Sinxron generatorlarni qo‘zg‘atish tokini nazorat qilish asosida ishonchliligini oshirish

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Dolzarblik: Ushbu maqolada sinxron generatorlarning qo‘zg‘atish tokini nazorat qilish asosida uning ishonchliligini oshirish usuli ishlab chiqilgan. Sinxron generatorning qo‘zg‘atish cho‘lg‘amlari o‘zgarmas tok manbasidan ta’minlanadi hamda qo‘zg‘atish tizimi ishlab chiqarilgan quvvatni boshqarish va himoya qilish elementlarini o‘z ichiga oladi. Ushbu usulning boshqa mavjud usullardan farqi shundaki, generator qo‘zg‘atish tokining o‘zgarish sabablari *Matlab/Simulink* dasturi yordamida ko‘rsatib berilgan.

Maqsad: Mazkur usulni amaliyotga joriy qilishdan ko‘zlangan maqsad generatorlarning ishlash davrida qo‘zg‘atish cho‘lg‘amlarini izolyatsiyasini shikastlanishini, quvvat o‘zgarishlarini, elektr tarmog‘iga beriladigan kuchlanishning tushuvlari bilan bog‘liq bo‘ladigan avariyalarini oldini olish orqali ularning normal ishlash davrini uzaytirish, texnologik jarayonning uzliksizligini ta’minlash, generatorning texnik - iqtisodiy qismlariga sarflanadigan xarajatlarni kamaytirish hamda iste’molchilarini uzluksiz elektr energiya bilan ta’minlashdan iborat.

Usullar: Tadqiqotni tizimli yondashuv, regression tahlil va eksprerimentni nazariy rejalashtirish metodlari orqali olib borilgan. Elektr stansiyasi bir qancha qurilmalardan tashkil topgan bo‘lib bir-biriga bog‘liq ravishda ishlaydi. Shuning uchun tizimli yondashuv murakkab tizimlarni tasvirlashda muhim rol o‘ynaydi. Sinxron generatorlarni qo‘zg‘atish tokini nazorat qilishda elektromexanik parametrlarini vaqtga bog‘liq holda o‘zgarish funksiyasini matematik kutilma orqali tasvirlash va optimal yechimni topish uchun regression tahlil metodidan foydalanish qulayroqdir.

Natijalar: Tadqiqot natijalari “Navoiy issiqlik elektr stansiyasi” AJ da ishlab turgan 110 MVatt quvvatli sinxron generator parametrlari asosida olingan. Elektr stansiyalarida joylashgan sinxron generatorlarni qo‘zg‘atish tokini nazorat qilishda generatorning stator xamda rotor cho‘lg‘amlarining izolyatsiyasini shikastlanishi, kuchlanish tushuvlarini, tarmoqga beriladigan quvvat o‘zgarishlarini, texnologik jarayonning uzluksizligini, generatorlarning texnik-iqtisodiy qismlariga sarflanadigan xarajatlarni kamaytirish, iste’molchilarni uzluksiz elektr energiya bilan ta’minlash orqali energiya ta'minoti ishonchliligi va barqarorligini oshirishga erishildi.

Kalit so‘zlar: generator, qo‘zg‘atish tizimi, tok, kuchlanish, chastota, quvvat, stator, rotor, manba, ta’minot, avariya, shikastlanish, elektr energiyasi iste’moli, Matlab/Simulink.

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Повышение надежности синхронных генераторов на основе управления током возбуждения

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Актуальность: В данной статье описывается разработанный метод повышения надежности синхронных генераторов на основе управления током возбуждения. Возбуждающие цепи синхронного генератора питаются от источника переменного тока, а система возбуждения включает в себя элементы управления и защиты. Отличие этого метода от других существующих заключается в том, что причины изменения тока возбуждения генератора определяются с помощью программы Matlab/Simulink.

Цель: Целью является внедрение данного метода в практику для продления срока нормальной работы генераторов путем предотвращения повреждений возбуждающих колец, изменений мощности из-за аварий, связанных с падением напряжения, подаваемого на электрическую сеть; снижение технико-экономических затрат на элементы генератора и обеспечение потребителей бесперебойной электроэнергией.

Методы: Исследование проводилось на основе системного подхода, методов регрессионного анализа и теории планирования эксперимента. Электростанции с синхронными генераторами состоит из многих устройств, которые работают независимо друг от друга. Поэтому системный подход играет важную роль в описании сложных систем. При управлении током возбуждения синхронных генераторов удобнее описать функцию изменения электромеханических параметров во времени в виде математического ожидания, а также использовать метод регрессионного анализа для определения оптимального решения.

Результаты: Результаты исследования были получены на основе анализа параметров синхронного генератора мощностью 110 МВт, на АО “Навоийская тепловая электростанция”. Повышение надежности и устойчивости энергоснабжения достигается за счет контроля тока возбуждения синхронных генераторов электростанции, контроля изоляции статоров и роторов, падений напряжения, изменений мощности; снижаются затраты на технико-экономические компоненты генераторов, обеспечивается бесперебойное электроснабжение потребителей.

Ключевые слова: генератор, система возбуждения, ток, напряжение, частота, мощность, статор, ротор, источник питания, авария, повреждение, потребление электроэнергии, Matlab/Simulink.

Increasing the reliability of synchronous generators based on the control of the excitation current

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Relevance: In this article, a method has been developed to increase its reliability based on controlling the excitation current of synchronous generators. The excitation circuits of the synchronous generator are powered by an alternating current source, and the excitation system includes controls and protection of the generated power. The difference between this method and other existing ones is that the reasons for the change in the excitation current of the generator are indicated using the Matlab/Simulink program.

Aim: The purpose of introducing this method into practice is to extend the period of normal operation of generators by preventing damage to the insulation of the exciting rings, power changes, accidents associated with a drop in voltage supplied to the electrical network, ensuring the continuity of the technological process, reducing the cost of technical and economic parts of the generator and providing consumers with uninterrupted electricity.

Methods: The study was conducted using a systematic approach, regression analysis methods and theoretical experimental planning. The power plant consists of several devices that operate independently of each other. Therefore, a systematic approach plays an important role in the description of complex systems. When controlling the excitation current of synchronous generators, it is more convenient to describe the function of changing electromechanical parameters over time using mathematical expectation and use the regression analysis method to find the optimal solution.

Results: The results of the study were obtained based on the parameters of a 110 MW synchronous generator operating at Navoi Thermal Power Plant JSC. Increasing the reliability and stability of power supply was achieved by controlling the excitation current of synchronous generators located at power plants, damage to the insulation of the stator and rotor of the generator, voltage drop, changes in power supplied to the network, continuity of the technological process, reducing the cost of technical and economic components of generators, uninterrupted power supply to consumers.

Keywords: generator, excitation system, current, voltage, frequency, power, stator, Rotor, Source, Power supply, accident, damage, power consumption, Matlab/Simulink.

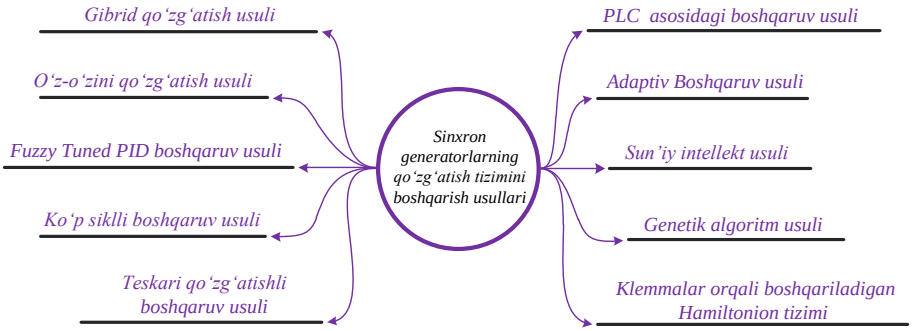
1. Kirish (Introduction)

Hozirgi vaqtda respublikamizda elektr energiyani ishlab chiqarish bo‘yicha sinxron generatorlardan keng ko‘lamda foydalanilib kelinmoqda, qolaversa sinxron generatorlar elektr stansiyalarning asosiy negizi hisoblanadi. Shunday ekan, sinxron generatorlarning ish jarayonlarida sodir bo‘ladigan avariyalarni erta aniqlab bartaraf etish bugungi kunning dolzarb vazifalardan biri hisoblandi [1–2]. Sinxron generatorlarning ish jarayoniga ta’sir qiluvchi avariyalardan biri bu uning qo‘zg‘atish tizimidagi tokning o‘zgarishi oqibatida vujudga keladigan avariyalardir. Ushbu tizimda vujudga

keladigan avariyalar tufayli ishlab chiqarilayotgan elektr energiyaning sifatiga katta ta’sir ko‘rsatadi, natijada, stator va rotor orasida hosil bo‘ladigan magnit maydonining o‘zgarishi, chastotaning og‘ishiga, stator va rotor qismlarining harorati ko‘tarilishiga, izolyatsiyaning yemirilishiga, bu holatlar esa generatorning ish rejimlariga salbiy ta’sir ko‘rsatadi. Sinxron generatorlarni qo‘zg‘atish tizimidagi tok bilan bog‘liq bo‘lgan muammolarni oldini olish uchun generatorlarning qo‘zg‘atish tokini muntazam ravishda nazorat qilib, diagnostik tahlil olib borish lozim bo‘ladi. Natijada, generatorning qo‘zg‘atish toki bilan bog‘liq bo‘ladigan avariyalarni erta aniqlanib ularni bartaraf etish imkoni yaratiladi [3–4].

2. Materiallar va usullar (Materials and Methods)

Issiqlik elektr stansiyalari hamda gidroelektr stansiyalarida joylashgan katta quvvatli sinxron generatorlarning rotoriga o‘rnatilgan qo‘zg‘atish chulg‘ami generatorning asosiy magnit maydonini hosil qilish uchun xizmat qilib kelmoqda. Ushbu chulg‘am o‘zgarmas tok manbaidan ta’minlanadi. O‘rta va katta quvvatli sinxron generatorlarning qo‘zg‘atish chulg‘amlari shu generatorning valiga o‘zgarmas tok generatoridan ta’minlanadi [6]. Qo‘zg‘atish tizimining asosiy vazifasi har qanday ekspluatatsiya ishonchlilik, foydalanishning qulayligi, texnik xizmat ko‘rsatishda va barqarorlikda o‘tkinchi jarayonning turg‘unligini saqlash hisoblanadi. Zamonaviy virtual kompyuter dasturlari orqali generatorning qo‘zg‘atish tizimini boshqarish usullarining bir nechtasi mavjud (1-rasm).

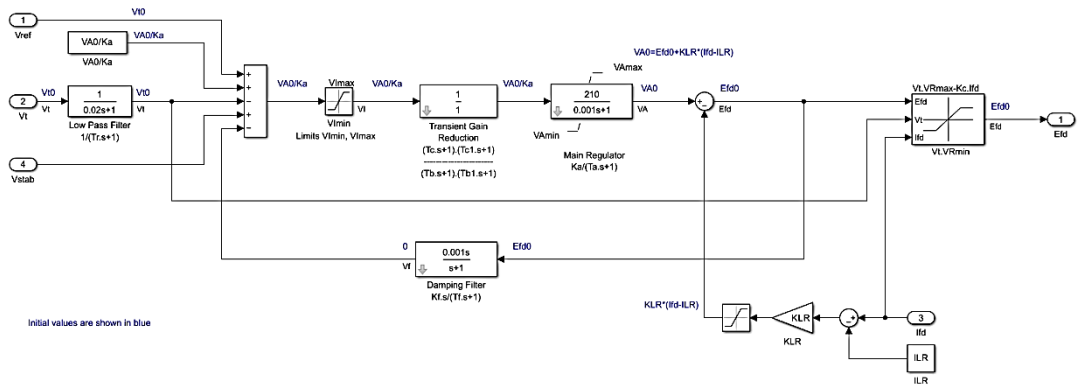


1-rasm. Sinxron generatorning qo‘zg‘atish tizimini boshqarishning usullari
Fig.1. Methods for controlling the excitation system of a synchronous generator

Statik qo‘zg‘atish tizimini joriy qilish hamda cheksiz katta quvvatli tarmoq bilan sinxron generatorni parallel ulab ishlatishning Matlab/Simulink virtual dasturi orqali simuliyatsiya modeli yaratilgan [7,8].

3. Natijalar (Results)

ST1A turidagi qo‘zg‘atish tizimida kuch hamda tok transformatorlar orqali generatordan ishlab chiqarilayotgan kuchlanish yoki tarmoqning yordamchi shinasidan olingan kuchlanish qo‘zg‘atkichga qaytariladi. Qo‘zg‘atkichga berilayotgan kuchlanish uch fazali to‘g‘rilagich yordamida to‘g‘rilanadi va boshqariladi. Ushbu turdagi qo‘zg‘atish tizimida maksimal qo‘zg‘atuvchi kuchlanish to‘g‘ridan-to‘g‘ri generator ishlab chiqarayotgan elektr enegiyasining kuchlanishiga bog‘lik bo‘ladi. Qo‘zg‘atish tizimining ST1A turida qo‘zg‘atkichga beriladigan kuchlanishni to‘g‘rilagich yordamida boshqarish imkoniyati yaratiladi (2-rasm) [9,10,11].

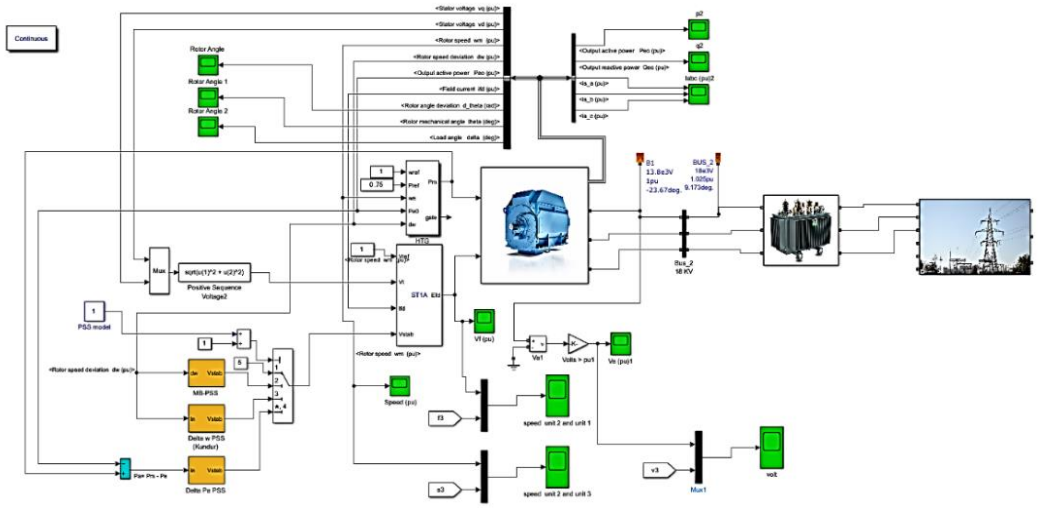


2-rasm. ST1A turidagi statik qo‘zg‘atish tizimining prinsipial sxemasi
Fig.2. A principled scheme of a static excitation system of type ST1A

Shunday qilib, yuqorida keltirilgan ST1A tizimda, generatorning klemmalarida vujudga keladigan nosozlik hamda qo‘zg‘atkichga beriladigan kuchlanishni kamayishini bartaraf qilish imkoniyati yaratish mumkin [12]. Qo‘zg‘atkichning maksimal kuchlanishi generatorning ishlab chiqarilayotgan kuchlanishga to‘g‘ri proportsional va to‘g‘rilagichning tartibga solish samarasi kirish signali (KS) qiymati bilan ifodalanadi. Ko‘p hollarda generator rotorini va qo‘zg‘atkichni himoya qilish uchun qo‘zg‘atish tokini cheklagich o‘rnatiladi [13,14].

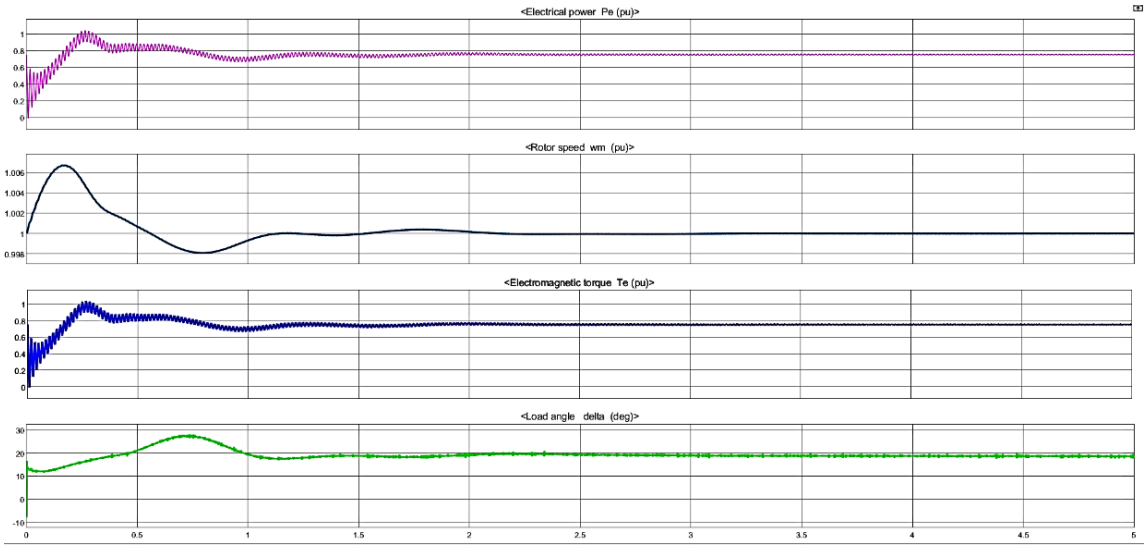
4. Muhokama (Discussion)

CHegaraviy dastlabki tokni (Id) parametri bilan, kuchaytirish koeffsentini esa (Cch) parametrlari orqali belgilanadi. Ushbu modelda cheklovchi ST1A turidagi qo‘zg‘atish modelining mos qiymatlari bilan chegaralovchi modelning qiymatlarini mosligini ta’minlash uchun o‘rnatiladi. Matlab/Simulink virtual dastur orqali SMIB (Single Machine Infinite Bus – katta kuvvatga ulangan tarmoq) ga ulangan sinxron generatorning ST1A turidagi qo‘zg‘atish tizimining virtual modeli ishlab chiqilgan (3-rasm).



3-rasm. Sinxron generatorning ulangan ST1A turidagi qo‘zg‘atish tizimining virtual modeli
Fig.3. Virtual model of the st1a type excitation system to which the synchronous generator is connected

SMIB ga ulangan sinxron generatorning ST1A turidagi qo‘zg‘atish tizimini quyida Matlab/Simulink virtual muhitida olingan simuliyasiya natijalari ko‘rsatilgan. Simuliyasiya vaqti t = 5 sek vaqt davomida amalga oshirildi (4-rasm).



4-rasm. Sinxron generatorining ST1A turidagi qo‘zg‘atish tizimi olingan natijalar
Fig. 4. Results obtained from the ST1A type excitation system of the synchronous generator

4- rasmda keltirilgan “____” rang generatorning ishlab chiqarayotgan quvvati o‘zgarishi; “____” rang generatorning rotorini o‘zgarishi holati; “____” rang generatorning elektromagnit momenti o‘zgarish holati; “____” rang generatorga beriladigan qo‘zg‘atish toki ko‘rsatilgan.

Yuqorida keltirilgan rasmda simuliyatsiya natijalari kelitirilgan bo‘lib, bular:

1 - holatda generator ishga tushishda quvvat o‘zgarishi 0 ÷ 1.5 sekund davomida o‘zgarishini kuzatish mumkin, 1.5 sekunddan keyin generator barqaror holatda ishlay boshlaydi;

2 - holatda rotorning tezligi qo‘zg‘atish toki berilgan holatda unda tebranish kuzatiladi va u 1.1 sekundda o‘z holatiga qaytib nominal tezlikda harakatlanadi;

3 - holatda generatorga qo‘zg‘atish toki boshlang‘ich holatda berilganda generatorning elektromagnit momentni 0 ÷ 1.1 sekund oralig‘ida o‘zgarishini ko‘zatiladi va u 1.1 sekunddan so‘ng barqaror holatga o‘tadi;

4 – holatda generatorga berilgan qo‘zg‘atish tokini o‘zgarishi kursatilgan bo‘lib unda boshlang‘ich 0 qiymatdan 0.5 sekundda berilgan nominal qiymatga erishadi, 0.5 ÷ 1 sekund oralig‘ida generatordagi o‘tkinchi jarayonning hisobiga qo‘zgatish tokini qiymati biroz ko‘tariladi va 1 sekunddan so‘ng qo‘zg‘atish toki nominal holatga tushishini kuzatish mumkin [14,15].

5. Xulosalar (Conclusions)

Xulosa qilib shuni aytish mumkinki elektr stansiyalarida joylashgan katta va kichik quvvatli sinxron generatorlarni qo‘zg‘atish tokini nazorat qilish generatorlarning elektromagnit-aylantiruvchi momentini, ichki qizishlarini, izolyatsiyaning yemirilishlarini, rotor aylanish tezligining o‘zgarishlari va ishlab chiqarilayotgan elektr energiyasining sifatining buzilishi hamda ish jarayonlarida buladigan avariyalarni aniqlash imkonini beradi. Natijada, generatorning ish jarayonlarida vujudga keladigan avariyalar erta bartaraf etilib, generatorlarning muddatdan oldin ta’mirga kelish holatlarining oldini olishga erishiladi.

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