Project number: 316654 Project acronym: TANGO

Project Full Name: Thermo-acoustic and Aero-acoustic Nonlinearities in Green combustors with Orifice structures

ITN Progress Report

Period covered: from 01/11/2012 to 31/10/2013

Period number: 1st

Project co-ordinator name: Dr Maria Heckl

Project co-ordinator organisation name: University of Keele

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ITN Progress Report

PROJECT PROGRESS REPORT

Grant Agreement number:	316654
Project acronym:	TANGO
Project title:	Thermo-acoustic and Aero-acoustic nonlinearities in Green combustors with Orifice structures
Funding scheme:	FP7-MC-ITN
Period covered – start date:	01/11/2012
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OVERALL PROGRESS OF THE PROJECT

UPDATE ON INDIVIDUAL RESEARCH TASKS

Task 1.1: Experimental and analytical study of a cold-flow combustor with virtual flame
ESR: Mr Luck Peerlings
Starting date: 01 February 2013
Supervisor: Hans Bodén/ Susann Boij, KTH

Luck has built an initial clod-flow test rig involving a tube with a sudden jump in cross-sectional area in order to study the passive and active acoustic properties of the sudden area expansion. He has taken measurements for a range of upstream Mach numbers (0 - 0.3) and will soon take detailed measurements of the flow field downstream of the area expansion. Also, he has started to investigate analytically the feasibility of mimicking the acoustic response of a flame by an electro-acoustic feedback system. He is in the process of deigning an instrumented test rig to prove this concept.

Luck has attended the n3l Summer School and Workshop in June 2013, and the 1st Communication and Outreach Workshop in September 2013.

Task 1.2:Numerical study of laminar dump combustor and its cold-flow equivalentESR:Ms Wei NaStarting date:22 May 2013Supervisor:Gunilla Efraimsson, KTH

As the first step in her task, Wei has familiarised herself with an in-house linearised Navier-Stokes equation solver in frequency domain, which has previously been used to simulate the coupling between the hydrodynamic and acoustic fields in duct flows. In the process, she has gained background knowledge in flow acoustics, as well as a deep understanding of the simulation methodology, how to run the numerical code and how to post-process the simulation data. As a test case, where validation data is available, Wei has applied this method for an acoustic characterization study of a 3-D impedance tube. She is currently preparing a paper, which she intends to present at the ICSV21 conference, to be held in Beijing in July 2014.

Wei has attended the n3l Summer School and Workshop in June 2013, and the 1st Communication and Outreach Workshop in September 2013.

Task 1.3:Numerical study of perforated plates with grazing and bias flowESR:Mr Jonathan TournadreStarting date:18 February 2013Supervisor:Paula Martinez-Lera, LMS

Jonathan has explored an existing numerical tool, the continuous higher-order finite element method (pFEM) for characterising flow-acoustic interactions at perforations. This allows one to study the mean flow and the acoustic perturbations, and to obtain

results for them individually. Based on pFEM, Jonathan has developed a 2-D linearised Navier-Stokes equations code in the frequency domain; this includes source terms, a flow boundary layer and an accurate representation of the mean flow. This code has been validated in collaboration with the KU Leuven. Also, Jonathan has done a literature review on analytical, experimental and numerical models to characterize the behaviour of single perforations and perforates

Jonathan has attended the n3l Summer School and Workshop in June 2013, and the 1st Communication and Outreach Workshop in September 2013.

Task 2.1:Experimental study of laminar dump combustorESR:Ms Samira HasaniStarting date:(unknown)Supervisor:R. I. Sujith, IITM

An instrumented test rig for the laminar dump combustor to be studied in this task was commissioned by non-TANGO students at IIT Madras, and data for flame images were recorded. Thus milestone 2.1 has been achieved.

Task 2.2:	Analytical study of laminar dump combustor
ESR:	Mr Nalini Mukherjee
Starting date:	01 September 2013
Supervisor:	Maria Heckl, KU

Nalini is currently working on a short-term research project relating to tasks 1.1, 1.2 and 1.3 (Work Package 1). This project is about a tube with a blockage that locally reduces the cross-sectional area of the tube. The flow in the blocked region is treated as a lumped inertia; on either side of this region, 1-D acoustic waves are assumed to propagate in the upstream and downstream direction. Nalini has calculated the field of an idealised normalised potential flow in the tube, and on the basis of that, he has calculated the lumped inertia. He has also calculated the tube's eigenfrequencies and is in the process of understanding the underlying physical processes. This work will form the basis of a paper, which he intends to present at the ICSV21 conference, to be held in Beijing in July 2014.

Nalini has attended the 1st Communication and Outreach Workshop in September 2013.

Task 2.3:Experimental study of turbulent swirl combustorESR:Mr Ako BahariStarting date:(unknown)Supervisor:R. I. Sujith, IITM

No scientific developments due to visa problems and delay in starting date.

Task 2.4:	Numerical study of turbulent swirl combustor
ESR:	Mr Alp Albayrak
Starting date:	01 October 2013
Supervisor:	Wolfgang Polifke, TUM

By solving the linearised G-equation in the time domain, Alp has studied the response of a laminar premixed flame to a sudden change in equivalence ratio (impulse response). He found that such an impulse leads to perturbations in the following three quantities: laminar flame speed, heat of reaction and flame surface area. In order to test his results, he transformed his time-domain results into the frequency domain. Thus he obtained the flame transfer function which is well documented in literature; Alp found an exact match between his results and those reported by other researchers. He has done this work in preparation for task 2.4, where he will study swirling flame dynamics.

Alp has attended the n3l Summer School and Workshop in June 2013, and the 1st Communication and Outreach Workshop in September 2013.

Task 2.5:	Consolidation of experimental, analytical and numerical results for
	laminar and turbulent combustor
ER:	Dr (Ms) Alessandra Bigongiari
Starting date:	: 01 May 2013
Supervisor:	Maria Heckl, Keele

The consolidation aspects of this task have been deferred until a later date when the required results are available. Instead, Alessandra is working on a project relating to task 2.2. This involves the development of an analytical model for the laminar dump combustor at the TANGO partner IIT Madras. Alessandra has determined the Green's function of this dump combustor and then used it, together with a generic nonlinear heat release law, to calculate the time history of the acoustic velocity in the combustor. She is in the process of analysing these time histories with phase-space software created at IIT Madras (by PhD student Vineeth Nair).

Alessandra has attended the n3l Summer School and Workshop in June 2013, and the 1st Communication and Outreach Workshop in September 2013.

Task 3.1:	Development of instability warning system
ESR:	Mr Driek Rouwenhorst
Starting date:	: 01 February 2013
Supervisor:	Jakob Hermann, IfTA

Driek started his task by exploring existing techniques to determine thermoacoustic stability margins. He is currently focussing on techniques that rely on the turbulent perturbations inherent in a combustion system, rather than on controlled external excitation. Generally speaking, these techniques rely on quantification of the transition from chaotic dynamics (stability) to ordered dynamics (instability) via an intermittent regime. Driek is applying these techniques to data obtained from a bluff-body stabilised methane burner, and is using phase-space reconstructions and wavelet

transforms. He has found coupling between low-frequency dynamics and intermittent excursions near instability.

Driek has attended the n3l Summer School and Workshop in June 2013, and the 1st Communication and Outreach Workshop in September 2013.

Task 3.2:	Study of passive control by micro-perforated plates
ESR:	Mr Muttalip Temiz
Starting date:	01 November 2013
Supervisor:	Inez Lopez Arteaga, TUE

As a first step in this task, Muttalip has performed a literature survey on microperforated plates (MPPs). He now understands the physical principles behind sound absorption by MPPs. He has developed a numerical model to predict the sound absorption by a single hole and compared these predictions with those from existing mathematical models. He has also performed experiments to validate his predictions with measured data. In October 2013, he visited the TANGO partners at KTH Stockholm, and with their help improved his numerical code. He is currently investigating the effect of different hole geometries on sound absorption.

Muttalip has attended the n3l Summer School and Workshop in June 2013, and the 1st Communication and Outreach Workshop in September 2013.

Task 3.3:Analytical study of idealised combustion system with heat exchangerESR:Ms Aswathy SurendranStarting date:10 October 2013Supervisor:Maria Heckl, Keele

Heat exchangers can be modelled as arrays of fluid-filled cylindrical tubes, surrounded by another fluid. Aswathy has familiarised herself with the governing equations for the motion of cylindrical shells. She has also studied several research papers from the 1990s that deal with fluid-loaded tubes and with arrays of tubes, and she has reproduced some of the results in these early papers. Aswathy is now in the process of calculating the acoustic reflection and transmission coefficient of a row of equally-spaced cylindrical tubes. This will enable her to investigate the influence of several parameters characterising an idealised heat exchanger; particular emphasis will be on losses due to viscosity and heat conduction in the boundary layers covering the inside and outside of the tube walls.

Task 3.4:Study of a thermo-acoustic system with heat exchanger in cross-flowESR:Ms Lin Strobio ChenStarting date:01 November 2012Supervisor:Wolfgang Polifke, TUM

Lin has been working on two fronts. Firstly, she derived the complete linear coupling relations for flow perturbations across a moving premixed flame front. She is now in a position to investigate the influence of the flame front movement on perturbations of flow quantities, such a s velocity, pressure and entropy. Secondly, Lin has simulated

the flow of a compressible fluid across a heat exchanger in the presence of broadband excitation. She used system identification to calculate the transfer function between heat transfer and flow velocity. Currently, she is validating these calculations against analytical results.

Lin has attended the kick-off meeting in November 2012, the n3l Summer School and Workshop in June 2013, and the 1st Communication and Outreach Workshop in September 2013.

Task 3.5:Numerical and experimental study of domestic burner with heat exchangerESR:Mr Naseh HosseiniStarting date:01 November 2013Supervisor:Joan Teerling, BEK

Before formally starting his TANGO position at Bekaert, Naseh had a secondment at the TANGO partner TU Eindhoven (from August to October 2013) in order to get up to speed quickly with thermoacoustics, modelling and experimental techniques. In a first step of task 3.5, Naseh developed a CFD model to simulate a heat exchanger. He is currently in the process of designing an experimental setup, which will provide physical data to complement his simulations. He intends to present his work in a paper at the ICSV21 conference.

Naseh has attended the 1st Communication and Outreach Workshop in September 2013. Also, he has taken the JMBC course on combustion and followed some of the online lectures available on the TANGO website.

Task 3.6:Measurement of FTF in industrial gas turbineESR:unknownStarting date:unknownSupervisor:Federico Dacca', AE

Preparations are underway to recruit an ESR for this 8-month project, which we hope will start in April 2014.

Numerical and analytical study of industrial gas turbine
Mr Dmytro Iurashev
25 March 2013
Federico Dacca', AE

Dmytro has familiarised himself with a proprietary Ansaldo Energia model implemented in COMSOL Multiphysics. He uses this to study two 1-D setups. The first is a small-scale laboratory test rig. His model for this rig showed that the fundamental mode could be excited purely by white noise, i.e. without application of external forces. The second setup is the industrial-scale test rig of Ansaldo Energia in Gioia del Colle. Dmytro has modelled this rig to predict the frequency of the unstable mode and found that this frequency value agrees well with the measured value. Moreover, Dmytro has investigated the impact of the flame position on the propagation and pressure amplitude of sound waves. Depending on the flame position, he observes growing amplitudes, decreasing amplitudes, or a limit cycle.

Dmytro has attended the n3l Summer School and Workshop in June 2013, and the 1st Communication and Outreach Workshop in September 2013.

UPDATE ON TANGO MEETINGS AND WORKSHOPS

20 – 21 November 2012 (month 1): Kick-off meeting, Keele University

17 – 18 June 2013 (month 8): 1st TANGO project meeting

18 – 21 June 2013 (month 8): n3l Summer School and Workshop, Technical University Munich (see page 10 of this report)

23 September 2013 (month 11): 1st Communication and Outreach Workshop, Deutsches Museum, Munich

Comments

The TANGO partners succeeded in recruiting a significant number of female ESR/ERs: of the 14 researchers recruited so far, 5 are female and 9 are male.

The TANGO website (<u>http://www.scm.keele.ac.uk/Tango/</u>) has been up and running from the very beginning of the project. Initially, it was used as a tool for recruitment. Now it offers various features for training and information, such a s online lectures, conference announcements, etc. There is also a pass-word protected section for all TANGO members.

In the first TANGO progress meeting, it was decided to simplify the governance structure as the structure detailed in Annex I was unduly complex. There is now the coordinator (Maria Heckl), deputy coordinator (Gunilla Efraimsson) and the supervisory board. The supervisory board has voting members (all supervisors and one fellows' representative) and non-voting members (all other partners, all fellows).

CONTRACT DELIVERABLES UPDATE:

M – Months RESR – Researcher FAC B – Fixed amount contract B(%)

RECRUITMENT

	Early Stage Researchers (ESR)								Experienced Researchers (ER)												
Participants	For M	eseen RESR	FAC B	Imp M R	emer ESR	nted FAC B	Differ M RE	ence ESR 1	FAC B	F M	ore 1 R	seen ESR ∃	FAC B		Imple M RI	emen ESR	ted FAC B	I N	Diffe И R	rence ESR 1	FAC B
KU	72	2	0	70.72	2	0	1.28	0	0	24	4	1	0		24	1	0		0	0	0
KTH	72	2	0	72	2	0	0	0	0	0		0	0		0	0	0		0	0	0
TUM	72	2	0	72	2	0	0	0	0	0		0	0		0	0	0		0	0	0
TUE	36	1	0	36	1	0	0	0	0	0		0	0		0	0	0		0	0	0
IITM	72	2	0	0	0	0	72	2	0	0		0	0		0	0	0		0	0	0
IfTA	36	1	0	36	1	0	0	0	0	0		0	0		0	0	0		0	0	0
LMS	36	1	0	36	1	0	0	0	0	0		0	0		0	0	0		0	0	0
AE	44	2	0	36	1	0	8	1	0	0		0	0		0	0	0		0	0	0
BEK	36	1	0	36	1	0	0	0	0	0		0	0		0	0	0		0	0	0

Comments

One of the two ESR posts at Keele University (KU) could not be offered as a 36 month contract, since the successful applicant suffered a delay in receiving her visa, causing her to miss her intended start date and resulting in her employment being constrained to 34.72 months. The other ESR post-holder has a full 36 month contract.

The two ESR posts at the Indian Institute of Technology Madras (IITM) have been offered but the successful applicants are experiencing long delays in obtaining their visas, which are still not issued. The posts are being held for these applicants on the basis that they should be issued visas in 2014.

INTERNATIONAL CONFERENCES / EVENTS OPEN TO EXTERNAL RESEARCHERS

Event No.	Participant hosting the event	Type of Event	Month when the event took place	Start Date of event	End Date of event	Total number of researcher days for researchers from outside the network attending	Website of the event
1	TUM	Summer School and Workshop	8	18-06-2013	21-06-2013	52	http://www.td.mw.tum.de/n31/

Comments

The n3l Summer School lectures were recorded live and can be downloaded from the n3l website.

Attachments: (0)

Name: Dr Maria Heckl

Date: 29th November 2013

Signature: Maria Heckl