ענף הנעה
מחלקת מטוסים
להק ציוד
חיל האויר

המעבדה למנועי סילון וטורבינות גז
הפקולטה להנדסת אוירונוטיקה וחלל
הטכניון, חיפה
http://jet-engine-lab.technion.ac.il

ענף הנעה
המחלקה לאוירונוטיקה
היחידה למו"פ-היחידה לתשתיות
מנהלת פיתוח אמל"ח ותשתיות
משרד הביטחון

יום העיון השביעי
במנועי סילון וטורבינות גז

יום ה', ח' בחשון תשס"ט,

6/11/2006, 9:00 – 17:30,

7th Israeli Symposium on Jet Engines and Gas Turbines

Faculty of Aerospace Engineering, Technion, Haifa

בחסות:

- **המעבדה למנועי סילון וטורבינות גז**,
הפקולטה להנדסת אוירונוטיקה וחלל, הטכניון
- **ענף הנעה**, המחלקה לאוירונוטיקה, היחידה למו"פ –
היחידה לתשתיות, מנהלת פיתוח אמל"ח ותשתיות, משרד הביטחון
- **ענף הנעה**, מחלקת מטוסים, להק ציוד, חיל האוויר

אולם האודיטוריום (אולם 235),
הפקולטה להנדסת אוירונוטיקה וחלל, הטכניון, חיפה.

ענף הנעה
המחלקה לאוירונוטיקה
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יום העיון הישראלי השביעי במנועי סילון וטורבינות גז
יום ה', ח בחשון תשס"ט, 6/11/2008 (9:00 – 17:00), אולם האודיטוריום (חדר 235),
בניין הפקולטה להנדסת אווירונוטיקה וחלל, הטכניון, חיפה

7th Israeli Symposium on Jet Engines and Gas Turbines

Faculty of Aerospace Engineering, Technion, Haifa (6/11/2008)

PROGRAM

08:30 - 09:30 הרשמה (Registration)

09:30 - 10:00 דברי פתיחה: פרופ' עמרי רנד, דיקן הפקולטה להנדסת אוירונוטיקה וחלל,

Opening:

- **Professor Omri Rand,** Dean, Faculty of Aerospace Engineering, Technion
- **Ltc. Baruch Bar Netz,** Chief Propulsion Branch, IAF
- **Ltc. Roni Gordana**, Head, Propulsion Systems Branch, Aeronautical Division, MOD

10:00 - 13:10 מושב ראשון (First Session)
Session Chairman: Dr. Moshe Shapira, V.P R&D, Bet Shemesh Engines, Israel.

1. New Developments for Military Gas Turbines,
Lars Seumenicht, Head of Defense Sales, Rolls-Royce, Germany.

2. Intelligent Incorporation of Advanced Technology into Legacy Fighter Jet Engines to Increase Time on Wing and Reduce Maintenance Cost,
Konstantino Kouris, F100 Engineering Manager, Pratt & Whitney, USA.

11:30-11:40 הפסקה וכיבוד קל (Break and refreshments)

3. Aviation Technology Strategy for the 21st Century,
Rolf Hetico, Manager, F136 Engine Systems Design and Integration, GE Aviation, Evendale, Ohio, USA.

4. Infrared Signatures Modeling of Aircraft Exhaust Plume,
Prof. Arvind G. Rao and Prof. J.P.van Buijtenen,
Faculty of Aerospace Engineering, Technical University of Delft, The Netherlands.

5. Unsteady Forces and Flutter in the Compressor of the Aircraft Engine, Numerical and Experimental Results.
Prof. Romuald, Rządkowski, Department of Aeroelasticity,
Institute of Fluid Flow Machinery, Polish Academy of Sciences, Poland.

13:00 - 15:00 ארוחת צהריים וסיור במעבדה (Lunch)

15:10 - 17:20 מושב שני (Second Session)
Session Chairman: Adam Weintraub, Manager, Engines Research, IAI
דברי פתיחה : דר' אבי וינרב, ראש מחלקת אוירונאוטיקה, מפא"ת

6. Incorporation of Gas Turbine with Combined Cycle (GTCC) in the Generation Expansion Plan of the Israeli Power System,
Dr. David Elmakis, V.P. Planning Development & Technology, Israel Electric Company.

7. RotorDynamics and Active Detection of Faults in Rotating Bodies - Theoretical and Experimental Results,
Prof. Izhak Bucher, Mechanical Engineering, Dynamics and Mechatronics Laboratory, Technion, Israel.

8. Atomization vs. Vaporization of Fuel in Micro Gas Turbines,
Daniel Kutikov, Faculty of Aerospace Engineering, Technion, Haifa, Israel.

16:10 - 16:20 הפסקה וכיבוד קל (Break and refreshments)

9. Swirling Flow in Annular Diffusers Between Two Counter-Rotating Turbines,
Dr. Vladimir Ehrenburg, Becker Turbo System Engineering, Givatayim, Israel.

10. Numerical Investigation of Burning Processes in a Small Gas Turbine Combustor,
Alex Dolnik, Turbo-Jet Engine Dept., RAFAEL Advanced Defense Systems Ltd., Israel.

11. Identification of Control Parameters of an Engine the Algorithm of Which is Partially Known,
Dr. Michael Lichtsinder, Bet Shemesh Engines, Bet Shemesh, Israel.

17:20 דיון ודברי סיכום (Closure)

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יום העיון השביעי במנועי סילון וטורבינות גז

יום ה', ח' בחשון תשס"ט, 06/11/2008 (9:00 – 17:00), אולם האודיטוריום (חדר 235),
בניין הפקולטה להנדסת אווירונוטיקה וחלל, הטכניון, חיפה

הפעילות בתחומי ההנדסה השייכים לתחום ההנעה הסילונית מתרחבת בשנים האחרונות בצורה משמעותית. פרויקטים חדשים במימון משרד הביטחון, תגבור יצור החשמל בעזרת טורבינות גז ע"י חברת החשמל ובעיות הנוגעות לתחזוקה שותפת ותכנון עתידי של מנועי סילון בח"א מהווים כח מניע לפתוחים ופרויקטים רבים בנושא. כל זאת בנוסף לפעילות הרגילה של יצור סדרתי של מנועים, חלקי חילוף שונים, תחזוקה ועוד. מספר רב של גופים עוסקים בארץ באופן פעיל ושוטף בתחום זה ובהם מפא"ת, ח"א, חיל הים, אל-על, תע"א, מנועי בית שמש, רפא"ל, תע"ש, אורמת, חברת החשמל, RSL, בקר הנדסה, טכנולוגיות להבים, הטכניון ועוד.
שיפורים הנדסיים, חידושים טכנולוגיים ופרויקטים חדשים המתנהלים בארץ מצדיקים את המשך קיומם של מפגשים מקצועיים המיועדים להפריה הדדית, החלפת מידע ומהווים קרקע נוחה לעידוד שיתופי פעולה. בחמשת ימי העיון שהתקיימו עד עתה התכנסו ונפגשו כל פעם כמאה מהנדסים ומדענים מתחום ההנעה, הוצגו עבודות מהתעשיות השונות, ממשהב"ט ומהאקדמיה ולהערכת המשתתפים, ימי העיון הוגדרו כמוצלחים והסתיימו עם טעם של עוד...

יום העיון הקרוב יכלול 3 הרצאות מבוא מוזמנות בנושאים נבחרים, ע"י מרצים אורחים מהחברות General Electric, Pratt & Whitney ו- Rolls Royce. בנוסף יום העיון יכלול הצגות קצרות ע"י מרצים מהארץ ומחו"ל, על נושאים שונים בתחום ההנעה הסילונית, על הפעילויות השונות במפעלים, במכונים ובאוניברסיטאות בארץ, דיון פתוח וע"פ דרישה, גם סיורים במעבדות הפקולטה. כמו כן, זו תהיה הזדמנות טובה למפגשים מקצועיים, החלפת דעות והצגת דגמים ומוצרים ע"י חברות שונות.

המחיר למשתתף הוא 220 ₪ (כולל ארוחת צהריים וחוברות תקצירים). לסטודנטים (תואר ראשון ולימודי מוסמכים) הרשמה לכינוס חינם.

בברכה,
פרופסור ישעיהו לוי
ראש המעבדה למנועי סילון וטורבינות גז
יו"ר יום העיון

הפקולטה להנדסת אווירונאוטיקה וחלל, קריית הטכניון, חיפה, 32000,
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Propulsion Branch
DDR&D-MOD

Turbo and Jet Engine Laboratory
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Propulsion Branch
IAF

7th Israeli Symposium on Jet Engines and Gas Turbines

Thursday, November 6, 2008 (9:00-17:00), Seminar Hall (Room 235)

Faculty of Aerospace Engineering,

Technion, Haifa, ISRAEL

The last few years has seen a considerable expansion of activities in Israel in jet propulsion, in addition to the serial production of small engines, various spare parts and maintenance. In Israel many bodies are active in this area including: MAFAT, IAF, Israel Navy, EL-AL, IAI, Bet Shemesh Engines, RAFAEL, TAAS, ORMAT, Israel Electric Corporation, RSL, Becker Engineering, the Technion and more.

Improved engineering & technological innovations and new projects in Israel calls for continued professional meetings for exchange of information and cross-pollination creating a fertile seedbed for cooperation. During the previous six symposia, about a hundred scientists and propulsion engineers met and presented work from various industries, the MoD and Academia. These symposia were a success, wetting the appetite for more such meetings.

The symposium will include invited introductory lectures on chosen subjects (from large manufacturers abroad; GE, P&W & Rolls Royce). In addition there will also be presentations of activities in Israeli firms, institutes and universities as well as an open discussion and tour of faculty laboratories. This will also be a good opportunity for professional meetings, exchange of ideas and presentation of models and products from various companies.
During the symposium there will be an opportunity to discuss all areas relevant to jet engines and gas turbines, including aerodynamics of turbo-machines, combustion, structures and dynamics, simulations, control, production processes and maintenance, combined cycles and more. Preference will be given to subjects of interest in Israel.

The price is 220 NIS, students (undergraduate and graduate) may register free of charge

Professor. Yeshayahou Levy
Chairman of the symposium

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לזכרו

דר' אברהם פרנק ז"ל (1921-2008).
מומחה בינלאומי למדחסים תעופתיים

LECTURE #1

New Developments for Military Gas Turbines,

Lars Seumenicht,
Rolls-Royce Deutschland, Germany

ABSTRACT

Rolls-Royce is one of the leading suppliers of propulsion systems and related service solutions in four global markets: Civil and Military Aviation, Marine and Energy. The installed product base comprises more than 54,000 gas turbines which are in daily operation with over 600 airlines, 4.000 corporate aircraft and helicopters, 160 armed forces, more than 2,000 naval operators, 70 navies and customer in the energy business in almost 120 countries.

The competitive product portfolio yields Rolls-Royce a strong position in all relevant sectors of the military aviation market: participation in the largest European and US fighter aircraft programmes, global market leader in transport engines, unique provider of short- and vertical take-off power solutions, reliable engines for fast jet training aircraft, wide range of military helicopter applications and long-term provider of engines for unmanned air vehicles.

The past decade has seen dramatic changes in the political and global security landscape and in many countries in their demographic distribution of its society. This affects the way we do business – in particular in the defence sector.
The paradox is that the past years have seen more hot conflicts, more deployment of stabilisation and peace-enforcing troops than during the “cold war”, whilst society is less prepared to fund “security”. The formats of these conflicts are changing and hence the requirements for future weapon systems are being redefined.

This yields a series of challenges to future military jet engines:

1. necessity to fulfil different and new types of missions
2. provide much more electrical power
3. remain affordable over the life-cycle
4. become easier to maintain, repair and upgrade
5. become more fuel efficient.

Two prominent examples for today's successful modern military jet engines are the EJ200 and F136. Both are setting markers in their respective class with outstanding features. Both are developed in a partnership: the EJ200 combines the leading European manufacturers – Avio, Industria de Turbo Propulsores, MTU Aeroengines and Rolls-Royce; whilst the F136 is being developed jointly between General Electric and Rolls-Royce.

Future military planning anticipates an increasing requirement for un-manned weapon systems. The first generation of information gathering and surveillance platforms are in service – here existing, often civilian, engines are being used. The next generation will seek more electrical power and much higher altitudes with much longer endurance. In parallel combat requirements are being shaped – for this engines will face challenges to sustain much higher g-loads, whilst the usage might actually be only sporadic but then very intense.
Both, the future UAV and the UCAV engine will no longer be able to use purely off-the-shelf products and technologies:

- the integration of the propulsion system into the air vehicle becomes more sophisticated
- the integration between the gas turbine and its accessory systems needs to be further enhanced
- solutions needs to become quicker available and be and remain affordable
- certain particular capabilities will remain "special-to-application" and require a dedicated product development.

In order address the changing market demands, Rolls-Royce benefits from its long and constant involvement in respective leading-edge programmes and the significant investment in people, infrastructure and capabilities.
Examples of such capabilities include:

- complex development and integration tasks like the LiftSystem™
- development of so-called Integrated Power Systems
- solutions to reduce the overall signature of the propulsion system and air vehicle.

Another prominent differentiator is Rolls-Royce's comprehensive service offering.
Rolls-Royce always provided comprehensive tailored support services to its defence customers. However, in the recent years the company has launched a series of initiatives to offer military customers "Availability" solutions similar to what airline customers already take for granted. The MissionCare™ commitment capitalises upon the experience and infrastructure developed in the past years for airline and corporate jet clients. Rolls-Royce today not only repair engines and provide

spare parts, but instead the company establishes a close partnership with the military users in order to manage their fleet and provide additional logistic and technical services. Almost all Rolls-Royce engines operated by the US DoD and the British MoD are now covered under variations of MissionCare™ contracts and the customers experience both an improvement of their engine readiness and a reduction in support cost.

LECTURE #2

Intelligent Incorporation of Advanced Technology into Legacy Fighter Jet Engines to Increase Time on Wing and Reduce Maintenance Cost.

Konstantino Kouris, F100 Engineering Manager, Pratt & Whitney, USA.

ABSTRACT

Key technologies developed for advanced weapons systems with long life cycles, if appropriately bundled and incorporated can be used on fighter jet engines to reduce the rate of unexpected engine removal, reduce the engine total cost of ownership, increase time on wing and dramatically improve safety for the engine. With intelligent insertion of key technologies, traditional engine life scenarios can be altered. These technologies extend the desirable and low failure rate of a mature system. Sometimes called the "bathtub curve", the system failure rate is a function of time, and it is characterized by an initial high "infant mortality", a period of low failure rate, and later by the increasing failures associated with worn material or "tired iron".

This paper reviews the technology insertion process used for the F100-PW-229 engine to demonstrate the principle asserted by the author. The F100-PW-229 has been the most reliable fighter engine in the United States of America Air Force fleet since its introduction in 1991. The new, F100-PW-229 Engine Enhancement Package (EEP) demonstrates the principle of incorporating high technology but low risk upgrades such as advanced turbine technologies, automated maintenance systems, and advanced prognostics derived from the F119/F135. These technologies are used to increase the Mean Time Between Engine Removals thereby reducing the requirement for both scheduled and unscheduled maintenance.

Incorporating new technologies requires commitment to research and development. The F100-PW-229 Engine Enhancement Package (EEP) is the culmination of 10 years of technology development, rethinking of engine requirements and specifications, and access to fifth generation engine technologies like those developed for advanced propulsion systems like the F-119 (USAF F22) and F-135 (F-35 Joint Strike Fighter).

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LECTURE #3

Aviation Technology Strategy for the 21st Century

Rolf Hetico, Manager, F136 Engine Systems Design and Integration, GE Aviation, Evendale, Ohio, USA.

ABSTRACT

Our customers are defining the requirements for the next generation of commercial and military propulsion systems. As we look ahead, it is clear that our industry will compete with machines that must be cleaner, quieter, faster and more affordable than ever before.

Much of the environment on both the military and commercial side revolves around costs. As fuel prices continue through a volatile period, improvements in efficiency and the associated environmental impact are becoming increasingly important. In the commercial world, these factors will be the ticket just to enter the competition. Greatly reduced emissions, noise, and cost of ownership will be essential. In addition, alternative fuels are being addressed in the context of an assured, sustainable supply, reduced net greenhouse gases, and price stabilization.

For the Military, variable cycle engines will need to optimize their performance throughout the flight envelope. The propulsion system will be physically and virtually integrated with the airframe to achieve capabilities well beyond today's vehicles. These new requirements are just a few of the challenges we face in this second century of flight, and the driving force behind our need to continuously improve our New Product Introduction process, or NPI.

LECTURE #4

Infrared Signatures Modelling of Aircraft Exhaust Plume

Arvind G. Rao and J.P.van Buijtenen

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ABSTRACT

In recent years, the survivability of an aircraft has been put to task more than ever before. One of the main reasons being the increase in the usage of Infrared (IR) guided Anti-Aircraft Missiles, especially due to the availability of Man Portable Air Defence System (MANPADS) with some terrorist groups. Thus, aircraft IR signatures are gaining more importance as compared to their radar, visual, acoustic, or any other signatures.

The focus of the present work is on modelling of IR radiation from exhaust jet of a typical military aircraft and to evaluate the lock-on range for the aircraft due to its plume for a simple case and against a typical SAM. The exhaust plume ejected from the aircraft is one of the important sources of IR signature in military aircraft with low bypass turbofan engines. Commercial CFD software has been used to predict the plume thermo-physical properties and subsequently an in-house developed code was used for evaluating the IR radiation emitted by the aircraft plume. The LOWTRAN code has been used to model the atmospheric IR characteristics. The results obtained from these models are in reasonable agreement with some available experimental data. The analysis carried out suggest that atmospheric IR transmissivity plays an important role in dictating the aircraft IR signature as perceived by an IR guided Surface to Air Missile (SAM).

LECTURE #5

Unsteady Forces and Flutter in the Compressor of the Aircraft Engine, Numerical and Experimental Results.

Prof. Romuald, Rządkowski,

Department of Aeroelasticity, Institute of Fluid Flow Machinery, Polish Academy of Sciences, J. Fiszera st.,14, Gdansk, 80 952 Poland
E-mail: z3@imp.gda.pl

ABSTRACT

Turbomachinery aeroelasticity methods have seen a very rapid rate of progress in the last years. It is therefore crucial to predict blade vibrations arising from self-excitation or inlet flow distortion. This is not only important with regard to aircraft compressor and fan blade rows, but also with regard to the last stages of steam and gas turbines that may work in highly loaded off-design conditions. In order to predict the unsteady pressure loads and aeroelastic behaviour of blades (including the computation of shock waves, shock/boundary layer interaction and boundary layer separation), complete Reynolds-averaged Navier-Stokes (RANS) equations are to be used in modelling complex and off-design cases of turbomachinery flows.

In this work the 3D RANS solver, coupled with the modified Baldwin and Lomax algebraic eddy viscous turbulence model is presented to calculate unsteady viscous flow through the turbine stage, while taking into account the blade oscillations but without the separating of outer excitation and unsteady effects caused by blade motion.

Here the numerical method used the second order by time and coordinates explicit finite-volume Godunov's type difference scheme and a moving H-O structured grid. The structure analysis used the modal approach and a 3D finite element blade model.

To validate the numerical viscous code a comparison of the numerical calculations results with the measured data for the 11th International Standard Configuration was performed.

Presented below are the numerical analysis results of the first stage compressor rotor blade in an S0-3 aircraft engine in a nominal regime. The experimental results of the tip-timing method of the first compressor rotor blade are compared with the numerical results.

LECTURE #6

Incorporation of Gas Turbine with Combined Cycle (GTCC) in the Generation Expansion Plan of the Israeli Power System,

Dr. David Elmakis,
V.P. Planning Development & Technology, Israel Electric Company.

שילוב טורבינות גז ומחז"מים בתוכנית הפיתוח של מערכת ייצור החשמל

ד"ר דוד אלמקיאס

תקציר

חברת החשמל עושה שימוש הולך וגובר באמצעי יצור המבוססים על טורבינות גז. במצגת תוצג תכנית הפיתוח של מערכת היצור בחברת החשמל . תכנית הפיתוח נעשית בעזרת מודל לדימוי שעתי מפורט של פעולת מערכת ייצור החשמל, תוך התחשבות במאפיינים טכנו-כלכליים ובדרישות מיוחדות של מדיניות התפעול של חברת החשמל. תוכנית פיתוח אופטימלית מראה צורך לשימוש רחב בטורבינות הגז ומעגלים משולבים על בסיס טורבינות הגז ברמת טכנולוגיה F ו-H. במצגת יוצגו טכנולוגיות נוכחיות ועתידיות בחברת החשמל.

LECTURE #7

RotorDynamics and Active Detection of Faults in Rotating Bodies - Theoretical and Experimental Results

Izhak Bucher

Dynamics Laboratory, Mechanical Engineering, Technion, Israel Institute of Technology

ABSTRACT

Rotating machines appear in almost every aspect of our modern life: cars, aeroplanes, vacuum-cleaners and steam-turbines all have many rotating structures whose dynamics need to be modelled, analysed and improved. The reliability, stability and the response levels of these machines, predicted by analytical models, are generally not satisfactory until validated by experimentally obtained data. For this purpose special measurement, testing and signal processing techniques have to be employed.

Rotating machine's dynamics depends on the speed of rotation which adds gyroscopic effects, centrifugal stiffening and parametric modulation of the response. These phenomena create a rich dynamics that is often overlapped in the frequency domain. During run-up, recorded vibrations can be measured by several sensors and using special techniques, the individual effects can be decomposed and understood.

This paper introduces a decomposition approach that separates disk vibration waves, faulty rotors and bearing properties. When a special probing forces is added, minor faults in the rotating part, can be detected. Unlike most fault detection methods, the present approach combines a physical model, sophisticated excitation and signal processing, and advanced rotordynamics concepts to enhance the detectability of minute imperfections in the structure.

The paper will cover the basics of rotating machine dynamics, speed dependent detection schemes and will provide some simulated and laboratory test cases to demonstrate the proposed approach.

LECTURE #8

Atomization vs. Vaporization of Fuel in Micro Gas Turbines,

Daniel Kutikov,
Faculty of Aerospace Engineering, Technion, Haifa, Israel.

ABSTRACT

The atomization of liquid fuel, its droplet size distribution, mixing and evaporation all affect the ignition and and combustion processes, its stability and efficiency. In small-scale jet engines, fuel atomization gain even higher importance due to the constraints which characterize small-scale engines: low ignition energy, small combustor volume and the need for simplicity of the atomizers.

The aim of current study is to perform a comparison between two methods of liquid fuel delivery into combustors of small-scale jet engines –using atomizers and using vaporizers. Typically, the properties of the atomizers and the vaporizers are provided for a single atomizer or vaporizer working outside the combustor in laboratory environment. The present study compares the performance of a small jet engine combustor while operating once with fuel atomizers and once with fuel vaporizers. The comparison refers to the operational range and efficiency of the combustor. Current study is based on experimental approach, the operational range and efficiencies were evaluated through experimental measurements.

It can be concluded that atomizers are preferable for higher fuel flow rates (and temperatures) and have stable operation over wider fuel supply ranges. The vaporizers are preferable for low fuel supply rates (and temperatures). As for combustion efficiencies, the efficiency values for the atomizers in the current study were significantly lower compared to those for the vaporizers. These low efficiencies can be explained by the shorter residence time, which was insufficient to complete the evaporation of fuel droplets, their mixing and combustion within the limited combustion volume. In order to solve the problem of the short residence time and the low efficiency, modification in the atomizer design and its incorporation within the combustor should be implemented.

LECTURE #9

Swirling Flow in Annular Diffusers Between Two Counter-Rotating Turbines

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ABSTRACT

Swirling flow in annular diffusers between two counter-rotating turbines has been numerically investigated to evaluate the pressure losses. The performance characteristics of these diffusers depend on their geometry and the inlet conditions. The inlet conditions are defined by HP turbine. The area function of diffusers and incline angles of directing vanes are determined on the base of study of flow in corresponding annular axisymmetric diffusers. The 2D- and 3D- total simulations were carried out using commercial code FLUENT. On the base of this modelling the diffuser satisfying required area dependence with optimal location and directions of directing vanes was chosen. The effect of turbulence models on pressure losses was studied. It is ascertained that total pressure losses for the inlet conditions Ma=0.6 and flow angle to axial direction α=48.5° are in limits 7…7.6%.

LECTURE #10

Numerical Investigation of Burning Processes in a Small Gas Turbine Combustor,

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ABSTRACT:

Development of a new gas turbine combustor was performed along with numerous tests to achieve a desired temperature profile at combustor exit. It required many months because of the need to overcome different design problems, such as thermal damage to vaporizers. Available and reliable CFD model would allow minimizing these tests and shortening significantly the time required to bring the combustor to the final working configuration.

The present research focuses on the modeling and simulation of a small gas turbine combustor. This study provides insight into physical and chemical processes of combustion and evaluates variations of combustor performance for different configurations of combustion chamber. The primary objectives of this study are: 1) to establish an efficient and accurate numerical framework for the support of development stage of a new combustor; 2) to investigate the parameters and mechanisms influencing and responsible for the temperature profile at the combustor exit.

Numerical simulation results showed good agreement with experimental data derived from the tests and were able to obtain and point out the exact place of "hot spots" causing thermal damage to the vaporizers. Numerical study was expanded to include changes made to the vaporizer and showed their impact on the combustion exit temperature profile. The last part of this study presents an optimization process in which the target was to obtain the optimal temperature profile at combustor exit. The objective was achieved in a relatively small number of iterations due to parametric approach and advanced visualization tools of the software postprocessor.

LECTURE #12

Identification of Control Parameters of an Engine the Algorithm of Which is Partially Known,

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במנועי בית שמש נקלט מנוע חדש עליו קיבלה החברה אחריות שיפוץ. המנוע מסוג טורבוסילוני עם צנ"פ בשטח קבוע.
מפת המדחס של המנוע התקבלה במב"ש יחד עם ספרות השיפוץ כך שהתאפשר מתוכה ומתוך ביצועיו הכוללים הידועים והמדודים לבנות דק סטטי וממנו דק דינמי טבלאי עם קבועי זמן שנמדדו בניסויים. דק זה שימש בעבודה זו.
בקרת הסל"ד במנועים טורבוסילוניים בשיטה המקובלת במב"ש מבוססת על משוב פרופוציונלי- אנטגרלי ועל מגבלים שונים (סל"ד, טמפ', החשה). היה עניין ללמוד אם גם במנוע החדש בקרת הסל"ד היא מטיפוס פרופוציונלי- אנטגרלי (או אחר) ומה הם מקדמי הבקרה.
נערכה אנליזה על-סמך ניסוח בקרה מסוג פרופוציונלי- אנטגרלי שהותאמה לדק מנוע ערום ב- SIMULINK ובחינת תוצאות של הקלטות ניסויים בהחשה של המנוע ונעשתה אנליזה מתמטית שאפשרה למצוא את מקדמי הפרופורציה והאנטגרציה במשוב הגורמים לשגיאה מינימלית בחיזוי תוצאות ניסויי ההחשה.
לפני פעולה זו היה צורך לזהות גם את פונקציות המעבר של הקוצב והמשוב שלו. פעולה זו בוצעה ע"י הנחת משוב פרופורציונלי ושימוש בקבוע הקוצב ובדיקת הצרופים עד שנתקבלה שגיאה מינימאלית ביחס לתוצאות מדודות.