List of the issues to be investigated, designed and developed *(analytical review of literary sources with the purpose to study global scientific and technological achievements in the target field, formulation of the research purpose, design, construction, determination of the procedure for research, design, and construction, discussion of the research work results, formulation of additional sections to be developed; conclusions).*	– To under the hydrodynamic process for heat transfer in VVER SG – Analytical and numerical calculations of steam quality – Determine the Structural and characteristics of the steam volume (with and without louver separator) are currently being carried out.
List of graphic material *(with an exact indication of mandatory drawings)*	N/A

Advisors to the sections of the Master's Graduation Thesis
(with indication of sections)

Section	**Advisor**
Introduction	Gvozdyakov D.V
Literature review	Gvozdyakov D.V
Theoretical aspect of the reconstruction	Gvozdyakov D.V
Practical aspect of the reconstruction	Gvozdyakov D.V
Social responsibility	Verigin D.A
Financial management	Menshikova E.V

Date of issuance of the assignment for Master's Graduation Thesis completion according to the schedule	

Assignment issued by a scientific supervisor / advisor (if any):

Position	**Full name**	**Academic degree,academic status**	**Signature**	**Date**
Associate Professor	Gvozdyakov.D.C	Ph.D		

Assignment accepted for execution by a student:

Group	**Full name**	**Signature**	**Date**
0АМ7И	Nnodi Akelachi Chinweikpe		

TOMSK POLYTECHNIC UNIVERSITY ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Министерство науки и высшего образования Российской Федерации
федеральное государственное автономное
образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

School Nuclear Science and Engineering
Field of training (specialty) 14.04.02 Nuclear Physics and Technology
Level of education Master's Degree
Division Nuclear Fuel Cycle
Period of completion (fall/spring semester 2018 /2019)

Form of presenting the work:

SEPARATION PROCESS IN HORIZONTAL STEAM GENERATOR OPERATING ON SATURATED STEAM WITH CAPACITY OF 150KG/S

SCHEDULED ASSESSMENT CALENDAR
for the Master's Graduation Thesis completion

Deadline for completion of Master's Graduation Thesis:	04.06.2019

Assessment date	**Title of section (module) /type of work (research)**	**Maximum score for the section (module)**
19.12.18	Literature Review and Methodology	...
05.03.19	Theoretical reconstruction analysis	...
12.03.19	Practical training and the development of the algorithm	
24.05.19	Financial management and Social Responsibility	
11.06.19	Compilation of the dissertation (full report)	

COMPILED BY:

Scientific supervisor:

Position	**Full name**	**Academic degree,academic status**	**Signature**	**Date**
Associate Professor	Gvozdyakov D.V	Ph.D		

AGREED BY:

Director of the programme	**Full name**	**Academic degree, academic status**	**Signature**	**Date**
Programme Director	Verhoturova V.V	**Ph.D**		

TASK FOR SECTION
«FINANCIAL MANAGEMENT, RESOURCE EFFICIENCY AND RESOURCE SAVING»

To the student:

Group	**Full name**
0АМ7И	Nnodi Chinweikpe Akelachi

School	Nuclear Science & Engineering	**Division**	Nuclear-Fuel Cycle
Degree	Master	**Educational Program**	14.04.02 Nuclear physics and technologies

Input data to the section «Financial management, resource efficiency and resource saving»:	
1. Resource cost of scientific and technical research (STR): material and technical, energetic, financial and human	Salary costs – ;85000 STR budget – ;95700
2. Expenditure rates and expenditure standards for resources	Electricity costs – 5,8 rub per 1 kW
3. Current tax system, tax rates, charges rates, discounting rates and interest rates	Labor tax – 27,1 %; Overhead costs – 30%;
The list of subjects to study, design and develop:	
1. Assessment of commercial and innovative potential of STR	comparative analysis with other researches in this field;
2. Development of charter for scientific-research project	SWOT-analysis;
3. Scheduling of STR management process: structure and timeline, budget, risk management	calculation of working hours for project; creation of the time schedule of the project; calculation of scientific and technical research budget;
4. Resource efficiency	integral indicator of resource efficiency for the developed project.
A list of graphic material *(with list of mandatory blueprints):*	
1. Competitiveness analysis *2. SWOT- analysis* *3. Gantt chart and budget of scientific research* *4. Assessment of resource, financial and economic efficiency of STR*	

5. *Potential risks*

Date of issue of the task for the section according to the schedule	05.03.2019

Task issued by adviser:

Position	**Full name**	**Scientific degree, rank**	**Signature**	**Date**
Associate professor	E.V. Menshikova	PhD		

The task was accepted by the student:

Group	**Full name**	**Signature**	**Date**
0АМ7И	Nnodi Chinweikpe Akelachi		

TASK FOR SECTION
"SOCIAL RESPONSIBILITY"

To the student:

Group	**Full name**
0АМ7И	Nnodi Chinweikpe Akelachi

School	National Research Tomsk Polytechnic University (TPU)	**Department**	Nuclear Fuel Cycle
Degree	Masters	**Specialization**	Nuclear Physics and Technology

Input data to the "social responsibility":	
1. *Describe workplace (work area) for occurrence of:*	Harmful factors of the environment (microclimate, illumination, noise, vibration, electro magnetic fields, ionizing radiation); dangerous factors of environment factors (electrical, fire and explosive nature).
2. *Acquaintance and selection of legislative and normative documents on the topic*	electrical safety; fire and explosion safety; labor protection requirements when working on a PC. radiation safety
The list of subjects to study, design and develop:	

1. Analysis of the identified harmful factors of the environment in the following sequence:	The effect of the factor on the human body; Reduction of permissible standards with the required dimensionality (with reference to the relevant normative and technical document); Proposed remedies (collective and individual).
2. Analysis of identified hazards of the environment:	Electrical safety (including static electricity, protective equipment); fire and explosion safety (causes, preventive measures, primary fire extinguishing agents).

Date of issue of the task for the section according to the schedule	

Task issued by consultant:

Position	**Full name**	**Scientific degree, rank**	**Signature**	**date**
Senior Lecturer	D.A Verigin	Ph.D		

The task was accepted by the student:

Group	**Full name**	**Signature**	**date**
0АМ7И	Nnodi Chinweikpe Akelachi		

Expected learning outcomes

Result code	The result of the training (the graduate should be ready) professional competencies	Requirements of the FSES HE, criteria and / or stakeholders
LO1	To apply deep mathematical, natural scientific, socio-economic and professional knowledge for theoretical and experimental research in the field of the use of nuclear science and technology	FSES HE Requirements (PC-1,2, 3, 6, UC-1,3), Criterion 5 RAEE (p 1.1)
LO2	Ability to define, formulate and solve interdisciplinary engineering tasks in the nuclear field using professional knowledge and modern research methods	FSES HE Requirements (PC-2,6,9,10,14 UC-2,3,4, BPC1,2), Criterion 5 RAEE (p 1.2)

LO3	Be able to plan and conduct analytical, simulation and experimental studies in complex and uncertain conditions using modern technologies, and also critically evaluate the results	FSES HE Requirements (PC-4,5,6,9,22 UC-1,2,5,6), Criterion 5 RAEE (p 1.3)
LO4	To use the basic and special approaches, skills and methods for identification, analysis and solution of technical problems in nuclear science and technology	FSES HE Requirements (PC-7,10,11,12,13 UC-1-3,BPC1,3), Criterion 5 RAEE (p 1.4)
LO5	Readiness for the operation of modern physical equipment and instruments, to the mastery of technological processes during the preparation of the production of new materials, instruments, installations and systems	FSES HE Requirements (PC-8,11,14,15, BPC-1), Criterion 5 RAEE (p 1.3)
LO6	The ability to develop multivariate schemes for achieving the set production goals, with the effective use of available technical means cultural competencies	FSES HE Requirements (PC-12,13,14,16, BPC-2), Criterion 5 RAEE (p 1.3)
LO7	The ability to use the creative approach to develop new ideas and methods for designing nuclear facilities, as well as modernize and improve the applied technologies of nuclear production	FSES HE Requirements (PC-2,6,9,10,14, UC-1,2,3), Criterion 5 RAEE (p 1.2,2.4,2.5)
	basic professional competencies	
LO8	Independently to study and continuously to raise qualification during all period of professional work.	FSES HE Requirements (PC-16,17,21, UC-5,6, BPC-1), Criterion 5 RAEE (p 2.6) coordinated with the requirements of the international standard EURACE & FEANI
LO9	Actively own a foreign language at a level that allows you to work in a foreign language environment, develop documentation, present results of professional activity.	FSES HE Requirements (BPC-3, UC-2,4), Criterion 5 RAEE (p 2.2)
LO10	To demonstrate independent thinking, to function effectively in command-oriented tasks and to have a high level of productivity in the professional (sectoral), ethical and social environments, and also to lead the team, form assignments, assign responsibilities and bear responsibility for the results of work	FSES HE Requirements (PC-18,20,21,22,23 UC-1,4, BPC-2), Criterion 5 RAEE (p 1.6,2.3) coordinated with the requirements of the international-al standard EUR-ACE & FEANI

Abstract

The master's dissertation consists of (136) pages; 47 figures; 34 tables; 23 references; 30 and 1 appendix.

Keywords: Horizontal SG, heat exchanger tubes, NPP water chemistry, nuclear steam generator design/ specification, separator and hydrodynamics of heat transfer.

The goal and objective of the research is to study the mechanics and working fluid process in VVER 1000 horizontal steam generator with saturated steam.

From the result of the research, the goal was achieved with the mathematical, numerical, geometrical and algorithmic deep understanding relating to hydrodynamics of heat transfer process in tubes of VVER steam generator with saturated steam of 150Kg/s. Practical section was also carried out on the detection of defect using capillary testing at the ROSTOV NPP manufacturing industry in Russia

The degree implementation on theoretical studies and analytical effect in assessment of pressure of working fluid (steam) on its basic parameters, as well as the moisture content of the steam entering the louvered separator or steam receiving ceiling was calculated. The obtained values allowed to estimate the preliminary capital costs for the design and creation of a steam generator.

List of abbreviations

SG –Steam Generator

ECT – Eddy current testing

VVER – Analyzer – Based Imaging

PWR – Pressurized water reactor

NPP-Nuclear power plant

MSLB – Main stream line break

RCP -Reactor coolant pump

DG- Diesel generator

TG- Turbine generator

RCC- Reactor collection chamber

MSIV -Main steam isolation valve

PRZ- Pressurizer

RP- Reactor plant

PSD- Pulse safety device

EFWP- Emergency feed water pump

NPP- Nuclear power plant

HPIS- High pressure injection system

TS- Technical specification

Introduction

The horizontal steam generator (SG) is a Russian pressurized water reactor which belongs to the principal NPP equipment of WWER Nuclear reactors [1].Steam generators (SGs) are large shell and tube heat exchangers, containing several thousand tubes. They transfer heat from the primary reactor coolant to the secondary side to produce steam, which then powers turbine generators to produce electricity. Most nuclear power plants (NPPs) have anywhere from 2 to 6 SGs per reactor; however, some designs have up to 12, with a total of more than 1300 SGs being in service in 357 of the total 450 reactors in the world.

The performance of SGs is critical to the overall efficiency and safety of an NPP, particularly as plant ages. Operating experience has shown that overtime SGs become more susceptible to material degradations, which can affect plant life expectancy and overall safety. Generally, SG tubes must withstand more than 15 MPa of pressure from within the tube, while maintaining a safe and structurally important barrier between the primary and secondary side.

Tube damage may decrease the integrity and lead to leakage and possible release of contaminants into the secondary side. The significance of these issues exemplifies the importance of maintenance, inspections, and testing of SG components, especially because of the safety significance of SG tubing (Revankar and Riznic, 2009). As of Jan. 2017, there were 450 operational nuclear reactors in the International Atomic Energy Agency's (IAEA) Power Reactor Information System (PRIS), representing 392 GW of electrical power.

Aging is a relevant factor due to the fact that the majority of NPPs within the PRIS database are over 30 years of age. NPPs over the age of 30 are responsible for the highest total net electricity capacity of operational reactors, possessing 251,069 MW of the 392,012 MW of total operational net electricity capacity. However, many