SUB. F

DA CONSEGNARE AL <u>COORDINATORE DEL CORSO</u> PER LA PRESENTAZIONE DEL DOTTORANDO AL GIUDIZIO DEL COLLEGIO DEI DOCENTI IN VISTA DELL'ESAME FINALE

SCHEDA INFORMATIVA SULLE ATTIVITA' DEL TRIENNIO

- Cognome e Nome **ALINEJAD, FARHAD**
- Titolo di studio posseduto **Master in Mechanical Engineering**

conseguito in data **2009** presso l'Università/Politecnico di
K. N. Toosi University of Technology, Tehran

- Dottorato di Ricerca in **Mechanical Engineering**
- Ciclo **XXX** Anni accademici di riferimento **2014-2017**
- Dipartimento **Mechanical and Aerospace Engineering (DIMEAS)**
- Coordinatore **Prof. LUIGI GARIBALDI**
- Tutore **Prof. Daniele Botto**
- Titolo della Tesi di Ricerca (in Italiano e/o in Inglese)

Development of advanced criteria for blade root design and optimization

A. DESCRIZIONE DELL'ARGOMENTO DELLA TESI (massimo 20 righe)

The blades in gas and steam turbines are critical components that play important role in specifying the efficiency and performance of the engine and endure significant mechanical and thermal loading. The inability of the blade root in handling loads may terminate to a blade shoot out of the blade and disc assembly and causes massive domestic object damage and outage time. The blades are joined to the disc through the attachment which undergoes high stress states. To confront the high stress in the blade and disc attachment, in addition to apply advanced materials, the designer tries to exploit the available material properties by finding the best shape of the attachment. However, due to the fact that the number of parameters to define a blade attachment, even in a simplified shape of the attachment, is too high that makes it difficult (if not impossible) to find the best set of parameters by trial and error, the optimization algorithms are applied. In addition to finding an optimum solution to a problem, one should consider that always in engineering problems, there are some uncertainty which appear in the input parameters and the designer may have no control over them. In a Robust design, the demand is to minimize the effect of uncertainty in the design parameters by finding a set of parameters for which the corresponding objectives are less affected by the uncertainty. In this thesis, the aim was to optimize the blade and disc attachment with different attachment topologies using the Genetic Algorithm (GA). Optimization was performed in terms of stress in the critical areas of the attachment. Moreover, an improved and more applicable penalty function was developed to take advantage of non-feasible space information for a faster convergence. Also, it was found that embedding a Meta model (Kriging function) in the optimizer algorithm will significantly decrease the time of the total optimization process.

B. ATTIVITA' DI RICERCA SVOLTA NEL TRIENNIO

B.1 descrizione complessiva e sintetica dell'attività di ricerca

A parametric intelligent model was developed to optimize the firtree and dovetail shape of a typical blade and disc attachment. A combination of GA and Meta model was applied as an optimization method. An innovative Penalty method was proposed and proved as an effective method in reducing the convergence time. Different topologies were optimized and compared. Robustness analysis was embedded to the optimization process as a post-process operator on the Pareto front. Optimum attachment was found having significant improvement in stress state in comparison with the original design.

B.2 argomenti di ricerca specifici affrontati

- Developing a general but thorough parametric geometry of the attachment having the most variability and identifying the dependent and independent parameters.
- Constructing a Meta model for obtaining a rough estimation of the objective values in order to reduce the time for convergence of the optimization.
- Applying the physical and geometrical principals to filter out the non-feasible sets of parameters.
- Developing an innovative penalty method to benefit the non-feasible space of the search domain.
- Embedding the Meta model into the Genetic Algorithm evaluation loop to minimize the convergence time.
- Applying a punch test as a benchmark to study different topologies of the contact.
- Study the stress state of the blade and disc attachment applying different topologies.
- Optimizing the Dovetail and the firtree blade root.
- Obtaining the robust solution of the optimization by applying a post-optimization stage using Meta model.

B.3 risultati più rilevanti ottenuti nel triennio

- It was found that embedding a Meta model in the optimization algorithm will reduce the number of call backs to high fidelity model, hence, reducing the time to convergence.
- An innovative penalty method based on Latin hypercube sampling (LHS) was developed and found to be effective for a faster convergence.
- Applying a post-optimization robustness analysis instead of incorporating the high cost robustness evaluation into the optimization process to speed up the total process.
- State of stress could be improved highly by the attachment topology change.

B.4 collaborazioni di ricerca avute con Università, Centri di ricerca ed Industrie nazionali ed internazionali (specificare il quadro entro cui sono avvenute: contratti di ricerca, periodi di formazione, ecc.)

This Thesis was defined within a research contract demanded by ANSALDO ENERGIA.

B.5 ulteriori attività di ricerca (progetti e contratti di ricerca nazionali ed internazionali)

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B. 6 brevetti conseguenti l'attività di ricerca

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B. 7 altre attività che si ritengono degne di menzione

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C. ATTIVITA' DI FORMAZIONE

C.1 partecipazione ad attività interne di supporto alla didattica (specificare su quali corsi, e se eventualmente il dottorando sia stato nominato cultore della materia)

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C.2 corsi e seminari più significativi seguiti (interni, esterni, ecc. - indicare solo il tipo ed il numero)

1- Analysis of structures subjected to impulsive loading
2- Probabilità applicata e processi stocastici
3- Progettazione di strutture meccaniche in materiale composito
4- Progettazione dinamica di ingranaggi
5- Programmazione in labview: parte 1 e parte 2
6- Strumenti e applicazioni del systems engineering
7- Tecniche innovative per l'ottimizzazione
8- The Boundary Element Method for Anisotropic Bodies and Multilayered
9- Usura dei materiali

C.3 periodi di formazione esterni al Politecnico (tipo di formazione, luogo e durata)

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D. PUBBLICAZIONI FATTE E IN CORSO (indicarne il numero e il tipo: riviste nazionali ed internazionali, congressi, capitoli libri ecc.)

1- Daniele Botto, Farhad Alinejad, "Innovative design of attachment for turbine blade rotating at high speed". Proceedings of ASME Turbo Expo: Turbomachinery Technical Conference and Exposition", GT2017, June 26-30, Charlotte, NC, USA.
2- Farhad Alinejad, Muzio M. Gola, Andrea Bessone, Daniele Botto, "Gas turbine concept design approach: design space reduction for the optimization of the blade fir-tree attachment", Proceedings of ASME Turbo Expo: Turbomachinery Technical Conference and Exposition", GT2018, June 11-15, Olso, Norway. (Abstract Accepted)
3- Daniele Botto, Farhad Alinejad, "Robust and optimal design of different contact profiles for dovetail attachment", Latin American Journal of Solids and Structures. (Submitted)

Data,

(firma del Tutore)

(firma del dottorando)