



UNIVERSITÀ DI PISA

NUCLEAR THERMAL HYDRAULICS

FRANCESCO SAVERIO D'AURIA

Anno accademico	2023/24
CdS	INGEGNERIA NUCLEARE
Codice	1088I
CFU	12

Moduli	Settore/i	Tipo	Ore	Docente/i
NUCLEAR THERMAL HYDRAULICS	ING-IND/19	LEZIONI	120	FRANCESCO SAVERIO D'AURIA

Obiettivi di apprendimento

Conoscenze

fondamenti di fisica tecnica

Modalità di verifica delle conoscenze

esame orale: tre esercizi allo studente: dopo la soluzione degli esercizi, domande sul programma

Capacità

progetto termoidraulico dei reattori nucleari ad acqua

Modalità di verifica delle capacità

come verifica delle conoscenze

Comportamenti

risposte alle domande

Modalità di verifica dei comportamenti

come da verifica di cui sopra

Prerequisiti (conoscenze iniziali)

fisica tecnica principalmente e/o fluidodinamica

Indicazioni metodologiche

fisica tecnica ==> esame attuale

Programma (contenuti dell'insegnamento)

NUCLEAR ENGINEERING COURSE' – YEAR 2020/2021

Title: 'Thermal-hydraulics in Nuclear Technology'

Professor: F. D'Auria

The program includes three key topics as listed below. Integration lectures and Seminars will be held in the areas of 'CFD (Computational Fluid Dynamics)', 'Nuclear Fuel' and 'Boron-Dilution-Issue'.

1) THERMAL-HYDRAULICS AND NPP TECHNOLOGY. The following sub-topics are considered: a) NPP key components and design principles; b) PWR & BWR RCS thermal-hydraulic design; c) The Safety Technology of NPP: the DBC, the DEC-A and DEC-B; d) The criteria for ECCS design from 10 CFR 50.46. Meaning and content of 'Nuclear Thermal-hydraulics (NTH)' according to recent review of NTH books (6th recommended Journal Special Issue, below).



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2) DESIGN OF NUCLEAR FUEL PIN. This includes the applications of the Fourier Equations and of the Fourier Law. The concepts of LHGR, MDNBR and MCHFR are introduced

3) MODELING IN NUCLEAR THERMAL-HYDRAULICS. The following sub-topics are considered: a) fundamentals including flow regimes, b) pressure drops, c) balance equations, d) multi-dimensional surface for HTC (the condensation, the CHF and the reflood), e) structure of a system thermal-hydraulic code for design & transient analysis of NPP performance, f) constitutive/closure equations, g) (verification) and validation (V & V) for SYS TH codes, h) scaling and uncertainty issues, i) the BEPU approach.

4) IDENTIFICATION AND CHARACTERIZATION OF THERMAL-HYDRAULIC PHENOMENA IN LWR. IT and SET phenomena are distinguished. Reference made to OECD/NEA/CSNI CCVM and to IAEA SRS 23. The boiling channel. The blow-down and the TPCF. The CCFL. The containment pressurization following LOCA

5) NATURAL CIRCULATION. NC constitutes a key IT phenomenon relevant for design and safety of NPP. Application to recent reactor technological aspects will be considered: RCS, Containment and ECCS design, SMR design. Instability in fluid-dynamics and in two-phase conditions (DWO). Reliability of NC and of passive systems.

6) THERMAL-HYDRAULIC ASPECTS OF KEY ACCIDENTS IN NPP TECHNOLOGY: Three Mile Island – 2 (PWR, 1979), Chernobyl – 4 (RBMK, 1986), La Salle & Oskarshamn (BWR, 1988 & 1999), Fukushima 1-4 (2011).

SUGGESTED BOOKS (IN ADDITION TO LECTURE MATERIAL)

- Lahey-Moody “Thermal-Hydraulics of a Boiling Water Reactor” – ANS 2nd – 1993
- Todreas-Kazimi “Nuclear Systems, I & II” – CRC (Taylor & Francis Group), 2nd – 2011
- D’Auria F. (Editor) “Thermal-hydraulics in Water Cooled Nuclear Reactors”– Elsevier – 2017
- IAEA, SRS 23 Accident Analysis (available from web) – 2002
- IAEA, SRS 52 Uncertainty Analysis (available from web) – 2008
- Elsevier Journal ‘Nuclear Engineering and Design’ (J NED), Special Issue n. 354 (December, Ed. F. D’Auria, available from web) – 2019
- OECD/NEA/CSNI, A state of the art report on scaling in system thermal-hydraulics applications to nuclear reactor safety and design (Ed. F. D’Auria available from web) – 2017

Bibliografia e materiale didattico

vdi casella sopra

Indicazioni per non frequentanti

è suggerito frequentare - i - on frequentati dovrebbero interloquire cn il docente

Modalità d'esame

indicata sopra

Altri riferimenti web

vedais programma del corso

Note

è suggerito frequentare le lezioni del docente

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