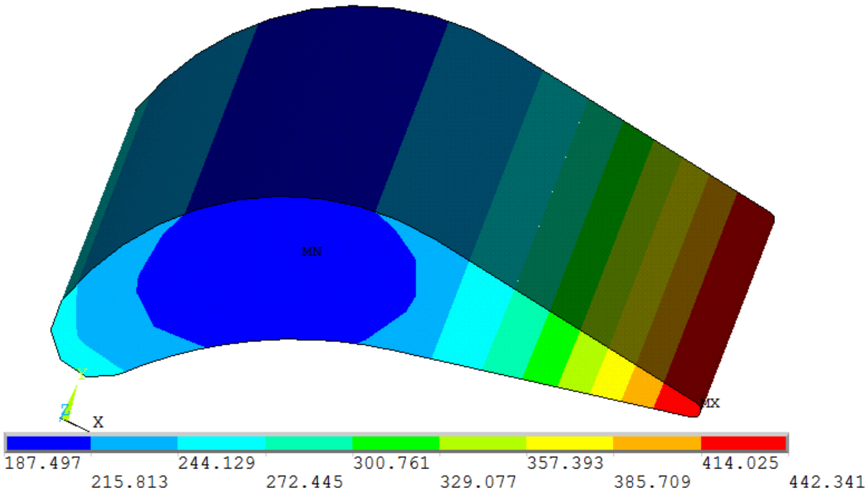

Figure 2.a. The thermal simulation results in temperatures (°C) for the uncoated blade

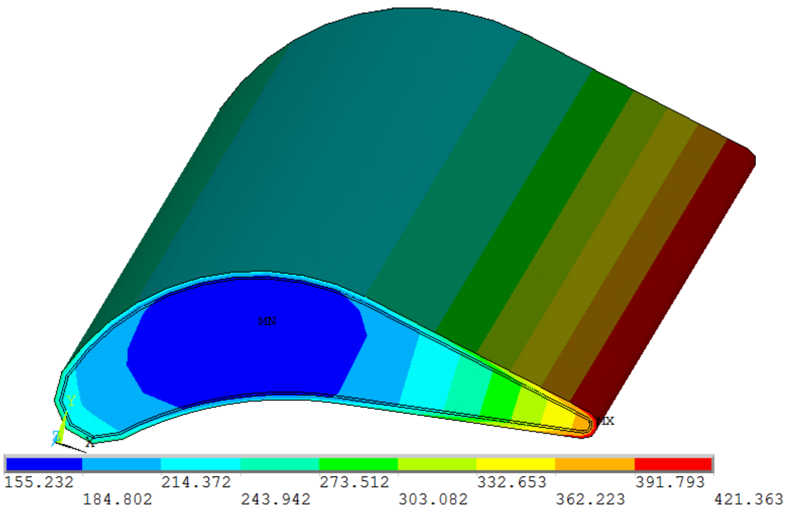

Figure 2.b. The thermal simulation results in temperatures (°C) for the coated blade

For the evaluation of the Temperature-Distance and Equivalent Stress-Distance curves, a distance profile was defined on the edge of the blade. The distance profile is started at the point which is defined in the figure 3 and 5, below the curves. As it is mentioned on the figure 3 and 5, arrows define the distance's trajectory.

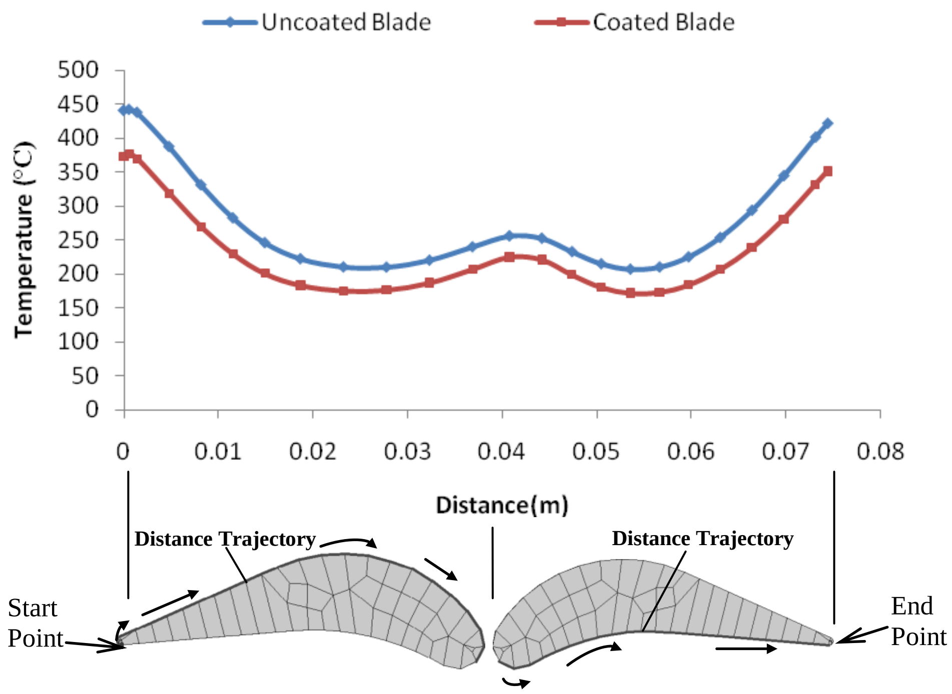

Figure 3. The temperature distribution (°C) of the uncoated and coated blades

In the figure 3, the temperature distribution could be observed through the whole process. During the thermal process coated turbine blade temperature is always smaller than the uncoated one, as it is wanted from the coated turbine blade geometry. For the critical trajectory, TBC was reduced the blade's mean temperature about 48°C. To understand the general thermal behavior of the blades, maximum, minimum and the mean temperature values for the distances of the uncoated and coated turbine blades are given in table 2.

Table 2. The maximum, minimum and mean temperature values for the trajectory distances of the uncoated and coated blades

	Max. Temp. (°C)	Min. Temp. (°C)	Mean Temp. (°C)
Uncoated Blade	442,29	206,68	290,88
Coated Blade	376,35	171,93	242,93

When the figure 4 is considered, stress curves of the uncoated and coated turbine blades can be compared. The uncoated turbine blade's maximum equivalent stress value was 3270MPa and the coated one's maximum equivalent stress value was 2550MPa. Used TBC was reduced the blade geometry's stress distribution in considerable values as 720MPa which was given the 22% equivalent stress reduction. More detailed evaluation of the stress behaviors of the uncoated and coated turbine blades' stress curves can be observed in figure 5.

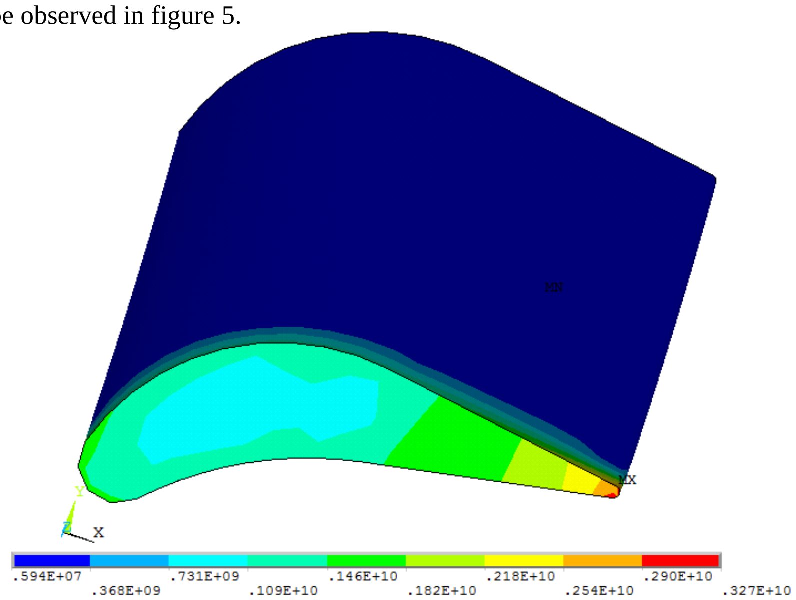

Figure 4.a. The structural simulation of equivalent stress results (Pa) for the uncoated blade

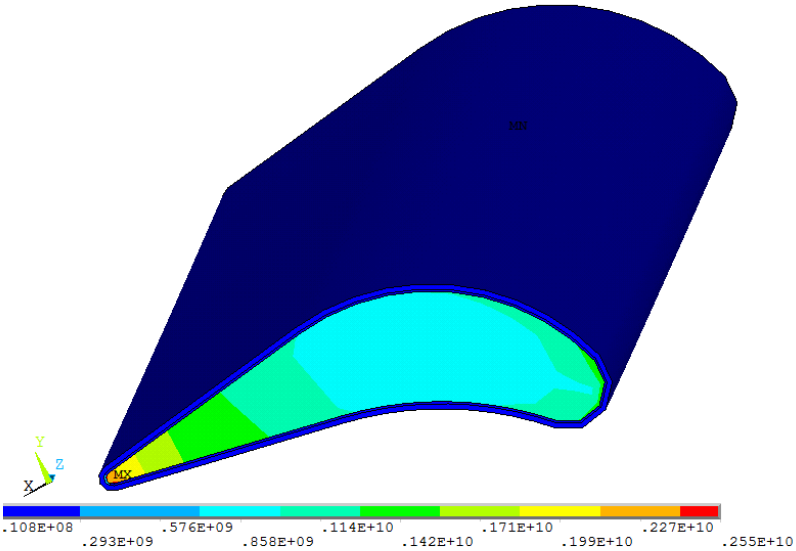

Figure 4.b. The structural simulation of equivalent stress results (Pa) for the coated blade

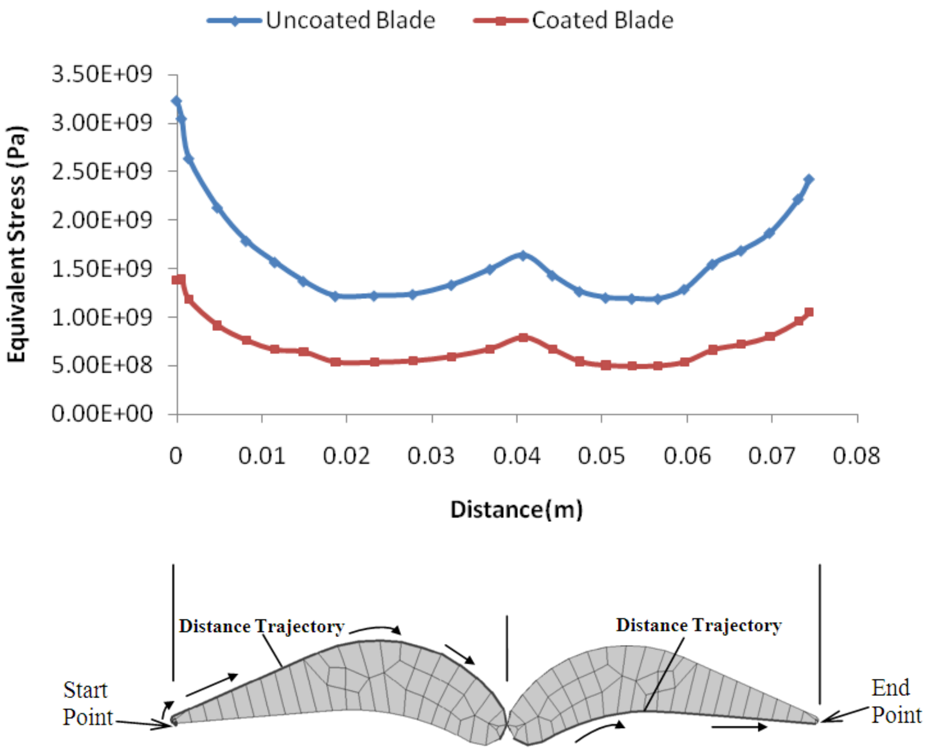

Figure 5. The equivalent stress distribution (Pa) of uncoated and coated blade for trajectory distance

As in the figure 3, figure 5 shows that the equivalent stress distribution of the coated turbine blade is always smaller than the uncoated turbine blade during the process. Little fluctuations can be observed from the curves. For the critical trajectory of the thermal barrier coated blade was reduced only blade's mean stress about 963MPa (29.4% equivalent stress reduction). To determine the stress distribution of the blades, maximum, minimum and mean stress results for the distances of the uncoated and coated turbine blades are shown in table 3.

Table 3. The maximum, minimum and mean equivalent stress values for the trajectory distances of the uncoated and coated blades

	Max. Stress (Pa)	Min. Stress (Pa)	Mean Stress (Pa)
Uncoated Blade	3,24e9	1,19e9	1,72e9
Coated Blade	1,4e9	4,95e8	7,53e8

Finally, in this study, used thermal barrier coated blade geometry, with the help of finite element technique, is proved that the coating decreases the temperatures and the stresses of the turbine blade.

Conclusions

From the present study following results can be drawn:

- In the present study, used TBC reduced the whole blade geometry's mean temperature about 80°C. Using Mullit as a top coating material, 18% thermal protection is received for the turbine blade.
- For the critical trajectory, TBC was reduced the blade's mean temperature about 48°C.
- TBC used blade geometry's reduced mean stress value of 720MPa was given 22% equivalent stress reduction. The indicated level of stress reduction is considerable and protects the blade from the thermal stress more than expected.
- For the critical trajectory of the thermal barrier coated blade was reduced only the blade's mean stress about 963MPa (29.4% equivalent stress reduction).
- This study showed that; after thermal and structural finite element simulations for the uncoated and coated turbine blade, the reduction of the temperatures and stresses are satisfactory and can be determined easily.

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