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核电厂全范围模拟机

Nuclear Power Plant Full-scope Simulator

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China Nuclear Power (Beijing) Simulation Technology Co.,Ltd



产品功能

Product Functions

核电厂全范围模拟机参考核电厂实际机组主控室 1:1 仿真。该设备主要由仿真控制室、仿真计算机系统以及教控系统组成，能够逼真地模拟核电厂运行过程中各种运行参数和设备状态变化，以及各种实际发生或假想的瞬态和事故工况，满足核电厂操纵员培训和执照考试需要，为核电厂应急演练提供支持。该产品主要性能指标达到或超过国际行业标准，相关成果获得多项国家级成果奖。



The nuclear power plant full-scope simulator is 1:1 simulated with reference to the actual nuclear power plant main control room, and is comprised of the simulation control room, simulation computer system and instructor station system. It can simulate the changes of various operating parameters and equipment states in the operation process of the nuclear power plant, as well as all kinds of actual or assumed transient and accident conditions. Therefore the requirements of nuclear power plant operator training and license examination was met, supporting the emergency exercises for plant. The product main performance has reached or exceeded the industrial standard worldwide, and the related achievements have won many national achievement awards.



产品技术特点

Product Features

- 采用业界公认的最佳估算分析程序建立反应堆和一回路热工水力仿真模型
 - 高度一体化仿真平台，真正具备模型在线修改能力
 - 仿真运行中可随时插入单个或组合设备故障
 - 拥有图形、列表等多种模拟机运行控制模式
 - 可实现实时、快时、慢时、步进等多种仿真运行方式
 - 可实现暂停、快存、回放等丰富的仿真功能
 - 安全级 DCS 系统与非安全级 DCS 系统的仿真采用虚拟激励技术
- Adopt universally recognized optimal estimation analysis program to establish reactor and primary-loop simulation model;
 - Highly Integrated simulation platform with model online modification capabilities;
 - Insert single or combined equipment malfunctions any time during simulator operation;
 - Variety of simulator control modes including graphs and lists;
 - Many simulation operation modes including real-time, fast, slow and step modes;
 - Abundant simulation functions including freeze, snap, and backtrack;
 - The Virtual stimulation approach is used for the simulation of safety and non- Safety DCS system.



业绩

Performance

- 宁德核电 #1#2 机组全范围模拟机
 - 宁德核电 #3#4 机组全范围模拟机
 - 阳江核电 #1#2 机组全范围模拟机
 - 阳江核电 #3#4 机组全范围模拟机
 - 阳江核电 #5#6 机组全范围模拟机
 - 防城港核电 #1#2 机组全范围模拟机
 - 防城港核电 #3#4 机组全范围模拟机
 - 红沿河核电 #5#6 机组全范围模拟机
 - 石岛湾核电高温气冷堆 HTR 全范围模拟机项目
 - 陆丰核电 #1#2 机组全范围模拟机
- Ningde NPP Units #1/#2 FSS
 - Ningde NPP Units #3/#4 FSS
 - Yangjiang NPP Units #1/#2 FSS
 - Yangjiang NPP Units #3/#4 FSS
 - Yangjiang NPP Units #5/#6 FSS
 - Fangchenggang NPP Units #1/#2 FSS
 - Fangchenggang NPP Units #3/#4 FSS
 - Hongyanhe NPP Units #5/#6 FSS
 - Shidaowan NPP FSS
 - Lufeng NPP Units #1/#2 FSS



产品技术参数

Technical Specification

主要技术指标 main technological indexes	行业标准 (NB/T 20015-2010) Industry standard(NB/T 20015-2010)	产品技术指标 Product performance
稳态运行 25 ~ 100% 功率水平 Steady state 25 to 100% power levels	主要参数误差 <1% ~ 2%， 辅助参数误差 <10%。 The main parameter error is <1% to 2%, and the auxiliary parameter error is <10%.	主要参数误差 <1%，辅助 <3% The main parameter error <1%, auxiliary error <3%
稳态运行 0 ~ 25% 功率水平 Steady state 0 to 15% power levels	与实际电厂调试试验的验收标准则相同。 参数变化趋势相同。 可模拟执行规程。 报警和自动响应与实际电厂一致。	主要参数误差 <1 ~ <2%，辅助 <5% The main parameter error is <1% to <2%, auxiliary <5%
I、II 类运行瞬态 I&II types of running transient	The acceptance criteria are the same as those of actual power plant commissioning tests. The changing trend of parameters is the same. Simulate execution rules. Alarm and automatic response are consistent with the actual power plant.	主要参数值误差 <10%，出现峰值的时间误差 <10%。 The main parameter value error <10%, the peak time error <10%.
III、IV 类运行瞬态 III&IV types of running transient		主要参数值误差 <20%。出现峰值的时间误差 <20%。 Main parameter value error <20%.Peak time error <20% .
异常和事故工况 Abnormal and accident conditions	应实现 25 类事故现象 25 types of accidents should be realized	I、II、III、IV 类工况，事故叠加。特殊故障数量约 600 个，所有设备均有通用故障。 Conditions of class I, II, III and IV, accident superposition. There are about 600 special malfunctions and every simulated unit has some common malfunctions.

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核电厂工程仿真机

Engineering Simulator of Nuclear Power Plant

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产品功能

Product Functions

核电厂工程仿真机是利用系统仿真技术建立核电厂主要系统仿真模型，对核电厂的正常运行和事故过程进行仿真分析和实验研究的设备。可用于核电厂工艺系统设计验证、电气系统和仪控系统设计验证、运行规程验证与优化、主控室布置与人机接口设计验证与优化，以及人因工程研究等。

工程仿真机采用成熟的仿真平台，集成了国际先进水平的工程计算软件，为设计验证提供了可靠的测试环境；具备验证过程管理工具，能够对验证过程中的文件和数据进行统一的管理；支持设计数据的自动导入，快速响应设计阶段的数据更新，方便并有效地完成设计验证工作。

The engineering simulator of nuclear power plant is utilized for simulating and analyzing the normal, abnormal operation and accident process of the nuclear power plant. It can be used for design verification of nuclear power plant process system, electrical system, instrument and control system, verification and optimization of plant operation procedures, layout of main control room and man-machine interface, and study of human engineering factors, etc.

The engineering simulator adopts a mature simulation platform and integrates the international advanced level of engineering computing software, which provides a reliable test environment for design verification, and has a verification process management tool, which can manage the documents and data in the verification process unify, and the automatic import of the supporting design data can quickly be carried out. Quick response to data update in design phase facilitates the design validation work effectively and effectively.



产品技术特点

Product Features

- 采用业界公认的最佳估算分析程序建立反应堆和一回热工水力仿真模型
- 高度一体化仿真平台，真正具备模型在线修改能力
- 提供设计验证所需要的平台功能与管理功能
- 人机界面设计数据自动转换成仿真模型，具备相同的外观以及动态特性和交互特性，画面逼真度高
- 逻辑与控制数据自动转换成仿真模型，具备完整与准确一致的逻辑和控制

- Adopt universally recognized optimal estimation analysis program to establish reactor and primary-loop simulation model;
- Highly Integrated simulation platform with model online modification capabilities;
- Provide platform functions and management functions required for design verification;
- MMI design data automatically converted into simulation model, with the same appearance as well as dynamic and interactive features, with high fidelity;
- Logic and control data are automatically converted into simulation models with complete and accurate logic and control.



产品图片

Product Picture



工程仿真机仿真精度

Simulation Precision

主要技术指标 Main Technical Specifications		产品技术指标数据 Product Data
稳态运行 Steady-state operation	25 ~ 100% 功率水平 25 ~ 100% power level	主要变量误差 $< \pm 1\%$ ，辅助变量 $< \pm 3\%$ Key variable error $< \pm 1\%$, Auxiliary variable error $< \pm 3\%$
	0 ~ 25% 功率水平 0 ~ 25% power level	主要变量误差 $< \pm 2\%$ ，辅助变量 $< \pm 5\%$ Key variable error $< \pm 2\%$, Auxiliary variable error $< \pm 5\%$
瞬态运行 Transient operation	一、二类运行瞬态 I、II running transient	主要变量误差 $< +10\%$ ，出现峰值的时间误差 $< +10\%$ Key variable error $< +10\%$, Peak time error $< +10\%$
	三、四类运行瞬态 III、IV running transient	趋势一致，报警和自动动作响应与设计一致 Consistent trend, alarm and automatic response consistent with design.



业绩

Performance

- 核与辐射安全中心全范围验证模拟机
- 华龙一号工程仿真机
- ACPR50S小型堆工程仿真机
- CIADS工程仿真机项目
- Full Scope Verification Simulator for Nuclear and Radiation Safety Center
- HPR1000 Engineering Simulator
- ACPR50S SMR Engineering Simulator
- CIADS Engineering Simulator Project

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核电厂事故分析模拟机

NPP Accident Analysis Simulator



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产品功能

Product Functions

核电厂事故分析模拟机以核电厂的事故分析课程为基础，建立与之对应的可用于该课程培训的事故分析模拟机。该模拟机由仿真系统、动态画面系统与事故分析系统三部分组成。仿真系统可以逼真地模拟核电机组运行过程中各类运行参数和设备运行状态的变化，可覆盖正常运行、瞬态工况及设计基准事故。动态画面系统基于Unity3D软件进行开发，可以生动形象地展示在各类事故工况下核电机组参数的变化过程。事故分析系统将包含与各类事故工况相关的重要信息显示、重要设备的操作等。运用该模拟机可以给受训人员生动形象地展示事故的演变过程，以加强其对事故原理及事故规程的理解，并使其了解事故过程中的关键操作与事故发展的内在联系。

NPP accident analysis simulator is based on the NPP accident analysis training courses. The simulator consists of three sections: simulation system, dynamic graphics and accident analysis system. The simulation system can simulate the changes of various operating parameters and equipment running states in the operation process of nuclear power plant, and the simulation ability can cover the normal operation, transient condition and design base accident. The dynamic display system is developed with Unity3D. It can vividly demonstrate the changing process of NPP parameters under all kinds of accident conditions. The analysis displays will contain important information related to various accident conditions, important equipment operation and so on. The simulator can vividly display the evolution process of the accident to the trainee, in order to strengthen its understanding of the accident principle and accident regulation, and make them understand the inner connection between the key operation and the accident development in the accident process.



技术特点

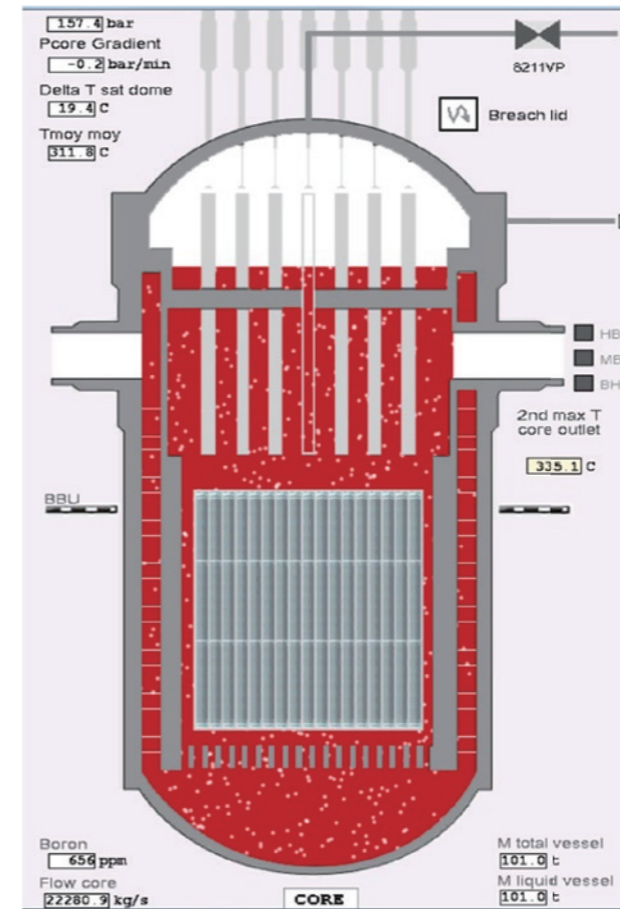
Product Features

- 国内首个用于事故理论分析培训的模拟机产品
- 采用业界公认的热工水力分析程序建立一回路热工水力模型
- 提供事故分析专业模块，显示与对比事故相关重要参数、曲线趋势
- 事故现象与进程通过专业实时动画显示
- 具有可扩展性，可通过修改模型和画面添加新功能
- 采用模块化结构，易于不同堆型的应用
- The first domestic simulator product based on accident theory analysis
- Adopt the universally thermal hydraulic analysis tools to establish the primary loop thermal hydraulic model
- To provide professional accident analysis modules, access and comparison to accident related important parameters, curve trend
- The professional real time display of the accident phenomenon
- Extensibility. New functions can be added by modifying the model and display
- Adopt modular structure. It is easily to be applied in different types of reactors



产品图片

Product Picture

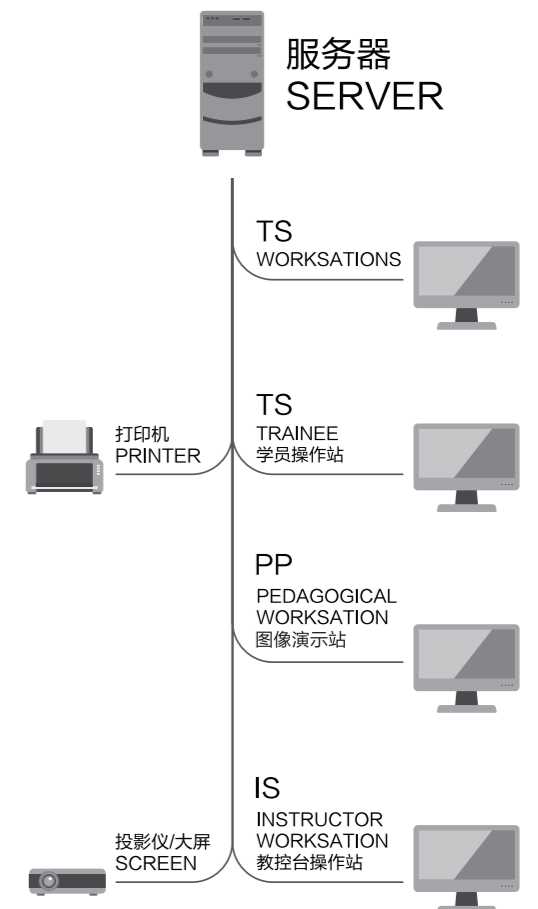


事故工况

Accident Conditions of AAS

- 一回路大破口
- 一回路中小破口
- RRA连接一回路破口
- 蒸汽发生器传热管破裂
- 二回路破口
- 蒸汽发生器失去所有给水
- 全厂失电
- ATWT事故
- 其他事故
- LOCA(large break)
- LOCA(small break)
- LOCA(RRA connected)
- SGTR
- Steam line break
- Loss of Feed Water
- SBO
- ATWT
- Others

事故分析模拟机构架 Accident analysis simulator structure

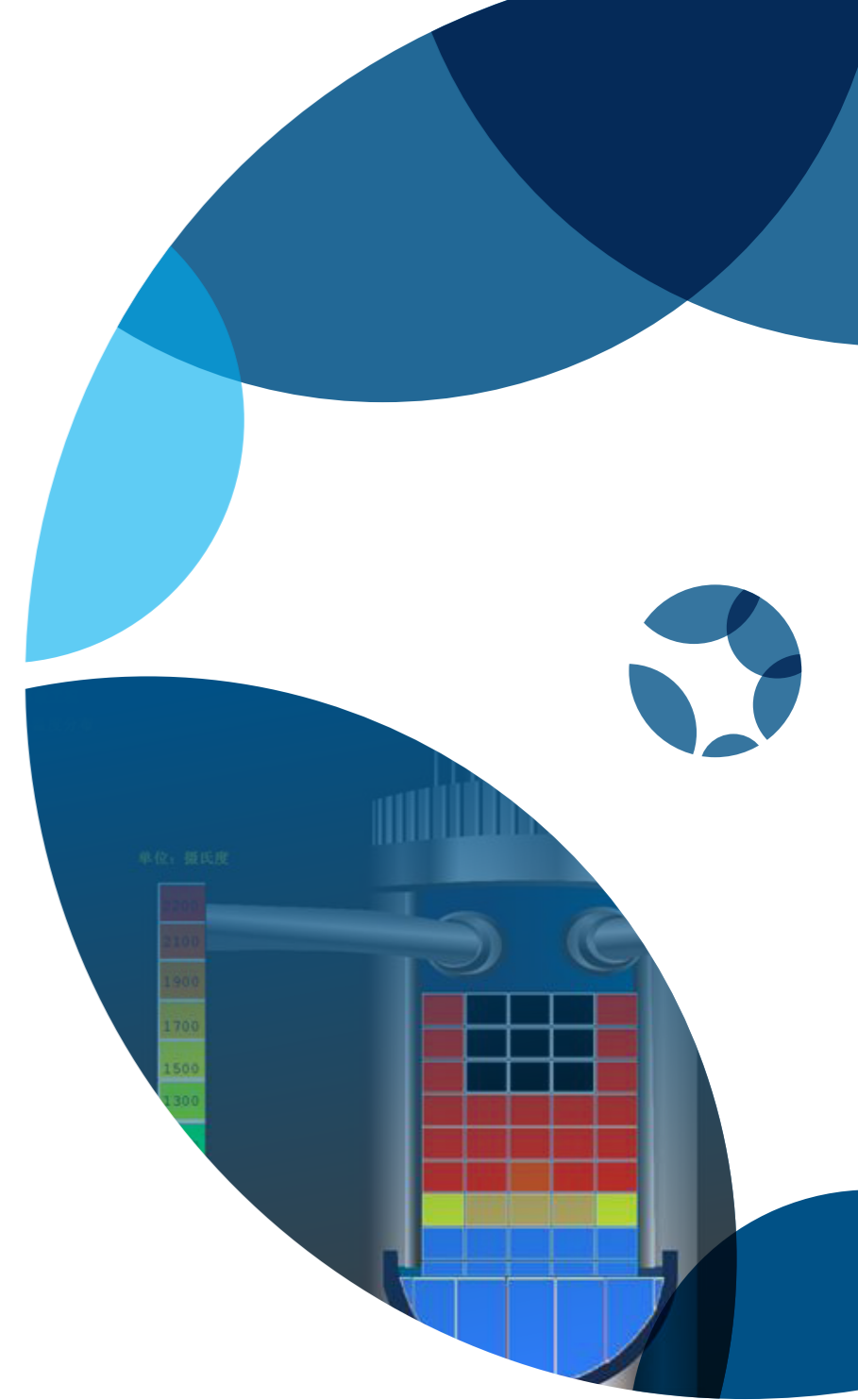


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严重事故模拟机

Severe Accident Simulation

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产品功能

Product Functions

可以实现从正常工况、设计基准事故工况和严重事故工况的连续仿真，从而对所有工况的运行状态和演变进程进行有效地分析和验证；能够满足运行核电厂、研究设计单位在严重事故应对培训、事故缓解研究、验证等方面需求，具有严重事故应对操纵培训、严重事故规程验证、事故分析、应急演练等作用。

It can effectively analyze and validate all of the operation conditions and evolution processes by continuous simulation of the operation condition from the normal condition to design basis accident condition, and then to severe accident condition; Correspondingly, it can provide the severe accident operators training, severe accident management guidelines verification, accident analysis and emergency drilling, etc., to meet the requirements about severe accident response training, accident mitigation research, verification and so on concerned by the NPP and design research institutions.



产品技术特点

Product Features

- 国内首台自主研发的大型核电站严重事故模拟机
- 符合核电严重事故模拟机国际国内建设标准
- 采用业界公认的最佳估算分析程序建立反应堆和一回路热工水力模型
- 采用业界公认MELCOR2.1等严重事故分析程序建立严重事故模型
- 实现正常工况到严重事故工况演变进程的连续模拟和不同仿真模型间的自动切换
- 严重事故现象2D/3D实时动画显示
- 全图形化建模工具，真正具有在线修改功能
- The first Severe Accident Simulation for large NPPs developed in China
- Meet requirements of both domestic and international Severe Accident Simulation standards
- Adopt universally recognized optimal estimation program to establish reactor and primary thermal hydraulics modeling
- Engineering codes recognized by the industry, such as MELCOR2.1, are utilized to establish the simulation model of the severe accident
- Realize the continuous simulation and automatic switch between different simulation stages and models
- Severe accident phenomena 2D/3D real time animation display
- Graphics-based modeling tools with on-line modification functions

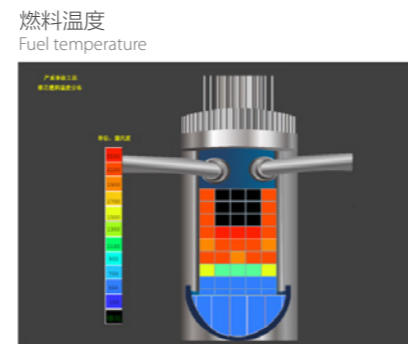


产品图片

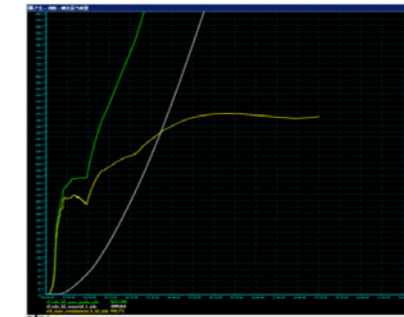
Product Picture

可灵活选择任意变量生成趋势图和表格显示来分析模型的响应。下面的例子显示了一个压水堆大破口事故场景下的一些变量的响应。

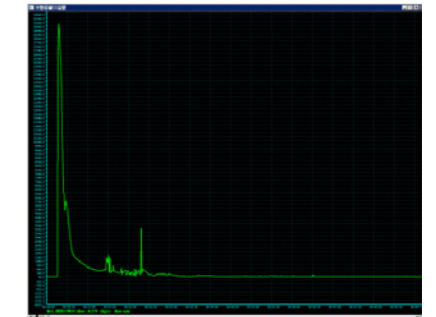
Any simulated variable can be observed with trends and tabular displays for analyzing model response. Examples below show trends from a PWR LBLOCA.



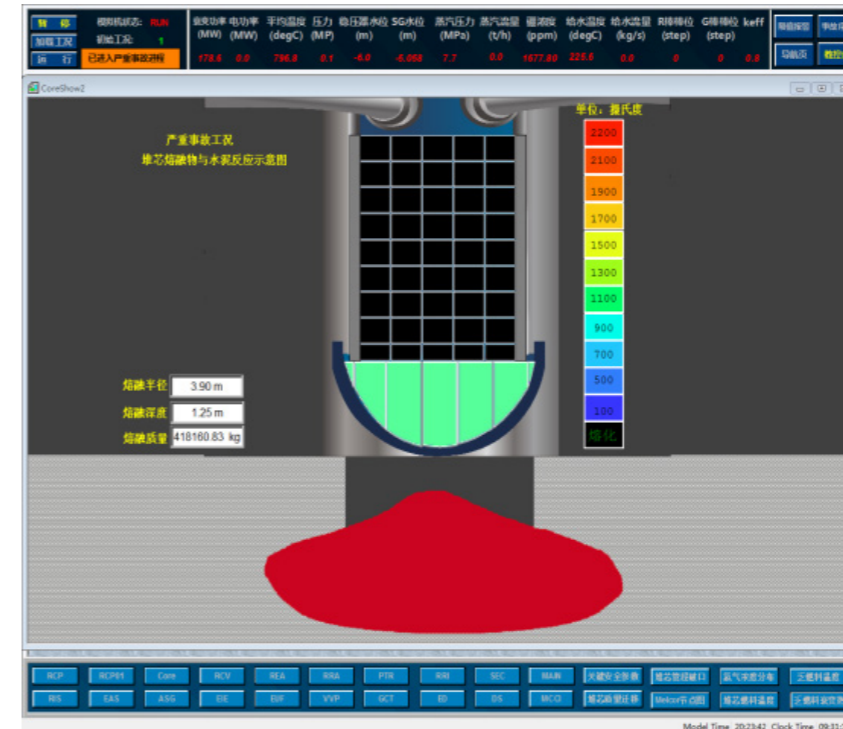
燃料温度
Fuel temperature



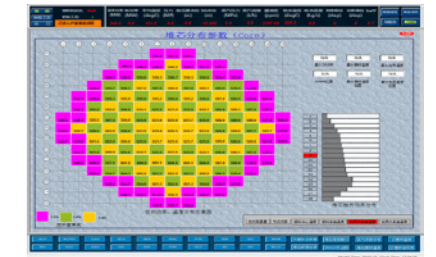
生成的、移除的和剩余的氢气质量
Productive, removed and remainder hydrogen mass



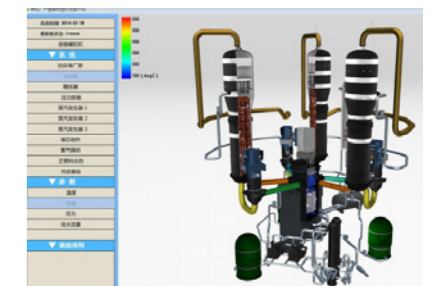
破口流量
Leak flow



熔融物温度
Core melt temperature



堆芯参数显示
Core parameters display



三维显示
3D display



供货业绩

Projects

- 环境保护部核与辐射安全中心全范围验证模拟机项目
- 国家能源局核电厂全范围严重事故仿真平台研发项目
- 广西防城港核电厂#3、4机组华龙一号全范围模拟机项目
- 宁德核电#3、4号机组严重事故模拟机
- Full-scope verification simulator for Nuclear and Radiation Safety Center
- NPP Full-scope Severe Accident Simulation Platform, R&D project funded by National Energy Administration
- Fangchenggang NPP Unit 3&4 HPR1000 FSS Project
- Ningde NPP Unit 3&4 Severe Accident Simulator Project



产品技术参数

Technical Parameters

技术指标 Technical Specifications	产品参数 Product Parameter
可同时运行的工况数量 The number of simulator instances that can run at the same time	20 个 20
可用于培训的终端数量 The number of terminals used for training	系统可支持 100 个 The system supports 100 terminals accessing.
简单指令时间 Response time of simple instruction	≤ 2s
复杂指令时间 Response time of complex instruction	≤ 3s



产品业绩

Projects

- 南京工程学院百万千瓦级压水堆核电站智能型网络原理模拟机仿真系统
- 深圳大学核电虚拟仿真实验教学系统
- 华北电力大学CPR1000核电站仿真系统
- 东北电力大学原理模拟机项目
- 厦门大学原理模拟机项目

- 1000MW PWR nuclear power plant web-based generic simulator for Nanjing Institute of Technology
- Experimental teaching system of virtual simulation for Shenzhen University
- CPR1000 nuclear power plant simulation system for North China Electric Power University
- Nuclear Power Virtual Reality Simulation Platform for NORTHEAST ELECTRIC POWER University
- PWR Theoretical Simulator for Xiamen University

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网络模拟机
Web-Based Simulator

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产品功能

Product Functions

网络模拟机是结合互联网技术和传统模拟机技术，研究开发的新一代互联网+模拟机产品。该产品使用户能在互联网环境中，通过账户登录，利用浏览器，开展核电运行基本原理、核电站操作、维护等知识培训。网络模拟机基于B/S（Browser/Server）培训模式，克服了传统模拟机分布功能弱，场地固定，时间、教员资源有限的不足，不受培训场地、培训时间、教员资源的限制，只要网络所到之处，用户就能开展培训、自学，想学就学，轻松方便。

The web-based simulator has been developed by combining internet technology and traditional simulator technologies. By using the browser, user can carry out the basic principle of nuclear power operation, the operation and maintenance of nuclear power plant and other training course on the internet with the web based simulator. With the B/S (Browser/Server) training mode, user can conveniently carry out training and self-learning at any time users will not be restricted by the training site, resources of computers and instructors, as long as they have access to Internet.

传统功能 Traditional Functions

我们将操作员站和教练员站等传统模拟机功能无缝移植到网络模拟机中，使得用户能够在浏览器中以惯有的方式操作模拟机。

The traditional simulator functions, such as operator station and instructor station, are seamlessly transplant to web-based simulator, so the user can operate the simulator in the customary way by using browser.

- 操作员站功能：画面显示与操作，趋势查看，报警，日志等。
- 教练员站功能：模拟机状态控制，IC控制，就地、故障操作，场景等。
- Operator station functions: HMI display and operation, trend view, alarm, log and so on.
- Instructor station functions: Simulator mode control, IC control, RF/MF operation, scenario and other simulator control functions.

管理功能 Management Function

网络模拟机和传统模拟机的重要差别之一，就是提供了更为系统和完整的管理功能。

One of the important differences between web-based simulator and traditional simulator is that web-based simulator provides a fully integrated management functions.

- 为了将学员管理和教学管理结合起来，实现教务信息管理一体化，提供了用户管理、学员组管理、课程管理、学员监管、成绩管理等功能。
- 为了能够让多个学员同时在一个模拟机实例上进行操作学习，系统提供成组管理功能。
- 用于角色访问控制的安全设计，权限和角色相关，角色赋予不同权限，用于完成不同的操作。
- In order to realize the integration of educational information management, it provides the functions of user management, user group management, course management, operator supervise and performance management.
- It provides group management to enable multiple trainees to operate and learn on a same simulator instance.
- Role management is used for the security design of role-based access control, and then assigns different privileges to different roles according to the character of the roles.

智能教学功能 Intelligent Tutoring Function

智能教学功能支持在没有教员指导的情况下，学员在智能教学课件的帮助下自主学习，获得与在教室学习的同等效果。

The intelligent tutoring function makes trainees to learn independently with the help of intelligent courseware instead of guidance of instructors, and achieve the same effect as classroom.

- 智能教学分为测试、提示和教学三种模式，不同模式其帮助信息难易程度不同。
- 帮助信息支持文本、图片、音频和视频等多媒体方式。
- Intelligent tutoring function includes three modes: testing, prompting and teaching. The difficulties of help information are different under different modes.
- Help information supports text, image, audio, video and other multimedia formats.

产品技术特点

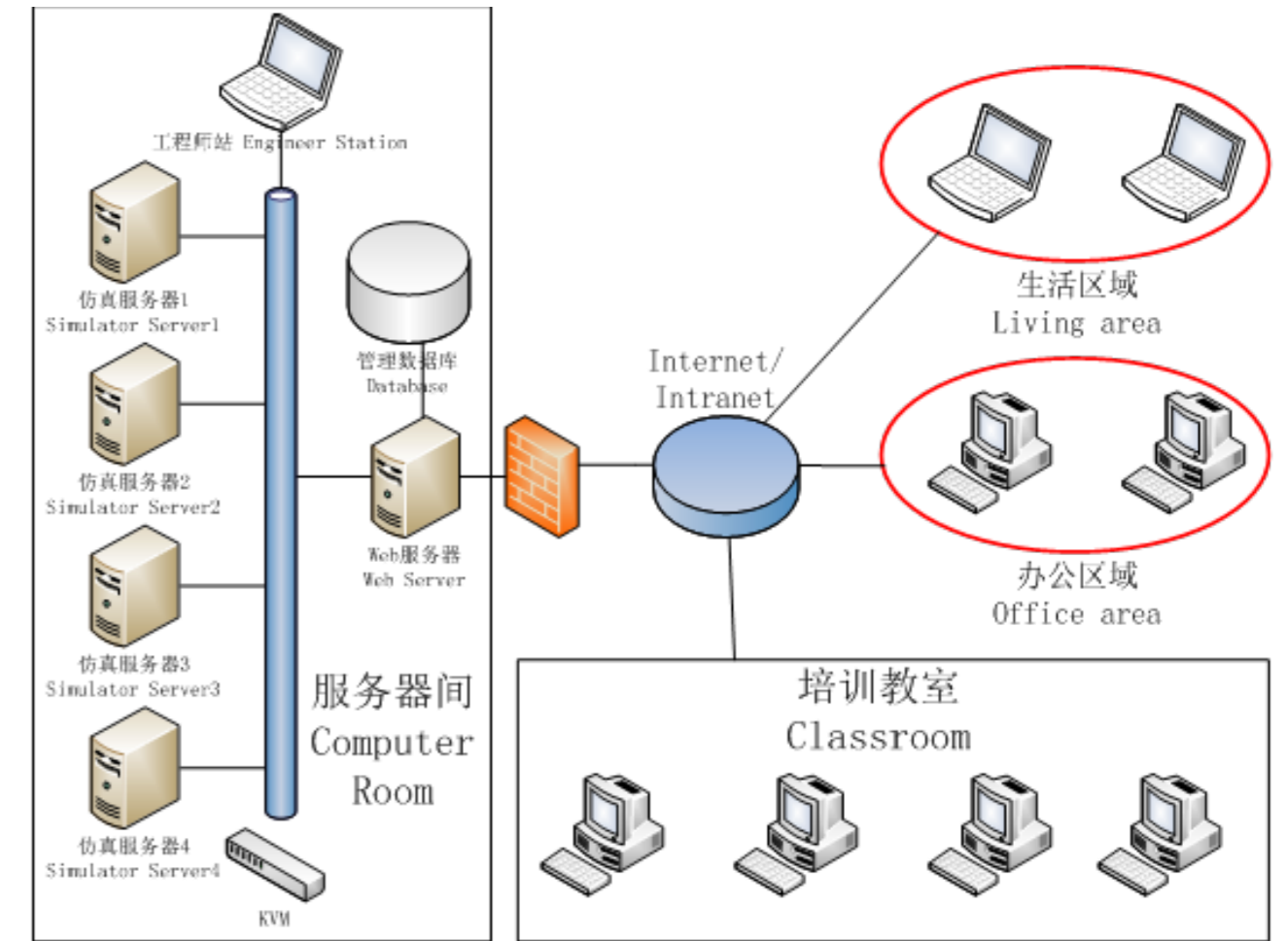
Product Features

- 具有分布式特点，不受地域、时间限制，使得用户可以随时随地使用网络模拟机进行教学，管理，学习，扩展了模拟机使用范围，极大提高了模拟机的使用效率。
- 带有管理功能，可以管理用户的登录，课件开发，用户的学习情况等信息，使得模拟机系统真正具备了教学管理功能。
- 具有智能教学功能，辅助用户学习各种知识点，并提供测试打分功能，用于反馈用户的学习情况，提升了用户学习效率及学习兴趣。
- 界面友好，具有导航功能，便于用户掌握网络模拟机的使用。
- 扩展性强，只需要改变网页，即可增加新的功能。
- 维护性强，只需要更新服务器上的网页及控件，即可实现所有用户的同步更新。

- With the ability of distributed deployment, web-based simulator is not restricted by the training site and time. Users can use it at anytime and anywhere to teach, manage and study. It expands the use range of the simulator, and improves the use efficiency of the simulator.
- With the management function, user can manage login of users, courseware development, learning situation of the users, and so on.
- The intelligent tutoring function assists users to learn a variety of knowledge points, and provides scoring function which helps to feedback the learning situation of the users, and improves the efficiency and interest of the users.
- Web-based simulator features a user friendly interface with navigation function, and is easy to use for users.
- It has the advantage of strong expandability. New functions can be added just by changing web pages.
- It is convenient in maintenance. Only updating the web pages and controls on the server can synchronize all users.

产品图片

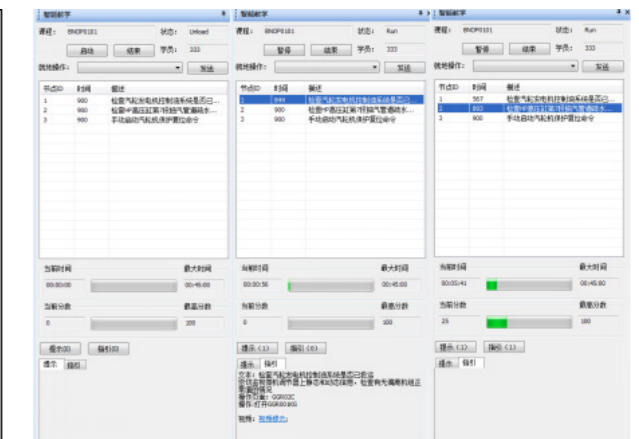
Pictures



硬件架构图
Hardware Architecture



基于角色的管理功能
Role-based Management Function



智能教学功能
Intelligent Tutoring Function

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核电厂 虚拟现实仿真系统

Nuclear Power Plant VR System



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China Nuclear Power (Beijing) Simulation Technology Co.,Ltd



产品功能

Product Functions

虚拟现实是利用计算机技术、仿真技术和传感器技术对真实环境进行模拟并生成一个三维的虚拟环境，用户可通过外设与虚拟环境中的对象进行交互，以达到等同真实环境的感受和体验。由于核电站的特殊性，进入核电站现场受到严格限制，绝大多数人员无法亲临现场，给相关教学、宣传和培训工作带来困难。核电厂虚拟现实仿真系统为用户足不出户进行核电厂虚拟漫游，身临其境感受和体验核电厂的内部结构和流程提供了可能，效果显著。

Virtual Reality (VR) take use of computer technology, simulation technology and sensor technology to simulate the real environment and generate a three-dimensional (3D) virtual scene, users can interact with virtual objects through 3D devices, the same feelings and experience of the real environment can be achieved. Because of the particularity of nuclear power plant, it is difficult to enter the nuclear power plant for teaching, propaganda and training. Virtual Reality of nuclear power plants provide the possibility to interact with plant objects in virtual environment through peripherals.

虚拟现实仿真系统主要包括以下几个功能

Nuclear Power Plant VR System Functions

- | | |
|------------------|---|
| ● 核电站漫游 | ● Plant/Internal Roaming |
| ● 应急演练 | ● Emergency Drills |
| ● 技能培训 | ● Skilling training |
| ● 虚拟检修 | ● Virtual Maintenance |
| ● 设计验证、评估及现场活动规划 | ● Design verification, evaluation and field activity planning |
| ● 人因工程研究及验证 | ● Research and verification of human factor engineering |



产品技术特点

Product Features

- 三维模型来自设计数据
 - 具备主要厂房和重要设备模型
 - 场景多视角设置
 - 场景热点设置（不低于30个热点区域的设置和交互）
 - 成熟的渲染引擎，运行平稳
 - 可扩展，与模拟机连接显示实时3D状态
 - 支持多种发布方式，桌面、多通道、立体显示
- The 3D model data from design data, which is high fidelity for the real environment
 - Main plant building and important equipment are included
 - Setting the scene in multiple perspectives
 - Scene hot settings
 - The mature rendering engine, and runs smoothly
 - The extensible, can connect to simulation machine and visually display 3D state
 - Support a variety of publishing methods, desktop, multi-channel, stereodisplay



产品图片

Product picture



供货业绩

Projects

- 中广核大厦文宣展厅核电站虚拟漫游项目
- 西安交通大学核电厂虚拟现实仿真平台项目
- 中广核研究院ATF综合性能分析平台后处理仿真系统开发项目
- CAP1400主控室和关键设备虚拟现实项目
- 宁德核岛虚拟现实项目
- 深圳大学核电虚拟仿真实验教学系统项目
- NNP Roaming System for exhibition room in the CGN Building
- Nuclear Power Plant VR System for Xi'an Jiaotong University
- ATF simulation system for CNPRI
- CAP1400 Main Control room And Key Equipment Virtual Reality Project
- Ningde NPP Virtual Reality Project
- Nuclear Power Virtual Reality Simulation Laboratory for SHENZHEN University

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模拟机运维服务

FSS Operation and Maintenance Services

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电话：0755-84431764 / 网址：<http://cnpsc.cnpri.com.cn/>

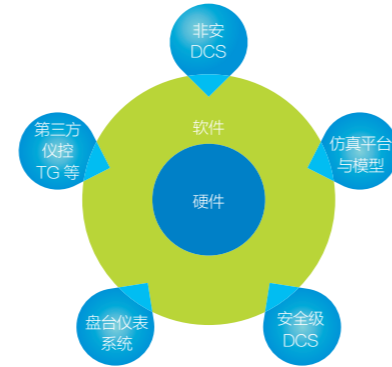
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中广核（北京）仿真技术有限公司
China Nuclear Power (Beijing) Simulation Technology Co.,Ltd

服务对象 Function

中广核（北京）仿真技术有限公司下设运维支持部，以专业化的模拟机运维服务团队，致力于为核电厂运营单位或业主提供核电站模拟机的专业技术支持与运维服务，运维服务范围涵盖了模拟机硬件、仿真软件及接口软件系统。

CNPSC has operation and maintenance support department, Established a professional team of simulation operation and maintenance service. CNPSC are committed to providing professional technical support and operation service for the operators or owners of NPP. For the FSS and the auxiliary system, our service covers hardware、software and interface system.



技术服务内容 Technical service content



1 集约化维护 Intensive maintenance

以专业化、系统化的服务向用户提供模拟机运行维护技术支持，在有效保障模拟机高可用率的同时，满足用户“降本增效”的要求。

With professional and systematic service, we provide users with technical support for the operation and maintenance of simulator, which can effectively guarantee the high availability of the simulator and meet the requirement of cost reduction and efficiency increase.

- 模拟机日常维护技术支持
- 模拟机重大故障的诊断与修复
- 模拟机系统预防性维护
- Daily maintenance technical support
- Major fault diagnosis and repair
- System preventive maintenance



2 模拟机升级服务 Simulator update service

模拟机升级包括数据软件及硬件的一致性升级，保证升级完成后模拟机主控室与参考机组主控室的高度一致，为操纵员的日常培训和考试提供有效支持。模拟机的数据升级可随着参考机组的商运和换料过程进行，也可跟随参考机组的重大变更或改造进行。

Including data consistency of hardware and software update, ensure the simulator main control room is height consistent with the reference unit. Also can providing effective support for daily training and test for operator. The update can carried out with the commercial operation and refueling process of the reference unit, or follow major changes.



3 模拟机改造包服务 Reform and Optimization

为满足用户对模拟机功能及性能持续提升的需求，定期发布模拟机功能及性能优化改造包，主要有：

In order to meet the needs of users for continuous improvement of the functions and performance of the simulator, CNPSC can releases the optimization reform package to our customers, mainly include:

- 系统模型的持续优化
- 模拟机设备更新换代方案提供与实施
- 火灾报警消防系统（JDT）功能完善与优化
- 仿真软件的升级与优化
- 教学辅助配套系统的升级与优化
- 用户的其他相关需求
- Continuous optimization of system model
- Provision and implementation of equipment upgrade scheme
- Function improvement and optimization for fire alarm system
- Simulation software upgrade
- FSS auxiliary system upgrade
- Other requirement of user

4 模拟机运维技术研发 Maintenance technology research and development

研究开发各基地模拟机运维服务管理信息化系统，提高模拟机运维服务日常工作效率及多基地模拟机运维的整体管理水平。信息化管理系统将通过移动终端设备进行信息交互，实现各基地模拟机运维人员及仿真公司模拟机维护人员的信息共享，有利于各基地模拟机问题处理方案的标准统一，在获得良好体验的同时提升用户满意度。

Development the FSS information management system, improve service efficiency of daily work. Information of maintenance will communicate by mobile device for all the users. Users can get good experience and improve satisfaction.

服务宗旨 Service purposes

以服务第一，客户至上为行动准则，充分考虑各核电厂现役模拟机运行维护的需要，保持模拟机与真实机组的一致性，在满足培训需求的同时保持运行稳定并不断提升模拟机性能，持续提升用户对模拟机的使用体验。

Service first, customer first is our rules. Fully considering the requirement of all the NPP users, keeping the consistency between the simulator and the real plant , more stable while meeting the training needs, continuously improving the performance and user's experience of simulator.

业绩 Service performance

- 核电全范围模拟机数据升级
- 核与辐射安全中心全范围模拟机日常维护技术支持服务
- 宁德核电模拟机日常维护技术支持服务
- 阳江核电模拟机长期运维技术支持服务
- 宁德核电模拟机备件供货
- 宁德核电第一套模拟机大修服务

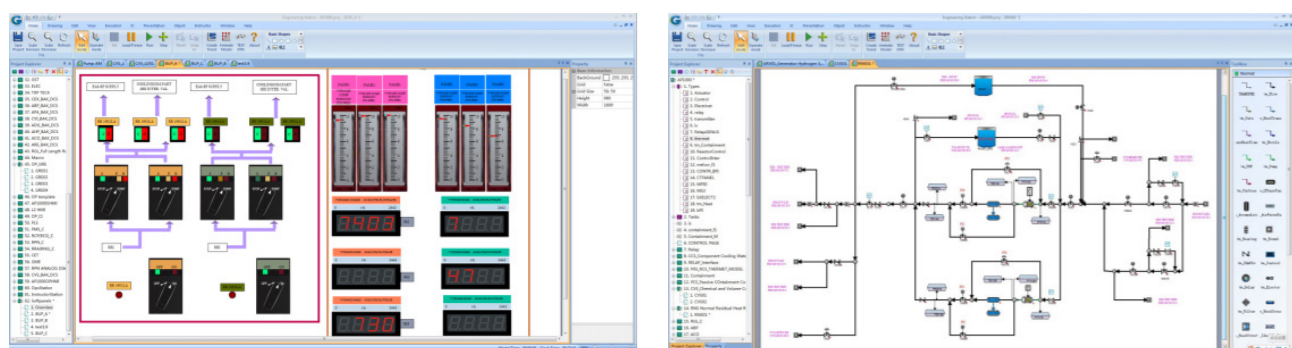
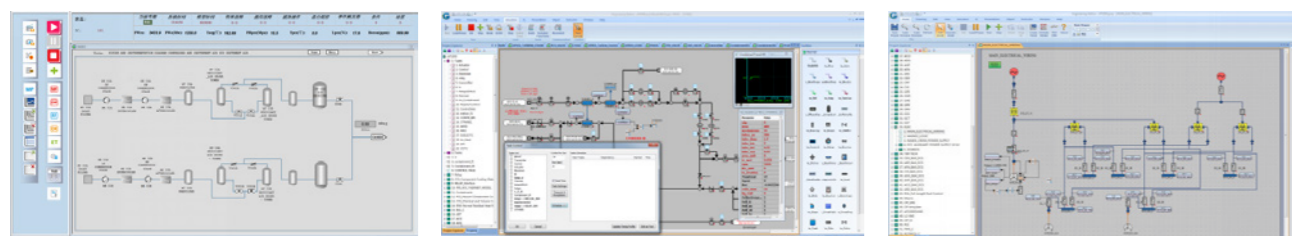
- Preliminary or final update of FSS in quality assurance period
- Daily maintenance technical support service for Nuclear and Radiation Safety Center
- Daily maintenance technical support service for Ningde Nuclear Power Plant
- Long-term maintenance technical support service for Yangjiang Nuclear Power Plant
- Spare parts supply for Ningde Nuclear Power Plant
- Reform and Optimization for Ningde Nuclear Power Plant



展示图例

Product Pictures

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GENUS应用

GENUS Application

- 开发全范围模拟机、部分范围模拟机
- 对现有模拟机升级
- 软盘台集成及硬盘台仿真
- 学习、测试以及验证
- 仿真辅助工程设计（SAE）—设计、测试，V&V以及评估管理中的先进仿真应用
- 跨部门部署，通过扩展用户群体提高效益
- Development of new full-scope or part-task simulators
- Refurbishment and modernization of existing simulation systems
- Soft-panel or integrated hard panel simulation
- Learning, test and certification
- Simulation Assisted Engineering (SAE) -advanced simulation applications in design, test, V&V, and asset management
- Multiple independent deployments across various departments -increasing the benefits by extending the user community

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GENUS仿真 支撑平台与建模工具

GENUS Simulation Platform & Modeling Tools

中广核（北京）仿真技术有限公司
China Nuclear Power (Beijing) Simulation Technology Co.,Ltd

GENUS是由中广核（北京）仿真技术有限公司推出的一款仿真支撑平台软件，提供了模型开发、集成、运行、测试、可视化以及分析等仿真相关功能，具有效率高、计算精确以及集成环境统一等特点。

The GENUS environment, developed by CNSPC, provides you everything to accomplish simulation tasks with time-saving efficiency and engineering rigor in one integrated environment, including model development, integration, execution, test, visualization, and analysis.

软件功能

Software function

1.1 图形工程师站&教练员站功能 Graphical Engineering Station (GES) & Instructor Station (IS) functions

- 功能全面的面向对象的图形化建模和操作环境，支持运行时仿真控制与数据可视化
- 完全可配置、可定制的UI
- 支持完整的矢量化图形操作，采用全新的Ribbon界面风格，操作更丰富、更方便、更贴近用户使用习惯；用户可轻松定制个性化界面
- 统一通用的图形化的Front-End工具，可为所有模型工具提供模型创建、参数化支持
- 支持趋势图、数据表以及监视对象等多种数据可视化手段，可同时监视多个参数
- 支持故障、就地和超控功能
- 支持模型对象外观、报警信息、通知信息动画显示
- 支持硬盘台与HMI图形仿真
- 支持实时记录HMI操作，并可生成场景文件并自动回放
- 在同一使用环境中可配置不同用户的角色(engineer, instructor, operator, trainee)
- Full-featured object-oriented graphical modeling & operating environment, with extensive run-time simulation controls and data visualization
- Fully configurable and customizable UI
- Supporting the complete operations of vector graphics, adopting a new Ribbon interface style, and the operation is more extensive, convenient and closer to target customers. User can personalize and customize look and feel
- Unified and common graphical front-end for model creation and parameterization for all modeling tools
- Powerful visualization -multi-variable trend charts, tables and watch objects
- Easy insertion of component failures, malfunctions, remote actions and overrides
- Dynamic condition animation of model object icons, alarms, and alerts
- Hard panel and HMI graphics emulation
- Scripting and HMI action recording tool for creating scenarios and playback
- Configurable role-based functions in a single environment (engineer, instructor, operator, trainee)

1.2 模型计算功能 Simulator executive functions

- 支持计算过程中动态配置和测试模型，平台在后台自动处理生成的模型文件并装载，模型可以快速修改和重新装载执行
- 适应多处理器计算环境，仿真计算负载可在多个处理器之间平衡处理
- 支持多种部署方式，可灵活实现远程操作以及多用户操作模式
- 支持多种通讯协议，可方便地与第三方软件、硬件、I/O系统、硬盘台集成
- 提供对现有模拟机升级改造的手段
- 提供用户已有代码移植机制(C, C++, FORTRAN)，避免重复投入
- Configure and test models dynamically without interruption of the simulation. Generation of source code and its compilation are handled in the background. Model designs can be quickly altered and re-loaded for execution
- The simulation load can be shared and balanced across multiple processors
- Supporting different kinds of deployments, it can realize the remote operation and multi-user operation mode flexibly
- Supporting a variety of communication protocols, it's easy to integrate with third-party software and hardware systems, I/O systems, and panels
- Providing means of upgrading the existing simulators
- Re-hosting or porting of legacy or custom code (C, C++, FORTRAN) -preserve your existing investments

1.3 高精度建模工具功能 High-precision modeling tool function

流体网络工具 / Flow Network Tool Thermet

- 流体网络仿真，如蒸汽、水、硼、空气、氮气等
- 密闭的空间仿真，如安全壳
- 换热设备、流体机械和部件仿真，如蒸汽发生器，汽轮机、泵、阀门、喷嘴等
- 设备内部结构的详细建模，如换热器管壁温度分布的计算
- 热工水力仿真程序
- 采用非平衡模型分析两相流体系统，对每个节点求解六个守恒方程——汽相和液相的质量守恒方程、能量守恒方程、动量守恒方程
- 不可凝气体和其他成份（如硼）的传输方程
- 更高的可靠度 - 采用工业级最佳估算模型能使操作员考取执照和获取计算数据支持取照等更可靠
- Fluid Networks - e.g., steam, water, boron, air, nitrogen, etc.
- Enclosed Spaces - e.g., containments
- Heat transfer equipment, fluid-flow machinery and components - e.g., steam generators, turbines, pumps, valves, nozzles, etc.
- Detailed modeling of internal structures of machinery - e.g., temperature distribution of heat exchanger tubes
- Thermal-hydraulic simulation code
- Non-equilibrium model for two-phase fluid systems, complete set of six conservation equations for each node, consisting of the conservation of vapor mass, liquid mass, vapor energy, liquid energy, vapor momentum, and liquid momentum
- Transport equations for the conservation of non-condensable gas, and material species (e.g., Boron)
- Greater credibility – use of industry standard best-estimate modeling provides greater credibility for operator certifications and for simulator generated data to support licensing

热工水力仿真程序 / Thermal-Hydraulic Simulation Code

- 采用非平衡模型分析两相流体系统，对每个节点求解六个守恒方程——汽相和液相的质量守恒方程、能量守恒方程、动量守恒方程
- 不可凝气体和其他成份（如硼）的传输方程
- 更高的可靠度 - 采用工业级最佳估算模型能使操作员考取执照和获取计算数据支持取照等更可靠
- Non-equilibrium model for two-phase fluid systems, complete set of six conservation equations for each node, consisting of the conservation of vapor mass, liquid mass, vapor energy, liquid energy, vapor momentum, and liquid momentum
- Transport equations for the conservation of non-condensable gas, and material species (e.g., Boron)
- Greater credibility – use of industry standard best-estimate modeling provides greater credibility for operator certifications and for simulator generated data to support licensing

中子动力学仿真程序 / Neutron Kinetics Simulation Code

- 完整的2能群中子动力学模型——更准确模拟堆芯全寿期，包括事故场景
- 两群中子截面反射层模型，更加精确地考虑了中子在不同条件下的泄漏
- 建模使用燃料设计单位提供的堆芯设计数据，以避免非平衡循环调试上花费大量时间
- 中子动力学模型与热工水力模型紧密耦合
- Complete 2-energy group neutron kinetics model – greater accuracy throughout the core and in accident scenarios
- Explicit reflector modeling with 2 – group cross-sections – more accurate accounting of neutron leakage across a wide range of conditions
- Model uses cycle-specific core design data from fuels group eliminating time-consuming cycle-specific tuning for non-equilibrium cycles
- Tighter coupling between neutron kinetics and thermal-hydraulics models

电网建模工具 / Electrical Network Tool

- 厂用电气网络仿真，例如厂用电电能分布、孤立电网、多电源网络、高压/低压电网
- 发电系统仿真
- 交流/直流网络仿真，含变压器、蓄电池、整流器、逆变器
- 电气驱动与电机仿真
- Power Plant electrical networks and circuits - e.g., electrical distribution in plants and machinery, isolated and stand-alone grids, multiple generator grids, high voltage and low voltage networks, and electrical circuits
- Power generation and electrical systems
- AC/DC network, including transformers, batteries, regulators, inverters and other circuit elements
- Electrical drives and motors

仪控工具 / Control Tool

- 丰富的控制系统通用模块算法库，包括信号线、传感器、比较、电源供给、选择开关、逻辑门、放大器、加法、指示、手操器、控制器、斜坡、速率、模拟量选择等
- 模拟控制系统数据流功能
- Comprehensive library of common types of control system objects, including wires, sensors, comparator, power supplies, switches, gates, amplifiers, summers, indicators, M/A stations, controllers, ramp, rate, analog selector, etc.
- Modeling of control system transfer functions

继电器工具 / Relay Tool

- 丰富的控制系统通用模块库，包括线路、继电器、开关、触点、断路器、电源供给、指示等等
- 多触点开关的模拟
- Comprehensive library of common types of control system objects, including wires, relay, switches, contacts, circuit breakers, power supplies, indicators, etc.
- Modeling of multi-contact switches

执行机构工具 / Actuator Tool

- 执行机构工具包含了电厂和设备中的通用类型的执行机构，用于执行机构特性的模拟。本工具提供了设备新类型创建的扩展能力，可追加于现有对象库中
- The Actuator library contains common types of actuators found in plant and equipment, and is used to model a device of actuator. The actuator provides the capability to create modeling objects for new types of plant and equipment actuators, which can then be added to the growing actuator library for reuse

技术特点

Technical characteristics

- 采用先进的面向对象、可视化建模方式，不需要模型工程师掌握复杂的编程知识
- 提供图形对象、计算模块和计算任务开发接口，可轻松定制个性化的人机界面以及扩展仿真应用领域，以实现对复杂系统完全仿真
- 具有完善的、基于物理机理的高精度建模工具包，覆盖核电厂全部系统模型
- 一体化的模型开发、集成测试和运行维护的高效平台
- 跨页面和跨工具的无缝模型集成
- 无需手动编译，模型可在线快速更新
- 开放的体系结构，易于集成
- 具有多种针对不同厂商的DCS系统的翻译、通讯工具，还可提供多种技术路线的DCS模拟和集成方案
- Using advanced object-oriented visual model method. No professional programming knowledge required
- Providing the graphics object, calculation module and computing tasks development interface, the platform can easily customize human-computer interface and extend simulation applications to provide the simulation of complex systems
- The perfect modeling tools based on the physical mechanism with high accuracy can be used to build all system models of nuclear power plants
- Provides an engineering environment to accomplish these tasks such as model development, system integration, execution, performance test, operation and maintenance
- Objects linking across pages and tools for seamless integration
- On-line and fast model updates with no manual recompile steps
- Open architecture, easy integration
- Provide tools for various DCS system simulation and communication. Multiple simulation methods to be chosen depending on different situation of DCS systems

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长湾仿真实验室由中广核（北京）仿真技术有限公司与中广核大学（党校）在长湾领导力发展中心共同建设，旨在借助仿真技术宣传中广核在核电科技攻关、堆型设计等领域的科技成果和实力，并研究、开发基于仿真技术和产品的相关培训及演示课程。

长湾仿真实验室主要包括核电厂全范围模拟机系统开发与展示平台，以及核电厂虚拟现实系统开发与展示平台两大部分。



核电厂全范围模拟机系统开发与展示平台

核电厂全范围模拟机有“虚拟核电厂”之称。融合了反应堆工程、热动力、电气、仪控、计算机数字计算等诸多领域的高新技术，对实际核电厂运行、系统、设备进行全范围、高逼真模拟，既是开展核电厂操纵员培训与资格考试所必需的重要装备，也是核电厂设计与安全研究人员开展相关研究的高效、便利的分析工具。

长湾仿真实验室对 CPR1000 核电全范围模拟机展示平台的硬件进行了适当简化，保留了全厂概貌大屏幕（POP）、NI 及 CI 操纵台，BUP/ECP 等盘台功能通过仿真平台的软盘台系统实现。

模拟范围包括核电厂与运行相关的两百多个系统；可实现机组正常启停堆、功率运行、设计基准事故等仿真；可在线干预仿真过程，实现人机互动；可实现严重事故进程和事故缓解仿真。



核电厂虚拟现实系统开发与展示平台

虚拟现实（Virtual Reality），是一种可以创建和体验虚拟世界的计算机系统，它利用计算机技术生成一个逼真的、具有视、听、触等多种感知的虚拟环境，用户通过使用各种交互设备，同虚拟环境中的实体相互作用，使之产生身临其境感觉的交互式视景仿真和信息交流。

与传统的模拟技术相比，虚拟现实技术的主要特征是：操作者能够真正进入一个由计算机生成的交互式三维虚拟现实环境中，与之产生互动，进行交流。通过参与者与虚拟仿真环境的相互作用，并借助人本身对所接触事物的感知和认知能力，帮助启发参与者的思维，以全方位地获取虚拟环境所蕴涵的各种空间信息和逻辑信息。

虚拟现实系统开发与展示平台是虚拟现实技术应用研究的重要载体。



长湾仿真实验室核电厂虚拟现实系统平台包括一套双通道正投式的虚拟现实环境，利用全新 VR 技术搭建的新型数据展示平台，可实现 CPR1000 核电厂三维漫游（厂区、厂房内部）、就地操作、应急演练，以及其他虚拟现实产品演示。

体验者可通过三维交互设备（如：动捕系统）对虚拟场景中的设备进行操作，与虚拟环境中的对象进行交互，可达到近乎真实环境的感受和体验，显著提升培训及宣传效果。

长湾仿真实验室的模拟机系统以及虚拟现实系统极强的自由体验和沉浸感，可以为使用者带来全新的体验，必将在核电知识推广、文化交流、公众参观教育等方面发挥越来越重要的作用。

