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Articles

Protection of Pipeline Elements from Stress Corrosion Cracking

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Abstract

The paper analyzes the causes of corrosion cracking under stress of main pipelines. To reduce the likelihood of cracking, it is proposed to insulate the inner wall of the main pipeline with a mineral-polymer coating. A mathematical model of heat transfer through a multilayer cylindrical wall in the soil is constructed, which takes into account the influence of soil temperature, the depth of the main pipeline on the heat flow through the pipe wall. As a result, the use of an internal insulating mineral-polymer coating reduces the heat flux through the pipe wall by almost half, which reduces the likelihood of stress corrosion cracking.

Keywords: stress corrosion cracking, gas main, heat equation, heat flow.

1. Введение

Обеспечение безопасной эксплуатации трубопроводов во многом является проблемой повышения их надежности и долговечности. Зачастую аварии на нефтепроводах и газопроводах влекут за собой экологические проблемы, устранение которых требует значительных материальных и экономических ресурсов. В настоящее время интенсивность отказов основной части трубопроводных систем в России увеличивается. Основная причина аварий – коррозионные повреждения. Анализ отказов и результаты диагностики состояния магистральных трубопроводов в России и за рубежом показывают, что коррозионному растрескиванию под напряжением (КРН) подвержены газопроводы и нефтепроводы, пролегающие в различных природно-климатических районах, сооруженные из труб разного производства, отличающихся по конструкции и размерам.

Согласно исследованиям Р.И. Богданова и др. установлено, что трещины могут быть как узкие без следов коррозии на берегах, так и широкие с растравленными берегами. Как правило трещины образуются вдоль оси трубы параллельно друг другу. Одним из факторов, влияющих на образование КРН является высокая температура. По некоторым данным образование трещин экспоненциально растет с повышением температуры (Богданов и др., 2016).

Теории развития процесса КРН в металлах посвящено много исследований. Следует отметить таких ученых, как В.И. Астафьев, Л.К. Ширяева, О.И. Стеклов, Д.П. Варламов, К.Б. Конищев, А.М. Семенов, С.А. Сильвестров, А.К. Гумеров, которые добились существенных результатов в моделировании возникновения, распространения напряжений

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и накопления поврежденности (Астафьев и др., 1996; Астафьев, 1998; Астафьев, Ширяева, 1998; Конищев и др., 2019; Сильвестров, Гумеров, 2018).

Экспериментальные исследования направлены на совершенствование способов защиты трубопроводов от коррозии и диагностирования состояния их стенок (Варламов, Стеклов, 2012; Агиней и др., 2012; Чучкалов, Гареев, 2014; Усманов и др., 2014). Предлагаются активные и пассивные методы защиты труб от коррозии. Основным способом диагностирования состояния трубопроводов является дефектоскопия.

Несмотря на то, что этой проблеме посвящены многочисленные исследования отечественных и зарубежных авторов, в настоящее время она еще полностью не решена и многие вопросы остаются открытыми.

Таким образом, целью работы является разработка способов защиты магистральных трубопроводов и отводов от коррозийных процессов растрескивания.

2. Обсуждение и результаты

С развитием химической промышленности появляются новые изоляционные покрытия, с хорошей адгезией и свойством абразивостойкости, с широким температурным диапазоном работы, с большим относительным удлинением до разрыва и другими свойствами (Отраслевой портал...; Копейский завод...).

Для коррозионной защиты трубопроводов в настоящее время применяются минерально-полимерное и цементно-полимерное покрытия. Их могут наносить как на внешнюю поверхность, так и на внутреннюю. Для защиты эксплуатируемых трубопроводов от КРН в рамках данной работы предложено использовать минерально-полимерное покрытие внутренней стенки. Это позволит продлить срок службы трубы.

Как уже описано ранее, основной причиной возникновения КРН является частые перепады температуры, в результате которых труба то расширяется, то сжимается. Следовательно, уменьшив диапазон колебания температур самой трубы, сможем уменьшить вероятность возникновения трещин на стенках трубопровода.

Для того, чтобы определить влияние внутреннего полимерного покрытия на КРН стенок трубопровода, рассмотрим процесс теплопередачи через многослойную цилиндрическую стенку без полимерного покрытия и с нанесенным на внутреннюю стенку полимерным покрытием.

Пусть трубопровод уложен в грунт с коэффициентов теплопроводности $\lambda_{гр}$ на глубину h (Рисунок 1).

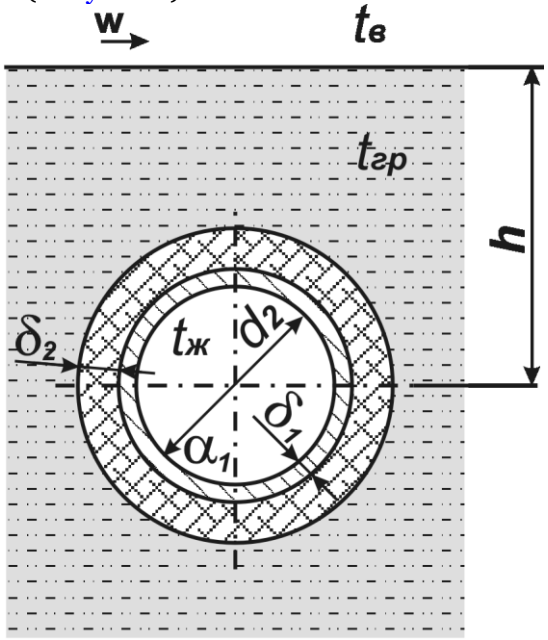

Рис. 1. Схема заглубленного трубопровода

Температура грунта в районе прокладки трубопровода $t_{гр}$, температура окружающего воздуха $t_в$, а скорость ветра у поверхности земли $w_в$.

По трубопроводу перекачивается природный газ с массовым расходом G. Температура газа после узла подключения газокомпрессорной станции $t_{ж1}$, а в конце участка перед следующей станцией – $t_{ж2}$. Коэффициент теплопроводности стенки трубы λ_1.

Определим изменение теплового потока через многослойную цилиндрическую стенку трубопровода с внутренним полимерным покрытием и без него.

Для этого рассмотрим первую задачу – процесс теплопередачи через двуслойную стенку без внутреннего изоляционного покрытия.

Дифференциальное уравнение стационарного теплообмена через стенку трубопровода в цилиндрической системе координат имеет вид:

$$\frac{d^2t}{dr^2}+\frac{1}{r}\cdot\frac{dt}{dr}=0$$

с граничными условиями второго рода:

$$\begin{cases} q_l=\dfrac{2\pi(t_1-t_2)}{\dfrac{1}{\lambda_1}\ln\dfrac{r_2}{r_1}} \\ q_l=\dfrac{2\pi(t_2-t_3)}{\dfrac{1}{\lambda_2}\ln\dfrac{r_3}{r_2}} \end{cases}$$

и с начальными условиями: температура газа внутри трубопровода после узла подключения $t_{ж1}$ = 30°С; температура грунта $t_{гр}$ = 16°С.

Примем следующие допущения:

1) грунт – суглинок, $\lambda_{гр}$ = 0,9 Вт/(м·К);

2) температура окружающего воздуха $t_в$ = 20°С, скорость ветра у поверхности земли $w_в$ = 5 м/с;

3) изоляция трубопровода – пенополиуретан, λ_2 = 0,04 Вт/(м·К), толщина δ_2 = 3 мм;

4) трубопровод – сталь, внутренний диаметр $d_{вн}$ = 1020 мм, толщина стенки δ_1 = 16 мм, λ_1 = 38 Вт/(м·К), глубина залегания h = 1,5 м;

5) скорость движения газа в трубопроводе 7 км/ч.

Коэффициент теплоотдачи от газа к поверхности трубопровода:

α_1 = 21.02 Вт/(м²·К)

Коэффициент теплоотдачи от поверхности грунта к атмосферному воздуху определяется по формуле

$$\alpha_2 = 9{,}77 + 0{,}04\,(t_{гр} - t_в) + 7\sqrt{w}_в = 25.26 \text{ Вт/(м}^2\cdot\text{К)}.$$

Линейная плотность теплового потока от заглубленного трубопровода

$$q_\ell=\frac{\pi(t_ж-t_в)}{\dfrac{1}{\alpha_1 d_1}+\dfrac{1}{2\lambda_c}\ln\dfrac{d_2}{d_1}+\dfrac{1}{2\lambda_u}\ln\dfrac{d_3}{d_2}+R_{гр}} = 22.87 \text{ Вт/м},$$

где $R_{гр}=\dfrac{1}{2\lambda_{гр}}\ln\left[\dfrac{2h_э}{d_3}+\sqrt{\left(\dfrac{2h_э}{d_3}\right)^2-1}\right]$ – термическое сопротивление грунта;

$$h_э = h+\frac{d_3}{2}\left[1+ch\left(\frac{2\lambda_{гр}}{\alpha_2\cdot d_3}\right)\right].$$

Рассмотрим вторую задачу – процесс теплопередачи через трехслойную стенку с внутренним изоляционным покрытием стенки трубопровода.

Дифференциальное уравнение стационарного теплообмена через стенку трубопровода в цилиндрической системе координат имеет вид:

$$\frac{d^2t}{dr^2}+\frac{1}{r}\cdot\frac{dt}{dr}=0$$

с граничными условиями второго рода:

$$\begin{cases} q_l=\dfrac{2\pi(t_1-t_2)}{\dfrac{1}{\lambda_1}\ln\dfrac{r_2}{r_1}} \\ q_l=\dfrac{2\pi(t_2-t_3)}{\dfrac{1}{\lambda_2}\ln\dfrac{r_3}{r_2}} \\ q_l=\dfrac{2\pi(t_3-t_4)}{\dfrac{1}{\lambda_3}\ln\dfrac{r_4}{r_3}} \end{cases}$$

и с начальными условиями: температура газа внутри трубопровода после узла подключения $t_{ж1}$ = 30°С; температура грунта $t_{гр}$ = 16°С.

Примем следующие допущения:

1) для трубы и внешней изоляции исходные данные те же, как и в предыдущей задаче;

2) характеристики внутреннего изоляционного минерально-полимерного покрытия: λ_n = 0,07 Вт/(м·К), толщина δ_n = 2 мм;

Коэффициент теплоотдачи от газа к поверхности трубопровода:

α_1 = 21.02 Вт/(м²·К)

Коэффициент теплоотдачи от поверхности грунта к атмосферному воздуху определяется по формуле

α_2 = 9,77 + 0,04 ($t_{гр}$ - $t_в$) + 7 $\sqrt{w}_в$ = 25.26 Вт/(м²·К).

Линейная плотность теплового потока от заглубленного трубопровода

$$q_l=\frac{\pi(t_{ж}-t_{в})}{\dfrac{1}{\alpha_1 d_1}+\dfrac{1}{2\lambda_n}\ln\dfrac{d_2}{d_1}+\dfrac{1}{2\lambda_c}\ln\dfrac{d_3}{d_2}+\dfrac{1}{2\lambda_u}\ln\dfrac{d_4}{d_3}+R_{гр}}=11.61\ \text{Вт/м},$$

где $R_{гр}=\dfrac{1}{2\lambda_{гр}}\ln\left[\dfrac{2h_э}{d_4}+\sqrt{\left(\dfrac{2h_э}{d_4}\right)^2-1}\right]$ – термическое сопротивление грунта;

$$h_э=h+\frac{d_4}{2}\left[1+ch\left(\frac{2\lambda_{гр}}{\alpha_2\cdot d_4}\right)\right].$$

В результате расчетов установлено, что тепловой поток после покрытия внутренней стенки защитным полимерным слоем в 2 мм уменьшился в 1,97 раз. Это означает, что стальная стенка трубопровода будет меньше нагреваться, как следствие будет меньше расширяться и сжиматься.

4. Заключение

Газовые отводы компрессорных станций после узла подключения эксплуатируются при широком диапазоне перепада температур. Перекачиваемый газ после

компримирования нагревается. Согласно требованиям ПАО «Газпром» его необходимо охлаждать. Чаще всего используют воздушное охлаждение при помощи аппаратов воздушного охлаждения, у которых эффективность днем в жаркую погоду снижается, а к вечеру – увеличивается. Соответственно, в процессе эксплуатации диапазон температур широкий, что не может не сказаться отрицательно на трубопроводе. Таким образом, внутреннее изоляционное минерально-полимерное покрытие позволяет уменьшить тепловой поток через стенку трубопровода. Как следствие, снижаются резкие перепады температур в процессе эксплуатации, что уменьшает вероятность образования КРН трубопровода.

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Защита элементов трубопровода от коррозионного растрескивания под напряжением

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Аннотация. В работе проведен анализ причин возникновения коррозионного растрескивания под напряжением магистральных трубопроводов. Для снижения вероятности возникновения трещин предложено изолировать внутреннюю стенку магистрального трубопровода минерально-полимерным покрытием. Построена математическая модель теплопередачи через многослойную цилиндрическую стенку в грунте, в которой учтены влияние, температуры грунта, глубина залегания магистрального трубопровода на тепловой поток через стенку трубопровода. В результате, использование внутреннего изоляционного минерально-полимерного покрытия позволяет уменьшить тепловой поток через стенку трубопровода почти в два раза, что уменьшает вероятность коррозионного растрескивания под напряжением трубы.

Ключевые слова: коррозионное растрескивание под напряжением, магистральный газопровод, уравнение теплопроводности, тепловой поток.

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Appraisal of Planning and Control as Management Tool for Optimum Productivity on Construction Sites

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Abstract

An appraisal of planning and control as management tool for optimum productivity on construction sites was assessed with the view of finding the various ways to establish the best alternative planning and control techniques for some particular kinds of projects. Questionnaires were distributed to professionals. Not all construction firms have a separate planning department, this means that they integrate the planning job into other department, and out of the 43 respondents, none had PhD, while majority had M.Sc. A minimum level of planning tools and procedure use is important but what kind of tools is of no importance. However, the most used planning technique for building projects is the Bar chart/Gantt chart and it was discovered that its choice was due to the reasons being that they are simple and easy to handle and manipulate, flexible and it graphically presents the activities with their start time and dates along with links and overlaps. It is suitable for all kinds of project irrespective of its size and nature. Planning tools like progress curve, line of balance, project evaluation and review techniques (PERT) are almost non-existence. The major challenge encountered on site when implementing the plan is delay in completion of the works and dispute does arise between the construction team. Most planners nowadays use computer Aided software to prepare and design their plan, and the major software used is Microsoft project among others. Furthermore, it encourages project managers to believe that although planning does not guarantee project success, lack of planning will probably guarantee failure. Finally, it was revealed from this research that planning is never an easy undertaking but it requires attention since it helps to achieve success. Similarly, Planning is considered a central element of modern project management, the assumption behind the position is that planning reduces uncertainty and increases the likelihood of project success.

Keywords: planning, control techniques, project evaluation, tools, disputes.

1. Introduction

For a construction project to be successful it is essential to have a plan. As it is normally acknowledged that to fail to plan, is to plan to fail, in other words, the upshot of failure to plan has led to quite a number of projects being abandoned before anticipated completion dates over the years. There is a fact that once a project has been planned there is need for accurate control so that the anticipated plan is achieved and monitored. Control in a broad knowledge is all management actions required to try to ensure strict adherence to plan so it do not affect the successful completion of the project (Tarigan, 2013).

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Considering millions of naira spent on construction projects by both private and government agencies, the daily development brought by technology in construction industry and the various sizes of firms, there is therefore need to examine planning and control as an effective tool for project management in building industries (Ugochukwu et al., 2014).

Construction project may be considered as a step unknown fraught with risk and uncertainty (Ogunberu et al., 2018). No two projects are ever alike and even a repeated project will defer from its predecessor in one or more commercial, administrative and physical aspect. However, without planning it is difficult to envisage the successful control of time, money or resources (Wang et al., 2017).

The basic function of project planning is to provide realistic plans, which become management tools to use as the basis for control action. Planning is also essential in order to deal with construction risks and devise safe working methods. This is true throughout all stages of the project from inception through the design, tendering, construction and commissioning stages of a project (Ugochukwu et al., 2014).

Finally, construction projects possess characteristic, which make the individual planning of each project essential, hence, there is therefore need for total project planning which has to be controlled within cost limits, schedule time with desired quality for successful project execution (Sinesilassie et al., 2017).

Consequently, the failure to effectively plan a project has led to a number of projects discarded, hideous and even belated completions (Wong et al., 2017).

2. Materials and methods

Population and study area

In view of this research topic and aim, the potential survey population in this study primarily includes professionals in the building industry, within Kaduna metropolis where a number of construction projects exist which makes the research a worthwhile venture. The target population of this study is completed and on-going projects within Kaduna and Zaria, and consultancy and contracting firms within Kaduna state were the area of the study.

Data collection and distribution

This section deals with approach to the study. The investigation was carried out through the use of multiple questionnaires administered to various construction sites and firms and also consultancy firms within Kaduna/Zaria metropolis.

Nature of the questions

The questionnaire was well designed to attain its objectives mentioned in chapter one of this research study. To facilitate easy response and analyses, the structured questionnaire was divided into two (2) sections A, B. Section A contains general information about the respondent, and his/her firm, while section B, contains questions about the use of planning and control techniques. These questions are also of different types, which are closed ended (restricted) questions with multiple answers for respondents to select as applicable. In addition, the open-ended (non-restricted) questions were included to allow respondents supply other answer where the ones on the body of the questionnaire were sufficient.

However, questions were asked to find the true situation existing planning in the techniques as state in the literature review and how often they were used to execute. Hench, each planning technique was design with open-ended question to know the reason why it is being preferred to the other techniques for a particular project at a point in time.

Statistical tool for data analysis

In order to test for the most widely used planning technique for a particular project with its effectiveness and control method applied, it is necessary to carry out the analysis of the various information collected from the questionnaire in a statistical manner. The type of statistical tool employed for analyzing the data and information gathered is the descriptive analysis; percentile method, frequencies, statistical summary by using, Statistical package for social science (SPSS).

3. Results

Table 1. Administered Questionnaires

QUESTIONNAIRE	NUMBERS	PERCENTAGES (%)
Administered copies	60	100
Returned	43	71.7
Not returned	17	28.3

The Table 1 shows that, a total number of 60 questionnaires were administered to different professional in construction firms and construction site. 43 copies which amount to 71.7 % was returned while 17 copies (28.3 %) were not retrieved giving 100 %.

Presentation and analysis of demographic variables

Table 2. Years of respondents in service

YEARS	FREQUENCY	PERCENTAGES (%)
0-5	12	27.9
6-10	13	30.3
11-15	13	30.3
16 and above	5	11.5
total	43	100

The Table 2 shows that the respondents within the years of service 6-10 years and 11-15 years have the highest frequency with 13 (i.e. 30.3 %), followed by those that falls within 0-5 years accounting 12 (27.9 %), while those within 16 and above are the least with 11.5 %.

Table 3. Area of specialization

SPECIALIZATION	FREQUENCY	PERCENTAGES (%)
Architect	14	32.5
Quantity Surveyor	17	39.5
Builder	10	23.3
Other (Engineer)	2	4.7
Total	43	100

The above Table 3 shows the total respondents specializations owing that out of the 43 respondents, 39.5 % were Quantity Surveyors, followed by 32.5 % who are Architects, and 23.3 % were builders while 4.7 % are engineers.

Table 4. Type of firm operated

TYPE OF FIRM	FREQUENCY	PERCENTAGES (%)
Consultants	17	39.5
Contracting	19	44.2
Both	6	14.0
No response	1	2.3
Total	43	100

From the above tabulation, it was shown that most respondents were operating contracting firms with a total of 19 (44.2 %), followed by 39.4 % who are consulting firms with 17, meanwhile,

6 (14.0 %) were operating both contracting and consulting at the same time. But among the respondents, 1 amounting to 2.3 % did not respond to this question giving a total of 100 %.

Table 5. Qualifications of respondents

QUALIFICATION	FREQUENCY	PERCENTAGE (%)
PhD	0	0
M.SC	20	46.5
B.SC/HND/B.TECH	22	51.2
OND	1	2.3
Total	43	100

It was shown above that the respondents with B.SC/HND/B.TECH degree were 22 amounting to 51.2 %, followed by M.SC degree holders with 46.5 % and 2.3 % were OND degree holder. However, it was shown that none of the respondents had PhD as a degree.

Table 6. Separate planning department

OPTIONS	FREQUENCY	PERCENTAGE (%)
Yes	27	62.8
No	16	37.2
Total	43	100

During this research study, the Table 6 shows the information giving by the construction firms and sites, it shows that 27 out of the 43 respondents i.e. 62.8 % of them do have a planning department were all there planning is being carried out, while 37.2 % of the 43 amounting to 16 do not have a planning department. However, this shows that not all construction firms have a separate planning department. They therefore believe planning works may be integrated into some other departments.

Table 5. Residential building projects

OPTIONS	FREQUENCY	PERCENTAGE (%)
Yes	42	97.7
No	1	2.3
Total	43	100

Most of the respondents have handled building projects meaning that 97.7 % with 42 said yes while only one had not handled a building project before.

Table 6. Commercial building projects

OPTIONS	FREQUENCY	PERCENTAGE (%)
Yes	38	88.4
No	5	11.6
Total	43	100

It was shown that 38 (88.4 %) of the respondents have handled commercial building, while 5 (11.6 %) are yet to handle any commercial building projects.

Table 7. Educational building projects

OPTION	FREQUENCY	PERCENTAGE (%)
Yes	35	81.4
No	8	18.6
Total	43	100

It was shown above that 35 (81.4 %) of the respondents have handled educational building projects while 8 respondents amounting to (18.6 %) respondents hadn't handled an educational building project before.

Table 8. Hospital (medical) building projects

OPTION	FREQUENCY	PERCENTAGE (%)
Yes	25	58.1
No	18	41.9
Total	43	100

The Table 8 shows that 25 (58.1 %) of the respondents have been involved in medical building projects and total number of 18 (41.9 %) have not handled medical building projects before.

Table 9. Recreational building projects

OPTIONS	FREQUENCY	PERCENTAGE (%)
Yes	19	44.2
No	24	55.8
Total	43	100

The above tabulated data shows that only 19 (44.2 %) of the respondents have handled recreational projects and most of the respondents have not handled this kind of building project before, this amount to 24 (55.8 %) out of the total 43 respondents.

Table 10. Type of building project affecting the choice of planning tool

OPTIONS	FREQUENCY	PERCENTAGE (%)
Yes	40	93.0
No	3	7.0
Total	43	100

The Table 10 depicts that 40 (93 %) of the respondents agreed that a building project type affect the choice of planning tool which whereby can be negative of positive, while only 7.0 % disagreed to the notion.

In addressing the first objective, the various planning control techniques were tabulated along the types of building projects they are used for. Among the various techniques were the Bar charts, Critical Path Method (CPM), Line of Balance (LOB) and the Programme Evaluation and Review Technique (PERT).

Table 11. Opinions of the respondents on the techniques they used for the various building projects

TYPES OF BUILDING PROJECTS	BAR CHARTS		CRITICAL PATH METHOD		LINE OF BALANCE		PROGRAMME EVALUATION AND REVIEW TECHNIQUE		NO RESPONSE	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Residential	36	83.7	2	4.7	0	0	4	9.3	1	2.3
Educational	25	58.1	8	18.6	1	2.3	4	9.3	5	11.6
Commercial	23	53.5	8	18.6	2	4.7	3	7.0	7	16.2
Hospital	12	27.9	8	18.6	2	4.7	3	7.0	18	41.8
Recreational	9	20.9	5	11.6	2	4.7	5	11.6	22	51.1

From the Table 11, for the residential buildings tools discovered to be commonly applied were the Bar charts. In this survey 36 out of the 43 or 83.7 % of the total respondents made use of Bar chart for residential building projects. The use of CPM was relatively low and accounted for only 4.7 % of the respondents. PERT was a little but higher than the CPM as tool for residential buildings. The respondents never used LOB at all for the residential building project.

In the case of educational building projects, the Bar charts was also the dominant tool used by the respondents with 25 or 58.1 % and accounted by the CPM was relatively higher with 18.6 % of the respondents using the tool for these type of project. PERT was used as a tool by 9.3 % of the respondents, and LOB was the least used tool and accounted for only 2.3 % of the respondents.

For commercial building projects, bar chart was revealed as the highest planning tool used and it accounted to 53.5 % of the total response. CMP again came behind with 18.6 % while LOB and PERT came least with 4.7 % and 7.0 % respectively.

As tool for hospital building projects, Bar charts still ranked the highest with 12 or 27.9 %, while CPM was ranked second with 18.6 %. PERT and LOB were scored 7.0 % and 4.7 % respectively. Hence, 41.8 % have not been involved in this project.

As for tools for recreational building projects, Bar Chart still scored the highest with 20.9 %, CPM and PERT were at par for 11.6 % each. LOB was the least used tool with only 4.7 % by the respondents. Hence, 58.1 % have not been involved in this project.

The Table 12 below also throws more light and the response is summarized below.

Table 12. Planning tool used for the various kinds of building projects

PROJECT TYPES	BAR CHART		CRITICAL PATH METHOD		LINE OF BALANCE		PERT		NO RESPONSE	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Large scale	17	39.5	14	32.6	1	2.3	7	16.3	4	9.3
Medium scale	30	69.8	6	14.0	1	2.3	4	9.3	2	4.7
Small scale	37	86.0	2	4.7	0	0	2	4.7	2	4.7

The Table 12 shows that about 39.5 % of those who undertook large scale projects made use of bar chart which is the highest followed by 32.6 % of the respondents who use CPM. While 16.3 % of them used PERT and 2.3 % used LOB which came last on the hierarchy, significantly, 9.3 % of the respondents had not been involved in large scale projects.

For the medium scale project types, bar chart still came top as the most used planning technique with 69.8 % of the response and 14.0 % followed for those who uses CPM, while PERT and LOB came behind with 9.3 % and 2.3 % respectively. It is also observed that LOB was still

ranked the rarely used planning technique while bar chart is the highly used technique. Also 4.7 % of the respondents did not give response.

For those who undertake small scale building projects, bar chart was still the most preferred planning technique, and 86.0 % of the total respondents chose bar chart, while CPM and PERT were at par with 4.7 % each, and it was obvious that none of the respondents in this case chose LOB.

Notwithstanding, from the summary of the above table, bar chart is dominantly used for all the different scales of project irrespective of size, and CPM and PERT followed respectively while LOB is still rarely used.

The Table 13 below shows the responses of the 43 respondents' opinions.

Table 13. Challenges encountered when implementing the plan on site

CHALLENGES	YES		NO	
	Frequency	%	Frequency	%
There was dispute	15	34.9	28	65.1
There was cost overruns	8	18.6	35	81.4
Total abandonment of the project	5	11.6	38	88.4
There was delay in completion	31	72.1	12	27.9
Project does not meet clients satisfaction	1	2.3	42	97.7
Others	2	4.7	41	95.3

From the above table it was deducted that most of the respondents were of the opinion that delay in completion was the major challenge they had while implementing the plan on site which is followed by there was dispute and there was cost overruns came 3rd on the list while other challenges followed with least percentages. Meanwhile, the reverse is the case for those who disagreed to this notion, meaning that a high percentage disagree that project does not meet clients satisfaction was a challenge, and total abandonment of the project was neither a challenge on site during the execution of the plan on site. Generally, the major challenge encountered by contractors in trying to implement the plan on site was delay in completion, while other alarming challenge was dispute on site.

Table 14. Projects with success (early completion) recorded

PROJECTS	FREQUENCY	PERCENTAGE (%)
0-15 %	3	7.0
16-30 %	5	11.6
31-50 %	7	16.3
51-70 %	25	58.1
70 % and above	3	7.0
Total	43	100

The research question above aims to see how many of the projects they completed early or as scheduled, and from the above table it was revealed that 25 (58.1 %) of the respondents said the projects they completed to time were between 51-70 % the above table is obvious that the highest is 51-70 % while the least was 0-15 % and 70 % and above respectively. In other words, the presentation shows that those who properly plan their projects in a separate planning department achieve success to an extent.

Table 15. Projects with success (within budget) recorded

PROJECTS	FREQUENCY	PERCENTAGE (%)
0-15 %	5	11.6
16-30 %	6	13.9
31-50 %	10	23.3
51-70 %	20	46.5
70 % and above	2	4.7
Total	43	100

Similarly, the Table 15 still shows the frequencies of the response on project success but as regards budget. 20 out of the 43 respondents said that they completed 51-70 % projects within project due to accurate planning and this accounts to 46.5 %, while those of 31-50 % came 2nd with 23.3 % and the least still remains 0-15 % and 70 % and above respectively. This table above revealed that there has never being a total project success irrespective of cost or time.

Table 16. Planning techniques suitable to use

TECHNIQUES	FREQUENCY	PERCENTAGE (%)
Bar chart	28	65.1
Critical path method	7	16.3
Line of balance	2	4.7
Pert	6	14.0
Total	43	100

The above question was asked to find out which of the planning techniques the respondents find suitable to use irrespective of the type of project and size of project. And from all above table the presentation shows that 28 respondents out of the 43 respondents chose bar chart which amounts to 65.5 % and the other techniques were nowhere to be compared to bar chart, but CPM was chosen next by 7 (16.3 %), while PERT and LOB followed with 14.0 % and 47 % respectively. It was noted that LOB is the most rarely used planning technique because it always come last on all ranking.

Table 17. Duration used by firm to prepare the plan using the planning techniques

TIME (IN WEEKS)	FREQUENCY	PERCENTAGE (%)
1-2	32	74.4
2-4	9	21.0
4-6	1	2.3
6 and above	I	2.3
Total	43	100.0

From the Table 17 it is obviously shown that 32 respondents out of the total 43 respondents amounting to 74.4 % takes one to two weeks to prepare their project plan, except the project is complex which will take them about 2-4 weeks, and they followed up with 21.0 %. It was observed that this above result is mostly for those who have a separate planning department.

It is shown from the Table 18 that accuracy of project planning depends on a large extent upon the ability of the planner to handle the tool properly follow up was the determinant, nature and size of the project.

Table 18. Determinants of the accuracy of project planning

DETERMINANTS	YES		NO	
	Frequency	%	Frequency	%
Availability of time	13	30.2	30	69.8
Ability of the planner to handle the tool properly	32	74.4	11	25.6
Nature of and size of the project	18	41.9	25	58.1
Accuracy/success of the project	14	32.6	29	67.4
Others	6	14.0	37	86.0

Table 19. Project manager could achieve a good degree of control on the project plan

CONTROL STRATEGIES	YES		NO	
	Frequency	%	Frequency	%
Threaten workers with punishment	0	0	43	100
Motivate workers with incentives	37	86.0	6	14.0
Move freely and frequently amongst those working on project site	13	30.2	30	69.8
Shows less concern about the workers working on the project site	0	0	43	100
Others	5	11.6	38	88.4

From the Table 19 it was shown that 37 respondents agreed that motivating workers with incentives would achieve a good degree of control on the project plan, and it followed by the manager moving freely and frequently amongst the workers on project site. In other words, none of the respondents agreed that to control the project plan managers should threaten his workers or show less concern about them.

Table 20. Planning does not guarantee project success but lack of planning will probably guarantee failure

OPTIONS	FREQUENCY	PERCENTAGE (%)
Yes	37	86.0
No	6	14.0
Total	43	100.0

The Table 20 shows that 86.0 % of the respondents agreed that planning does not give guarantee to project success while 6(14.0 %) of them disagreed to the notion.

Table 21. Methods used when designing the project plan

METHODS	FREQUENCY	PERCENTAGES (%)
Computer base software	28	65.1
Manually (by hand)	15	34.9
Total	43	100.0

The Table 21 presents the response of professional when designing their project plan. 28 (65.1 %) of the respondents uses computer aided software to prepare their plan, while 15 (34.9 %) still prefer manual preparation using their hand to draw on cardboard.

4. Conclusion

Having critically analyzed all data that are involved in carrying out effective planning and its control towards the timely and successful completion of project in the construction industry and having statistically analyzed the primary data with the aid of aforementioned statistical tool i.e. frequency, percentile and pie and bar charts through the help of statistical package for social science (SPSS).

The followings are the conclusions drawn after the completion of this research.

Bar Chart is the most effective planning technique generally accepted in construction firms because of the fact that its product result as fast as possible at an acceptable cost, also it can easily be applied and manipulated, and its flexibility makes it easier to adjust, above all it is easily interpreted by most managers and understood by workers on site, hence the reason for its frequent use is that it shows all programme of work with start and finish time and dates respectively. However, Line of Balance is rarely used simple because it is mainly used for repetitive projects and most respondents were not involved in that operation.

However, CPM is equally a technique that is used by few contractors and planners because they said it is too theoretically based, and the other techniques are rarely used due to their unique nature.

Also an effective laid down plan which is strictly adhered to encourages timely completion of project thereby reducing the number of claims presented such as liquidated and ascertained damages as a result of project not completed on time. Regular supply of necessary information to planning department is very essential for an effective planning as it reduces the number of time spent on planning.

The educational background of people who are directly involved with the planning for the construction firm greatly affect the effectiveness of planning. Accuracy of the project planning depends upon the accuracy of input information and on large extent the ability of the planner to handle the tool properly. However, planning is a function of management, which should be done by the top executive or managers because it requires experience.

In addition, short-term planning could serve as check resources in order to keep the master programme under constant review to achieve completion of project by planned date.

The assumption behind this position is that planning reduces uncertainty and increase the likelihood of project success. Although planning does not guarantee project success, but lack of planning will probably guarantee project failure.

In addition, with the growing technology and advancement in computerized planning tools techniques, most plans are prepared via the use of computer and the most used software package today is Microsoft project.

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The Upshot of Time Overrun in Building Project

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Abstract

The effect of time overrun in building construction projects was assessed with the view of finding the possible ways of mitigating the effects of time overrun in construction project.

A quantitative research method was adopted and data were collected by means of questionnaires. Research findings indicates that the time factor that have impact on construction project delivery include poor budgeting system, lack of proper cash flow, poor resource utilization, improper time schedule plan, unnecessary delays, poor management of time. The view of contractors regarding time in construction is experiencing a positive change from factors that require less concern or factors needed for reference purpose to those factors that determine the success of a project, factors that help in avoiding liquidated damages and the major factors to be considered in the preparation and submission of tender. The research also indicates that various relationships exist between construction project time and cost depending on the perspective in which it is viewed and value considered, relationship ranging from a trade-off to direct professional relationship all explain how related cost and time are in construction projects.

Keywords: building construction, construction project, industry.

1. Introduction

The strength and versatility of a construction industry provides a great portion of national economy and measured as an indispensable component through which physical development is achieved (Dakhil, 2013). Better project performance leads to better construction industry. Cost, time and quality are the key variables used to measure the performance of the project. The negative effect of time overrun is not limited just to the construction sector but also influence the overall economy of a country. Time overrun is defined as "a condition where a construction project does not complete within the designed time period". It happens when the work of contract does not complete in its prescribed time. Time overrun is a most common incident which occurs nearly in all the projects related to the construction industry (DeVol et al., 1999).

One of the basic goals of construction industry practitioners is to achieve timely completion of projects within stipulated budget and required quality as each day of time overrun in the completion of any project has direct impact on the cost of project (Ullah, 2020). In order to manage and control construction projects, there are various procurements strategies being adopted. Most popular strategies include traditional, management, integrated services and in-house teams (Dakhi, 2013). Construction industry is one of the most complex, fragmented industries referred as schedule and resource driven. In construction industry timely completion of

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project is a major criterion of project success (Dakhi, 2013). Time overrun is any delay beyond the baseline construction schedule. Minimizing time and cost is the main goal in managing a construction project. However, time delay frequently occurs in all phases of a construction project and consequently increases project total duration (Toğan, Eirgash, 2019). Very rarely projects are completed on time (Dakhi, 2013). This leads to pay serious attention to control construction time as each day of delay contributes a significant amount of revenue which is hardly recovered. Hence, a number of studies have been conducted to identify the factors causing time overrun.

The most important factors causing time overrun are design changes, poor labor productivity, inadequate planning, and resource shortages. Through a comparative study of causes of time overruns in construction projects in Hong Kong (Kamalirad et al., 2017).

In Malaysian, traditional lump sum system, design and build/turnkey system and Construction Project Management/Contract Management are commonly adopted in procurement strategies (Memon et al., 2011). However, literature shows that in spite of adopting various management practices, construction projects in many countries are still facing problem of time overrun which needs very serious attention. Malaysian construction industry is also facing the same problem of time overrun. To avoid this issue, very first and most important step is to identify and understand the causes and factors responsible for that. Hence, this study was carried out to identify the major cause of time overrun in Malaysian construction industry. However, this study was focusing on management procurement projects only and the respondents were personnel from Project management consultants.

In Ghana, studies in groundwater project and illustrated that owners, contractors and consultants ranked poor contractor management, monthly payment difficulties from agencies, material procurement, poor technical performances and escalation of material prices as major factors that can cause time overrun (Chileshe et al., 2011). Similarly (Mansfield et al., 1994) showed that the most significant factors affecting construction schedules were financing and payment for completed works, poor contract management, changes in site conditions, shortage of materials, and improper planning (Jurf, Beheiry, 2012). According to some studies 70 % of projects experienced time overrun (Ameh, Osegbo, 2011). The average time delay ranges from 10 % to 30 % of the original duration of the project. The study identified 6 main causes including change order, delay in progress payment, ineffective planning and scheduling of project by contractor, poor site management and supervision by contractor, Shortage of labours and Difficulties in financing project by contractor as most critical factors responsible for this time overrun. Delayed payment was found to be the number one cause of schedule delays in the Zambian road construction industry followed by protracted financial processes in client organizations, financial difficulties that accompany the delayed release of funds by client organizations, contract modification, material procurement and changes in drawings, staffing problems, equipment unavailability, poor supervision, construction mistakes, poor coordination on site and changes in specifications (Ameh, Osegbo, 2011). Unforeseen site conditions were found most prominent cause of schedule delay affecting total project duration and cost of project.

Time overruns is one of the biggest problems often experienced on construction project sites. Time overrun can instigate negative effects such as increased costs, loss of productivity and revenue many lawsuits between owners and contractors and contract termination. There are many factors that induce time delay on construction projects, however in some of identified factors includes: lack of funds to finance the project to completion, changes in drawings, lack of effective communication among the parties involved, lack of adequate information from consultants, slow decision making and contractors insolvency, variations among others. Also project management problems such as mistake and discrepancies in contract document, equipment availability and failure, mistakes during construction, bad weather, fluctuation in prices of building materials, inappropriate overall organizational structure linking to the project and labour are among the factors that could be observed and could be a clue to preventing time overrun on construction sites.. Abdullah (Toğan, Eirgash, 2019).

Construction industry in Nigeria is faced with a lot of problems, among which is delay in project execution. It has been researched, that delay is a major setback in the construction industry in Nigeria. The problem of delays in the construction industry is a global phenomenon. In Nigeria, it was observed that the performance of the construction industry in terms of time was poor (Adekunle, Ajibola, 2015). Ugochukwu, Stanley and Onyekwena (2014) have shown that seven out

of ten projects surveyed in Nigeria suffered delays in their execution. They also studied delays in Hong Kong construction industry. They emphasized that timely delivery of projects within budget and to the level of quality standard specified by the client is an index of successful project delivery. Failure to achieve targeted time, budgeted cost and specified quality result in various unexpected negative effects on the projects Normally, when the projects are delayed, they are either extended or accelerated and therefore, incur additional cost. The normal practices usually allow a percentage of the project cost as a contingency allowance in the contract price and this allowance is usually based on judgment. Although the contract parties agreed upon the extra time and cost associated with delay, in many cases there were problems between the owner and contractor as to whether the contractor was entitled to claim the extra cost. Such situations, usually involved questioning the facts, causal factors and contract interpretation. Therefore, delays in construction projects give rise to dissatisfaction to all the parties involved and the main role of the project manager is to make sure that the projects are completed within the budgeted time and cost.

The effect of construction time overrun may lead to project abandonment, delaying project which can equally affect the economic status of that country. Also if the resources are adequately harnessed, issues that pertains to time overrun would not arise which could result to variations and claims. Some firms rely on claim as a result of variation incurred during the course of the project execution and afterward evaluate their profit after incurring necessary and unnecessary time on a project.

Improper time assessment can also cause additional time in the form of delay which results in poor utilization of resources, increasing social and economic time and affect the overall delivery time. Most contractors are not using the appropriate resources to execute building project. Also, lack of mobilization of the resources needed within the approved time frame cause delay to the contracts (Doloi et al., 2012). Project management involves managing the resources, worker, machines, money, materials and method used. Some projects are effectively and efficiently managed while others are managed, incurring much delay and time overrun (Doloi et al., 2012). Assessing construction project time is critical in today's market driven economy. This relationship between construction project and time is called time trade off decision, which has been investigated extensively in the construction management literature. Decisions in time trade are complex and require selection of appropriate construction method for each project task.

Effects such as delays, additional time and adversarial relationship among parties are identified as the effects of time overrun, in light of this these research work tends to investigate the effects of time overrun in construction to identifying factors of time overrun in building construction project in Nigeria.

2. Materials and methods

Research design

A quantitative research method was adopted and data were collected by means of questionnaire. Survey designs are suitable when results are intended to be generalized to a wider population as in this research. Likewise, questionnaire has the ability to enhance objectivity in response and to minimize respondents' bias. It will also provide higher response rates that cannot otherwise be achieved with qualitative methods especially when studies are geographically widespread as the current research.

Study population

The study population of 95 was adopted from the work of Ahmad Sani (2016) in his work title an assessment the readiness of Nigerian construction professionals in the adoption of Building Information Modeling (BIM) technology.

Sample size and sampling technique

The sampling technique adopted for this study was the random sampling technique.

For the purpose of this study, Cochran's (1977) formula was used to determine the sample size. Cochran (1977) developed a formula for calculating sample size when the population is infinite or very large (Alhaji, 2020).

The sample size of the population based on the formula above is therefore 95 construction professionals.

Sources of data collection

In this research questionnaires were used to collect necessary information so as to provide answers to the research question. Close-ended questions are to be used in the questionnaire.

Primary data was collected using questionnaires administered to the target respondents. Primary data collection will involve a close-ended question in the questionnaire. The questionnaires were administered personally. This approach is chosen because it is affordable, time saving and allows for in-depth data collection as it fosters high rates of personal responses.

On the other hand, secondary data was collected from extant publications and researches. Thus, such data was gathered from; government releases, editorial in newspapers, newsletters, published, non-published dissertations and conference papers, and books.

Method of data analysis

Descriptive statistical methods would be adopted in the analysis of data. Data obtained from the field was process and analyzed using statistical packages for social science (SPSS) which will consists careful tabulation, coding, and descriptive statistics, to get a clear picture.

3. Results

Table 1. Breakdown of Administered Questionnaires

Number. Distributed	95
Number Retrieved	44
Percentage Response	46.32 %

From Table 1 above, it can be explained that out of 95 questionnaires distributed, 44 which amounts to 46.32 % were properly filled and returned. Based on the assertion of Moser and Kalton (1971), the result of a survey could be considered significant if the response rate is not lower than 30-40 %. Therefore, the percentage of the returned questionnaires is adequate for analysis.

Table 2. Years of experience

S/N	Level qualification	Frequency	Percentage
1	Diploma	9	20.5
2	Degree	18	40.9
3	Masters	14	31.8
4	PHD	3	6.8
5	Total	44	100

From Table 2 20.5 % have diploma, 40.9 % have degree, 14 % have masters and 6.8 % are PHD holders. Therefore responses received are up to the required standard because they are received from professionals with a recommendable qualification on the required field of study.

Table 3. Current Job

S/No	Profession	Frequency	Percentage
1	Architect	11	33.3
2	Engineer	9	30.0
3	Builders	3	10.0
4	Quantity surveyor	5	16.7
5	Others	3	10.0
6	Total	44	100

Table above shows that 33.3 % of the respondents are architects, 30.0 % are engineers, 10.0 % are builders, 16.7 % are quantity surveyors and 10.0 % comprises of other different professionals. This indicates that the responses obtained are from professionals on the required field.

Table 4. Years of Experience

S/N	Years of experience	Frequency	Percentage
1	1-5	7	15.9
2	6-10	16	36.4
3	11-15	8	18.2
4	16-20	8	18.2
5	More than 20	5	11.4
6	Total	44	100

Table 4, shows that 15.9 % of the respondents have years of experience between 1-5 years, 36.4 % have 6-10 years, 18.2 % have 11-15 years, again 18.2 % have 16-20 years and 11.45 have more than 20 years. From the table above it can be deduced that the responses is from professionals with the required years of experience in the construction industry.

Table 5. Organization Type

S/NO	Type of organization	Frequency	Percentage
1	Client	13	29.5
2	Contractor	22	50.0
3	Consultant	9	20.5
4	Total	44	100.0

From Table 5, 29.5 % of the respondents are of client organization type, 50.0 % are contractor's organization and 20.5 % are consultancy firms.

Table 6. Contract Amount

S/NO	Amount in naira	Frequency	Percentage
1	Less than 10 million	6	13.6
2	10-50 million	14	31.8
3	60-100 million	12	27.3
4	Above 100 million	12	27.3
5	Total	44	100

Table 5, show that 13.6 % of the respondents are into the project of less than 10 million naira, 31.8 % are into contract of between 10-50 million, 27.3 % are into contract of 60-100 million naira and 27.3 % are above 100 million naira.

4. Conclusion and recommendations

In view of the objectives of the research, it can be deduced that;

1. The time factor that have impact on construction project delivery include poor budgeting system, lack of proper cash flow, poor resource utilization, improper time schedule plan, unnecessary delays, poor management of time.

2. The view of contractors regarding time in construction is experiencing a positive change from factors that require less concern or factors needed for reference purpose to those factors that determine the success of a project, factors that help in avoiding liquidated damages and the major factors to be considered in the preparation and submission of tender.

3. Various relationship exist between construction project time and cost depending on the perspective in which it is viewed and value considered, relationship ranging from a trade-off to direct professional relationship all explain how related cost and time are in construction project.

Based on this study, some recommendations are given as follows:

(a) Appropriate funding levels should always be determined at the planning stage of the project so that regular payment should be paid to contractors for work done.

(b) In order to improve contractors managerial skills there is need for continues work

training program for personnel in the construction industry to update their knowledge and be familiar with project management techniques and processes as this assist in the proper and efficient management of time.

(c) Effective and efficient material procedure system should be established within projects as material procurement has the potential to cause major delays to construction projects.

(d) There should be adequate contingency allowance in order to cover increase in material cost due to inflation and employers or owners of the project should allow more time and funds for the study phases of projects.

(e) Contractors should regularly try to identify and bring to the attention of the client to project risk such as an ill-defined scope in the early stages (tender clarification meetings) of a project etc. and project managers must agree that delays or impact which cause extension of time and or increase in cost are a frequent occurrence in project construction.

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Equivalent Circuit of Al/SiO_2/*n*-Si Structures Irradiated by Helium Ions with Energy 5 MeV at Fluence 10^{12} cm^{-2}

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Abstract

Recently, metal-oxide-semiconductor structures using silicon dioxide is the most common microelectronic structures. Silicon dioxide (SiO_2) is used to isolate pole gate dielectric, and it is also the main material used to make stable, high-performance devices of integrated circuits. Electrical parameters at the Si-SiO_2 interface created by gamma irradiation depends on the type and penetration of the implanted ions. The paper provides a method of determining the equivalent circuit of a metal-oxide-semiconductor structure to determine its electrical parameters. The structure Al/SiO_2/n-Si irradiated by helium ions with energy 5 MeV at fluence 10^{12} cm^{-2} are studied to find its equivalent circuit. Result, the structure's equivalent circuit composing of a resistor and parallel RC circuit in series does not describe the frequency dependence of the electric loss in an alternating current at the frequency range 20 – $3 \cdot 10^6$ Hz. In the inversion region with voltage U = -40 V, equivalent circuits are developed and implemented in a wide frequency range. These circuits allow us to easily calculate electrical parameters through the frequency dependence of impedance characteristics.

Keywords: equivalent circuit, Al/SiO_2/n-Si structures, fluence.

1. Introduction

Silicon dioxide (SiO_2) is used to isolate pole gate dielectric (Hsu et al., 2016), and it is also the main material used to make stable, high-performance devices of integrated circuits (Mogeb et al., 1986). At present, the models of defects responsible for localization of electrons and holes in SiO_2 still continue to be discussed (Skuja, 1998; Pacchioni, Ierano, 1998; Gritsenko et al., 1998). Electron levels at the Si-SiO_2 interface created by gamma irradiation depends on the type and penetration of the implanted ions (Kaschieva et al., 2003; Kaschievaa, Todorovab, 2004). The main reason for changing the parameters of such materials under the impact of irradiation is related to the charge accumulation in the gate dielectric, as well as the increase in the density of surface states at the interfaces of the silicon layer with dielectric (Ogorodnikov et al., 2019).

The electrical parameters of the structure when exposed to ionizing radiation are the charge buildup in the dielectric and the increase in the density of surface states at the interface of the insulator/semiconductor (Ogorodnikov et al., 2019; Sze, 2008; Bentarzi, 2011). Therefore, we need the equivalent circuit that replaces the irradiated structure measured at inversion region (with voltage U = -40V) to calculate its electrical parameters.

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The purpose of this paper is to study the frequency dependence of the electric loss and then propose the equivalent circuits in inversion region of Al/SiO_2/n-Si structures, such the metal-oxide-semiconductor structures using silicon dioxide, irradiated by helium ions with energy 5 MeV at fluence 10^{12} cm^{-2} which are provided by OAO "INTEGRAL" of Ruhr University (Bochum, Germany).

2. Experiment

Al/SiO_2/*n*-Si structures are manufactured at OAO "INTEGRAL" under the cooperation agreement with BSU. These structures are then irradiated with the helium ions at fluence 10^{12}, which are produced by the accelerator of Ruhr University (Bochum, Germany). All the irradiations are performed at room temperature. Al/SiO_2/*n*-Si structures are fabricated on single-crystal *n*-type silicon sheets developed by Czochralski method (Shimura, 2012; Shimura, 2007). The resistivity of silicon is 4.5 Ohm.cm. A 420-nm thick layer of silicon dioxide (SiO_2) is formed by thermal oxidation at 950 °C for 225 minutes. Aluminum is deposited in the plane on SiO_2 layer by thermal spraying. The area of aluminum needle having a thickness of 0.7 μm is 1.85 × 1.85 mm^2. Bridges to the uneven side are also formed by A_l sputtering. The plates are divided into chips with area of 2.5 × 2.5 mm^2.

The simplest experimental devices for measuring conductivity in alternating current (AC) are usually based on Wheatstone bridge circuit (Grafov, Ukshe, 1973; Poklonski, Gorbachuk, 2005). In order to calculate the frequency dependence of the electrical loss, the frequency dependence of the actual impedance and the virtual impedance are measured with the Agilent 4285A precision LCR meter in the frequency range from 20 Hz to 30 MHz. The sinusoidal voltage amplitude does not exceed 40 mV. At the same time as the measurement of alternating current, we add the direct current U from -40 V (the inverse voltage U_r) to 0.2 V (the positive voltage U_f) on two poles of the Al/SiO_2/*n*-Si structure. The measurements are made at room temperature.

3. Results and discussion

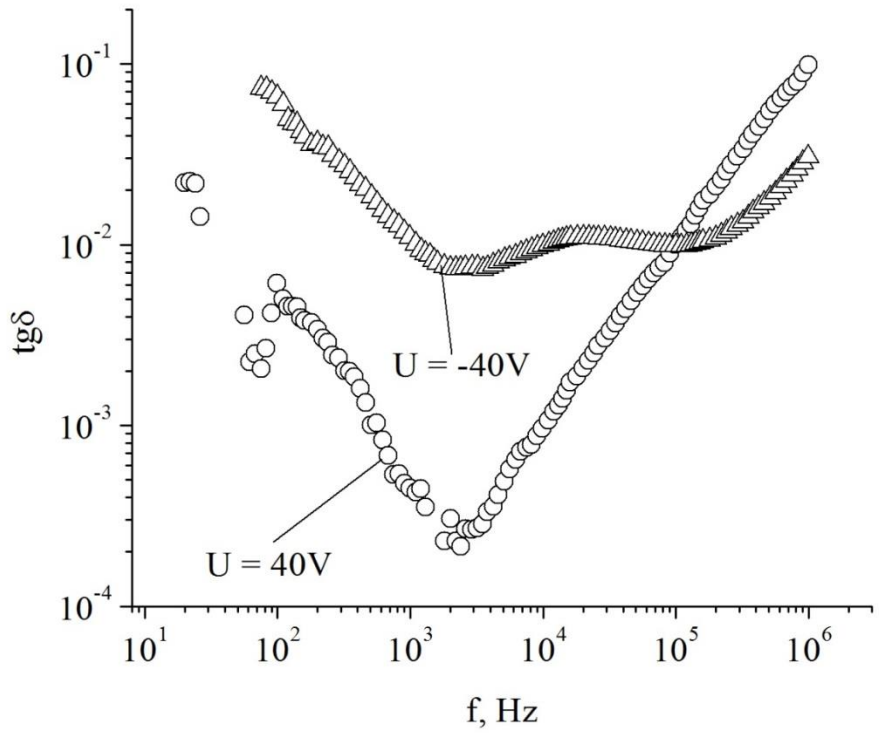

Fig. 1. The frequency dependence of the electrical loss on the structures irradiated by helium ions with fluence F = 10^{12} cm^{-2}

Figure 1 shows the frequency dependence of the electrical loss at the different voltage values U = -40 V (corresponding to inversion region) and U = 40 V (corresponding to accumulation region).

In the inversion region (U = -40 V), at 10-30 kHz, there is the presence of the maximum tgδ. However, the maximum position does depend on the polarity voltage. The higher the voltage is, the higher the transmission loss is, but the maximum is actually different among three regions. For p^+-n diodes, which are irradiated by electrons (Poklonski et al., 2010), the presence of the maximum loss at frequencies in the order of tens of kHz is determined by the charging loss of the radiation defect in the space charge region. With an decrease in the bias voltage, the tgδ increases, thereby leading the presence of the maximum. This maximum is associated with the reloading of radiation defects, and its position depends on the polarization voltage.

The position of the minimum depends on the U voltage. As the voltage decreases, the minimum moves to a higher frequency. The increase in tgδ under irradiation levels of 10^{12} cm^{-2} is also contributed by the recombination process which generated in the space charge region. The accumulation of radiation defects actually not only leads to the offset of impurities, but also increases the speed of generation of charged particles, which contributes to the increase of the current.

In the accumulation region (Sze, 2008), the equivalent circuit of the irradiated structure consists of a insulator capacitor (C_o) in series with a circuit whose a capacitor is connected in parallel with a resistor in series with the series resistance (R_s). In this parallel circuit, the capacitance of the capacitor corresponds to the C_d capacitance of the space charge, and the resistance of the resistor corresponds to its R_d resistance. However, in the case when $\omega = 2\pi f \gg 1/R_dC_d$, it is necessary to take into account the series resistance R_s (Figure 2, № 1).

The simplest equivalent circuit (Figure 2, № 1) does not allow us to explain experimental frequency dependencies of tgδ. This can be proved by analyzing the dependence of electric loss on frequency. The electric loss is determined for circuit № 1 by the formula (Poklonski, Gorbachuk, 2005; Barsoukov, Macdonald, 2005; Berman, Lebedev, 1981):

$$Z = R_s + \frac{R_d}{1+i\omega C_d R_d} + \frac{1}{i\omega C_0} = R_s + \frac{R_d}{1+\omega^2 C_d^2 R_d^2} - i\left(\frac{\omega R_d^2 C_d}{1+\omega^2 C_d^2 R_d^2} + \omega C_0\right) = Z' - iZ'' \quad (1)$$

Here, $\omega = 2\pi f$ – corner frequency, Z' and Z'' – real impedance and virtual impedance:

$$Z' = R_s + \frac{R_d}{1+\omega^2 C_d^2 R_d^2} = R_s + \frac{R_d}{1+(\omega\tau)^2} \quad (2)$$

$$Z'' = \frac{\omega R_d^2 C_d}{1+\omega^2 C_d^2 R_d^2} + \omega C_0 = \frac{\omega\tau R_d}{1+(\omega\tau)^2} + \omega C_0 \quad (3)$$

$\tau = R_dC_d$ – time constant

So from formula (2) và (3) we have:

$$\text{tg}\delta = \frac{Z'}{Z''} = \frac{R_s + \frac{R_d}{1+(\omega\tau)^2}}{\frac{\omega\tau R_d}{1+(\omega\tau)^2} + \omega C_0} = \frac{R_s\left(1+(\omega\tau)^2\right)+R_d}{\omega\tau R_d + (1+(\omega\tau)^2)\omega C_0} \quad (4)$$

Therefore, the minimum of the derivative $tg\delta$ in ω (corner frequency) is inconsistent in Figure 1 for the experimental data of the irradiated structure. In order to describe electrical loss depending on the frequency of the irradiated structure, the study should use more complex equivalent circuits, such № 2 and № 3 alternative equivalent circuits shown in figure 2 (Poklonski, Gorbachuk, 2005; Barsoukov, Macdonald, 2005). Equivalent circuit № 2 takes into account the capacitance C_{SC} and circuit № 3 contain a constant phase element (CPE). These two circuits correspond to the three-layer model: the first layer is the space charge layer, the second layer is the quasi-continuous radiation-disturbed layer and the third layer is the base layer.

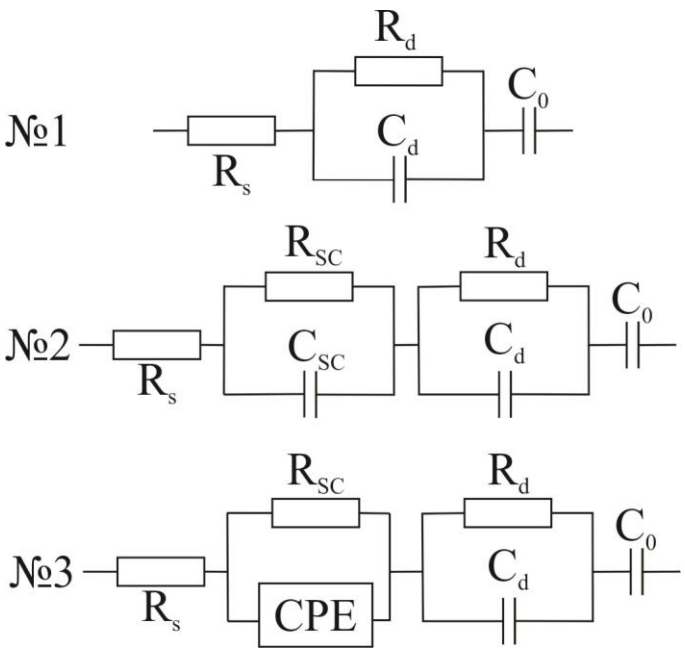

Fig. 2. The equivalent circuit replaces the structure Al/SiO_2/*n*-Si
№1 – structure in the accumulation region; №2 and №3 – structure in the inversion region

The calculation of parameters of equivalent circuits is made for frequencies in the range from 20 Hz to 30 MHz using the complex non-linear least squares (CNLS) method (Kaschievaa, Todorovab, 2004; Barsoukov, Macdonald, 2005):

$$\Omega = \sum_i \left\{ \frac{\left[C_m^*(\omega_i) - C_m(\omega_i)\right]^2}{C_m^{*2}(\omega_i)} + \frac{\left[G_m^*(\omega_i)/\omega_i - G_m(\omega_i)/\omega_i\right]^2}{G_m^{*2}(\omega_i)/\omega_i^2} \right\} \quad (3.1)$$

where $C_m^*(\omega_i), G_m^*(\omega_i)$ – experimental value of capacitance and admittance; $C_m(\omega_i)$, $G_m(\omega_i)$ – the values are calculated for equivalent circuits.

Therefore, to describe the frequency dependence of the impedance of the Al/SiO_2/*n*-Si structure in the accumulation region, we use the equivalent circuit shown in figure 2 (circuit №1). According to the approximate results, the values of Al/SiO_2/*n*-Si structure irradiated with fluence 10^{12} cm^{-2} are obtained for the elements of equivalent circuit № 1: R_d = (1.3±0.196)·10^6 Ω; C_d = (7.05±0.497) ×10^{-9} F; R_s = (29.15±0.24) Ω; C_o = (2.82 ±0.008)x10^{-10} F. Same to the equivalent circuits № 2 and № 3, the results are obtained in the Table 1.

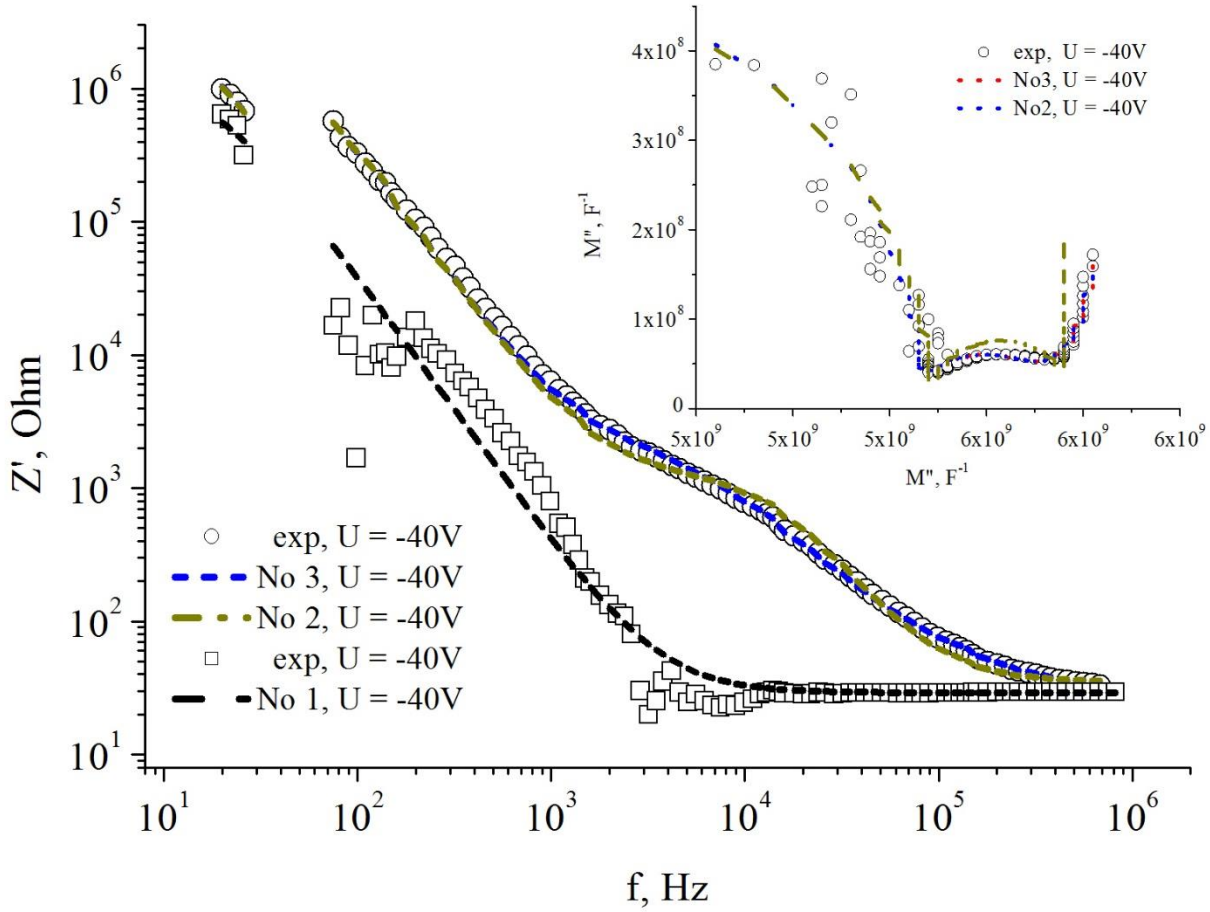

Fig. 3. Dependence of the real impedance Z' on the frequency f.
Right corner is the hodograph of the complex electrical module

Figure 3 shows the measurements at voltage U = -40 V (corresponding to the № 2 and № 3 equivalent circuits), U = 40 V (corresponding to the № 1 equivalent circuit), the real impedance Z' depending on the frequency of the structure irradiated with fluence 10^{12} cm^{-2} is calculated in most frequency bands.

Table 1. The values of equivalent circuits are obtained by approximating the real impedance depending on the frequency of the structure irradiated with fluence 10^{12} cm^{-2}.

Element	Equivalent circuit (fig. 2)		
	№ 1	№ 2	№ 3
R_d, MΩ	1.3 ± 0.19	4.29 ± 0.31	4.86 ± 0.31
R_{sc}, kΩ	-	1.242 ± 0.69	2.18 ± 0.18
R_s, Ω	29.15 ± 0.24	35.11 ± 1.21	25.5 ± 1.45
C_d, nF	7.05 ± 0.49	7.13 ± 0.15	1.01 ± 0.03
C_{sc}, nF	-	1.06±0.036	-
C_o, nF	0.28±0.0008	0.22±0.001	0.22±0.001
CPE – A_o, $10^{-8}\,\Omega^{-1}.s^{\alpha}$	-	-	3.46 ± 0.508
CPE - α	-	-	0.88 ± 0.010

The constant phase elemant (CPE) has an admittance Y:

$$Y_{CPE} = A_0(i\omega)^{\alpha} = A_0\omega^{\alpha}[\cos(0.5\pi\alpha) + i\sin(0.5\pi\alpha)], \quad (1.10)$$

where A_0 – coefficient depends on value α. If $\alpha = 1$, the CPE element is the capacitor and A_0 has a capacitive size, if $\alpha = 0$, the CPE is the load and A_0 has a resistor size. In the intermediate case we can consider that the size of A_0 is $\Omega^{-1}.s^{\alpha}$.

The CPE element introduced in the equivalent circuit №3 takes into account the additional frequency dispersion, which may be due to the recharge of depth centers in the space charge region (Sze, 2008; Barsoukov, Macdonald, 2005; Poklonski et al., 2010).

Therefore, it can be argued that the equivalent circuit of the Al/SiO_2/*n*-Si structure must take into account the *n*-Si resistance in the accumulative region and the space charge region resistance R_{sc} in the inversion region.

4. Conclusion

Experimental results show that equivalent circuit composed of a resistor (series resistance) and a parallel RC circuit in series does not allow us to describe the dependence of the electric loss on the frequency of the alternating current. In the accumulation region, it is advisable to take into account the resistance of a substrate. And in the inversion region, the additional frequency dispersion of the impedance in the space charge region should be taken into account.

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Formation of the World Picture

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Abstract

The article describes model of formation of the picture of the world. It is shown that every individual has personalized picture of the world. Personalized picture of the world is being formed as the objective necessity of development. The article notes that there are three pictures of the world: scientific, everyday world picture and personalized. Personalized picture of the world is formed by education. Personalized picture of the world is approaching the everyday picture of the world on the stage of training. Personalized picture of the world is approaching a scientific picture of the world at the stage of research. Personalized picture of the world can surpass the scientific picture of the world, which is the basis of development.

Keywords: knowledge, cognition, world view, a model picture of the world, scientific picture of the world, the everyday world picture.

1. Introduction

Picture of the world is one of the fundamental concepts in science. World Pictures have different forms of implementation. There is a scientific picture of the world. There is a picture of the world, which creates a person in everyday life. This picture of the world can be called the application view of the world (Lektorsky et al., 2014) or everyday picture of the world. There are qualitative differences between the scientific world and the application view of the world. The scientific picture of the world has a lot of implementations: general scientific picture of the world, world separate science and other. General scientific picture of the world is built as the system of knowledge, including the synthesis of scientific theories and scientific directions.

General scientific picture of the world includes and synthesizes the picture of the worlds of separate sciences. Many science: psychology (Zinken, Joerg, 2004), education (Tsvetkov, 2014a), quantum mechanics (Sukhanov, 2005) and others are exploring the construction of the world picture. The scientific picture of the world is not the body of all the knowledge on objective world. It is the integral system of main concepts regularities of current reality at the present moment. The development of science creates a lot of models and methods for the construction of a scientific picture of the World.

Periodically, there are contradictions between the new research findings and old ideas belonging to the scientific picture of the world. This situation requires a new systematization of knowledge, forming a picture of the world. Most of the work in this area describes the result of knowledge – the picture of the world. Little attention is paid to the process of forming a model picture of the world.

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2. Materials and methods

The material used for the publication of the formation of the world picture.

The used systems analysis, epistemology, qualitative analysis as a method.

Theory

General picture of the world is being built on the unity and variety of different disciplinary studies. It is realized on disciplinary and interdisciplinary levels. In contrast to this, education is being built as part of the subject system. Education is not aimed at creation of integral picture of the world, it is aimed at teaching the profession within the groups of disciplines.

Attention should be paid to the following. A human uses high information technologies in scientific investigations. That's why today the role of information technologies and approaches including the picture of the world building increases. Statistics records information growth. New IDC Digital Universe study (Gantz, Reinsel, 2011) finds world's data is doubling every two years – growing faster than Moore's Law (Schaller, 1997).

The scales and intensity of information interaction (Tsvetkov, 2013) increase. This creates big data problem which prevent the uptake of growing flow of information. Current branches of information industry grow actively and become global and new branches are being formed. The information component of economic activity of market entities as well as influence of information technologies on scientific-technical, intellectual potential and nation's health significantly increases.

Information component of the society is the basis of development. It reflects the application view of the world. The applied value of informatics and information technologies consists not only in information processing but also in the fact of how human and social picture of the world develops. The scientific value of informatics and information technologies in the sphere of scientific investigations consists in correspondence of the used model of human living environment. The instruments of use of information technologies at building picture of the world are information models.

The picture of the world in informational concept is the complicated compound information construction (Tsvetkov, 2014b). The basis for building simple and complex information constructions is information units (Kratzer, 2002; Tsvetkov, 2009).

Information technologies are the mediator useful for analysis and generalization of information. Human is the creator of picture of the world. The scientific world cognition consists of different components, of which the following should be pointed out:

- cognitive actions of a human, which leads to the creation of new concepts, principles, theories, models, methods;
- practical actions of a human which leads to the creation of computer-aided productions, i.e. the process of implementation of scientific investigations;
- generalization of accumulated experience which allows to form world models that correspond to the achieved level of scientific development and cognition of surrounding world;
- acquiring new knowledge in the process of education and self-education.

Utilitarian approach studies education as the total of processes of acquiring knowledge for further professional activity. However due attention is not paid to the building of picture of the world as the task of education. At the same time the system of education plays an important role in formation of picture of the world. However it is oriented not to the building of integral picture of the world, but to the formation of picture of the world of separate scientific studies within learning trades. Correspondingly it has a differential impact on formation of social-personal picture of the world.

Person of society must imagine world, i.e. he must be able to build and use picture of the world models. This means that professional specialist must have his own picture of the world as the basis for professional and social activity. However modern education doesn't teach to build picture of the worlds and a specialist has to use his own methods and intellect for creation of picture of the world.

The picture of the world model under the modern conditions needs the use of information constructions and information models. That's why the picture of the world model can be considered as a complex information construction which includes elementary integrative models.

Any modern information construction includes different information units as the basis (Kratzer, 2002; Tsvetkov, 2009). These information units are different in their purpose.

For example, the information construction is filled with content while using semantic information units. This is the objective way of picture of the world model building.

General picture of the world does not exclude the existence of personified picture of the worlds which are built by the separate subject during analysis and cognition of surrounding world. These personified picture of the worlds are significantly different depending on intellect, amount of knowledge, mindset, mentality, traditions and other factors. This is the subjective way of picture of the world model building. That's why the world model built by a separate person is called the naive model.

The method of building such picture of the world is often based on the analysis of an individual position in the information situation (Tsvetkov, 2012) in which he finds himself. In the process of cognition of the world and creation the model or picture of the world one can be lack of descriptive means of the subject. This situation characterises the so called the semantic gap (Snider et al., 2001). In the simplest situation it is characterised by the lack of language means for description of the reality. In the broader sense the semantic gap is characterised by the lack of means of scientific description of the world.

Education allows overcoming the semantic gap of a certain subject. This allows the education to create instruments of picture of the world building of every person. The higher accomplishment is the more corresponding is the personified picture of the world to the scientific picture of the world.

Not only education, but also the picture of the world itself, motivates human for different actions including the increase of the education level or get additional education. Perception of the external world is performed by a person by means of the use of available world model, information about the external world and used instruments of cognition.

3. Discussion and results

Such approach gives us grounds to show the basis for constructing a model of the world in the form of expression (1).

$$F\{I(t_{i-1}), PW(t_{i-1}), Ex(t_{i-1}), C(t_{i-1})\} \quad (1)$$

$I(t_{i-1})$ is previous information about the external world, available to a person; $PW(t_{i-1})$ is previous world model; $Ex(t_{i-1})$ is accumulated experience; $C(t_{i-1})$ are instruments of cognition (concepts, theories, methods) acquired on the basis of accumulated experience of studying the world.

$F\{I(t_{i-1}), PW(t_{i-1}), Ex(t_{i-1}), C(t_{i-1})\}$ is the generation functional which describes the way of generation information about the external world on the basis of current data, previous experience, familiar instrument of cognition. This functional depends on the accepted model of the external world and accepted familiar instruments of cognition.

In practice different processes of model building $PW(t_i)$ are possible. These processes are displayed by the expressions (2), (3), (4), (5), (6)

$$F\{I(t_{i-1}) + \delta I, PW(ti_{-1}), Ex(t_{i-1}), C(t_{i-1})\} \rightarrow \quad PW(t_i, \delta I) \quad (2)$$

The process (2) describes the construction of picture of the world based on new information about the outside world (δI), previous experience, well-known tools of cognition.

It leads to a new model PW (t_i, δI). This model of the world-to-date at the moment of time ti. This process describes the updating picture of the world only through the new information. The process (2) is called the actualization process.

There may be situations when it is found out inaccuracy or error in the details of the foregoing picture of the world and make corrections to it. This situation is described by the expression (3).

$$F\{I(t_{i-1}), [PW(t_{i-1})+\delta PW], Ex(t_{i-1}), C(t_{i-1})\} \rightarrow PW(t_i, \delta PW) \quad (3)$$

The process (3) is realized on the basis of accumulated information about the outside world and modification δPW picture of the world by eliminating errors or inaccuracies in the description. Process (3) leads to a new model of the world picture PW (ti, δPW). The process (3) is called the error recovery process. It reflects the well-known in the science of trial and error.

A possible situation where a new experience is accumulated in δEx knowledge. It serves as the basis for the modernization of the picture of the world. This situation is described by the expression (4).

$$F\{I(t_{i-1}), PW(t_{i-1}), [Ex(t_{i-1}) + \delta Ex], C(t_{i-1})\} \rightarrow PW(t_i, \delta Ex) \qquad (4)$$

The process of (4) is realized on the basis of accumulated information about the outside world, previous experience and modification of this experience δEx. It leads to a new model PW (ti, δEx). The process of (4) is called the process of extracting knowledge from experience or transformation process of tacit knowledge

Regularly in scientific research, new tools of cognition δS or improving old methods of knowledge δS. The new tools of cognition are the basis for building a new world view. This situation is described by the expression (5).

$$F\{I(t_{i-1}), PW(t_{i-1}), Ex(t_{i-1}), [C(t_{i-1}) + \delta C]\} \rightarrow PW(t_i, \delta C) \quad (5)$$

Process (5) is realized on the basis of new instruments δC knowledge. New of cognition tools give qualitatively new results. Process (6) is called the process of introducing a new quality in the picture of the world.

Perhaps a radical change (RC) picture of the world, when there is a change of values of the functional F. The new picture of the world due to a combination of changes and is described by the expression (6).

$$RC(PW(t_{i-1})) \rightarrow PW(t_i, \delta I, \delta PW, \delta Ex, \delta C) \qquad (6)$$

Process (6) is realized on the basis of important discoveries, new theories, the information revolution, breakthrough research. Process (6) is called the radical transformation of the world picture. Thus, depending on changes in the functional component can be prepared by converting various models world picture.

Changing the scientific picture of the world causes a change in the everyday world view. Changing the scientific picture of the world motivates change in a personalized view of the world.

It is possible to ascertain the presence of three high-quality pictures of the world: scientific, daily, personalized

Personalized picture of the world is based on the relationship of the individual with the world around them. It can be in different relationships to the scientific picture of the world.

The body of knowledge and human experience motivates him to create a personalized view of the world. Initially, his picture of the world is naive. After graduating personalized picture of the world is close to the everyday picture of the world. Scientific studies bring a personalized view of the world to the scientific picture of the world

Deep research the subject create a personalized view of the world, which is ahead of the scientific picture of the world. This motivates the creation of a new picture of the world in accordance with one of the processes (2-6).

The problem of constructing a scientific picture of the world is related to the issue of the role of personality in history. The person's existence in the world is accompanied by his respond to the perceived and realized information about the surrounding world. This respond is implemented in the cognitive activity, which actualises – explicitly or implicitly – In the picture of the world model, created by an individual person. Naive picture of the world is being built as the respond to the practical human needs – as a necessary cognitive basis of his adaptation to the world. That's why any person in the process of education builds his own naive picture of the world. In the process of education a human creates and approaches his naive picture of the world model to the everyday world picture.

In the process of research person brings a personalized view of the world to the scientific picture of the world. In the process of deep research subject generates a personalized view of the world, which is ahead of the scientific picture of the world

4. Conclusion

There are several pictures of the world, which are interconnected. The world picture is a coherent system of knowledge. Personalized picture of the world of man creates education. Personalized picture of the world with the development of the individual approaches to everyday picture of the world. Personalized picture of the world with the development of the individual approaches the scientific picture of the world, and may it exceed. It contribute to the development of society. Education is the starting point of the formation of the world picture. Education should not only provide professional knowledge, but also to teach the construction of the world picture.

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