UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

CORSO DI DOTTORATO IN INEGNERIA DEI PRODOTTI E DEI PROCESSI INDUSTRIALI
Ciclo 32°

Proposta di progetto di dottorato

Il sottoscritto Prof./Dott. _____Gaetano_____D'Avino_____

Nome *Cognome*

Professore IF ☐ Professore IIF ☐ Ricercatore ☐ Ricercatore a tempo determinato ☒

afferente al Dipartimento di Ingegneria Chimica, dei Materiali e della Produzione Industriale

chiede di essere inserito nell'elenco dei tutors per il 32° ciclo.

Tematica di ricerca proposta:

Dynamics of polymers reinforced with anisotropic particles in flow for aerospace applications

Curriculum di riferimento:

☐ Ingegneria dei Materiali e delle Strutture

☒ Ingegneria Chimica

☐ Tecnologie e Sistemi di Produzione

N° di dottorandi con borse ministeriali dei quali il proponente è stato tutor nell'ultimo triennio _0__

Curriculum del proponente (Max 500 parole. Indicazione di pubblicazioni, brevetti, responsabilità di o coinvolgimento in progetti di ricerca, esperienze scientifiche) con riferimento alla tematica proposta

Scientific experiences:

Ten-year expertise on the numerical simulation of the dynamics of rigid particles suspended in viscoelastic fluids.

Past projects:

One-year project in collaboration with Procter & Gamble on the sedimentation of non-spherical particles in viscoplastic fluids.

Relevant publications for the project:

G. D'Avino, F. Greco and P. L. Maffettone, Rheology of a dilute viscoelastic suspension of spheroids in unconfined shear flow, Rheologica Acta, 54, 915-928 (2015)

G. D'Avino and P. L. Maffettone, Particle dynamics in viscoelastic liquids, Journal of Non-Newtonian Fluid Mechanics, 215, 80-104 (2015)

G. D'Avino, M. A. Hulsen, F. Greco and P. L. Maffettone, Bistability and metabistability scenario in the dynamics of an ellipsoidal particle in a sheared viscoelastic fluid, Physical Review E, 89, 043006 (2014)

M.M. Villone, G. D'Avino, M.A. Hulsen, F. Greco and P.L. Maffettone, Particle motion in square channel flow of a viscoelastic liquid: Migration vs secondary flows, Journal of Non-Newtonian Fluid Mechanics, 195, 1-8 (2013)

M.M. Villone, G. D'Avino, M.A. Hulsen, F. Greco and P.L. Maffettone, Simulations of viscoelasticity-induced focusing of particles in pressure-driven micro-slit flow, Journal of Non-Newtonian Fluid Mechanics, 166, 1396-1405 (2011)

Sintesi del Progetto di Ricerca (Max 500 parole. Stato dell'arte, breve programma previsto per le attività e obiettivi)

State of the art

Short-fiber-reinforced polymer composite materials are widely used in various industries such as medical, aerospace, and automotive fields [1]. These materials are primarily chosen because they can be manufactured into complicate shapes and show superior mechanical properties as compared to other materials. A fundamental aspect that must be accounted for during the manufacturing process is the fiber orientation as it largely determines the mechanical, electrical, and thermal properties of the final product [1]. For instance, a product with aligned fibers has much better mechanical properties than that with random fiber orientation. The evolution of the fiber orientation during the processing stage depends on several parameters such as flow geometry and intensity, fluid rheology, filler shape and concentration. A tool able to predict the fiber dynamics for general geometries, fluids, and flow conditions is, then, highly desired in order to optimize the manufacturing process.
In this regard, several approaches have been proposed based on the Jeffery's model to determine the fiber orientation [2, 3]. All of them, however, assume that the fibers are suspended in a Newtonian fluid. In many relevant applications, however, the suspending fluid shows non-Newtonian properties that strongly alter the fiber orientation as experimentally and numerically reported in simple shear flow [4, 5]. To date, the dynamics of fibers suspended in non-Newtonian liquids in flow fields of industrial interest (e.g., pressure-driven flows) is unknown.

[1] Tucker CL III and Liang E. *Compos. Sci. Technol.*, **59**, 655 (1999)
[2] Advani SG and Tucker CL III. *J. Rheol.*, **31**, 751 (1987)
[3] Dihn SM and Armstrong RC. *J. Rheol.,* **28**, 207 (1984)
[4] Gunes et al., *J. Non-Newtonian Fluid Mech.*, **155**, 39 (2008)
[5] D'Avino et al., *Phys. Rev. E*, **89**, 043006 (2014)

Short program

The PhD research activity will be mainly performed through numerical simulations. A possible scheduling is the following:

1st year-2nd year:

- analysis of the existing literature
- analysis of the dynamics of a single ellipsoidal particle suspended in a viscoelastic fluid subject to a pressure-driven flow. Direct numerical simulations will be performed to investigate the effect of particle size and shape, flow rate, fluid rheology and channel geometry on the translational and orientational dynamics of the particle. An important outcome is to unveil migration phenomena and the existence of preferential orientations induced by fluid viscoelasticity.
- analysis of the dynamics of a multiparticle system to understand the effect of interparticle hydrodynamics interactions.

3rd year:

- integration of the results obtained during the preceding two years in an already existing viscoelastic flow solver for predicting the dynamics of fiber suspensions under realistic processing conditions. The developed code will be used to understand and predict the orientational state of fibers for problems taken from industry (e.g., injection moulding, extrusion, etc.).

Objectives:

- Understanding the dynamics of non-spherical particles suspended in viscoelastic fluids flowing in confined systems
- Development of a general computational fluid dynamics code able to predict the translational and orientational dynamics of fibers suspended in viscoelastic fluids flowing in complex geometries

Informazioni sintetiche relative a: attrezzature/software disponibili, disponibilità finanziaria, collaborazioni con altri enti di ricerca italiani e ed esteri (eventualmente anche con aziende) potenzialmente rilevanti con riferimento specifico alla tematica proposta.

The research activity will be carried out by extending an already available finite element code. The simulations will be run on the SCOPE datacenter freely available for UNINA personnel.
Collaboration with the Ecole Centrale de Nantes (possibly involving Airbus Group Company) due to the interest in the processing of fiber-reinforced materials for aerospace applications.

Informazioni sintetiche relative ad eventuale periodo all'estero previsto per il dottorando (periodo, gruppo di ricerca, Università, ente di Ricerca….)

Period: 6 months during 2nd year
Research group: group of Prof. Francisco Chinesta
University: Ecole Centrale de Nantes (FRANCE)

Period: 3 months during 2nd year or 3rd year
Research group: group of Prof. Martien Hulsen
University: Technische Universiteit of Eindhoven (THE NETHERLANDS)

Il sottoscritto garantisce, sotto la propria responsabilità, di poter accedere a risorse tecniche e finanziare adeguate a supportare le attività necessarie al corretto sviluppo del progetto di ricerca proposto.

Napoli, 18/07/16 Firma del richiedente: