Yem maydalash qurilmalarining asinxron motorini statik va dinamik rejimlarini boshqarish orqali energiya tejash

Nurali B. Pirmatov[1], Abdullo T. Panoyev[2]

[1] DSc, prof., Toshkent davlat texnika universiteti, Toshkent, 100095, O‘zbekiston; tstu_energy@mail.ru https://orcid.org/0000-0001-5212-2593
[2] PhD, dots., Buxoro davlat texnika universiteti, Buxoro, 200114, O‘zbekiston; panoev_abdullo@mail.ru https://orcid.org/0009-0001-2398-3068

Dolzarbligi: chastotaviy boshqarish tejamlidir, chunki u asinxron motorning tezligini rostlash hisobiga foydali ish koeffitsientini oshirish va quvvat isrofini kamaytirishni ta’minlaydi. Yem maydalash qurilmalarini ishga tushirish va boshqarishda chastota o‘zgartgich yordamida amalga oshirilishi ko‘rsatilgan bo‘lib, u avtomat va motor orasida o‘rnatiladi va motorning aylanish chastotasini boshqaradi. Elektr motorining tezligini o‘zgartirish uchun ilgari tishli uzatma (shesteryonka) reduktorlardan foydalanilar edi. Bu esa o‘z navbatida turli qiyinchiliklar keltirib chiqargan. Ishlab chiqarish texnologiyalarni o‘ziga xos tomonlaridan kelib chiqqan xolda elektr motorining aylanish sonini kamaytirish yoki ko‘paytirishga to‘g‘ri kelsa, elektr yuritmada qo‘shimcha mexanizmlardan foydalanish, o‘z navbatida elektr motorning quvvatini oshishiga olib kelgan. Chastota o‘zgartgichlar yordamida bevosita, elektr motor chastotasini o‘zgartirib aylanishlar sonini nazorat qilish mumkin. Bu usulning qulayliklaridan biri shundaki tok va aylanuvchi moment o‘rtasida mustahkam bog‘liqlik bo‘lgani bois, chastota o‘zgartgich motorni ishga tushirish vaqtida ishga tushirish tokini pasaytirish imkonini beradi. Motorni ishga tushirish vaqtida motor silliq ishga tushadi va ishga tushirish vaqtida elektr energiyasi tejaladi.
Maqsad: yem maydalash qurilmalarining asinxron motorini statik va dinamik rejimlarini boshqarish orqali energiya tejashni asoslash.
Usullari: chastotaviy boshqarish va eksperimental hamda qiyosiy tahlil usullaridan foydalanildi.
Natijalar: chastotani boshqarish elektr energiyasini 17% tejash, asinxron motorning tezligini rostlash, elektr yuritmani silliq ishga tushirish va to'xtatish, asinxron motorning quvvat isroflarini kamaytirish imkonini berdi.
Kalit so‘zlar: energiya tejamkorlik, elektr yuritma, chastota o‘zgartkich, optimal boshqaruv, energetik mezonlar, ishchi mexanizmlar, energiya samaradorlik, boshqaruv tizimlari, foydali ish koeffitsienti, quvvat koeffitsienti.

Экономия электроэнергии на основе управления статическими и динамическими режимами работы асинхронного двигателя кормоизмельчающих устройств

Нурали Б. Пирматов[1], Абдулло Т. Паноев[2]

[1] DSc, проф., Ташкентский государственный технический университет, Ташкент, 100095, Узбекистан; tstu_energy@mail.ru https://orcid.org/0000-0001-5212-2593
[2] PhD, доц., Бухариский государственный технический университет,, Бухара, 200114, Узбекистан; panoev_abdullo@mail.ru https://orcid.org/0009-0001-2398-3068

Актуальность: частотное управление является сберегающим, поскольку повышает коэффициент полезного действия асинхронного двигателя за счет выпрямления скорости асинхронного мотора и снижает потери мощности. Показано выполнение пуска и управления оборудования для измельчения кормов применением преобразователя частоты, который устанавливается между автоматом и мотором и управляет частоту вращения мотора. Ранее для изменения скорости электродвигателя использовались переднезубчатые (шестеренчатые) редукторы, что, в свою очередь, приводило к возникновению различных трудностей. В случае необходимости уменьшения или увеличения числа оборотов электромотора в связи с особенностями технологии производства, применение дополнительных механизмов в электроприводе, в свою очередь, приводило к увеличению мощности электромотора. С помощью частотных преобразователей можно напрямую регулировать число оборотов, изменяя частоту электродвигателя. Одним из преимуществ данного метода является то, что, поскольку ток и крутящий момент тесно взаимосвязаны, преобразователь частоты позволяет уменьшить пусковой ток при запуске мотора. При запуске мотор запускается плавно, что позволяет сберечь электроэнергию во время запуска.
Цель: обоснование экономии электроэнергии за счет управления статическими и динамическими режимами асинхронного двигателя кормоизмельчительных устройств.
Методы: применялись методы частотного управления, экспериментального и сравнительного анализа.
Результаты: частотное регулирование позволило сэкономить 17% электроэнергии, регулировать скорость асинхронного двигателя, плавно пускать и останавливать электропривод, а также снизить потери мощности асинхронного двигателя.
Ключевые слова: энергосбережение, электропривод, преобразователь частоты, оптимальное управление, энергетические критерии, рабочие механизмы, энергоэффек-тивность, системы управления, КПД и коэффициент мощности.

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Energy saving based on control of static and dynamic operating modes of asynchronous motors of feed grinding devices

Nurali B. Pirmatov[1], Abdullo T. Panoev[2]

[1] DSc, prof., Tashkent State Technical University, Tashkent, 100095, Uzbekistan; tstu_energy@mail.ru https://orcid.org/0000-0001-5212-2593

[2] PhD, dots., Bukhara State Technical University, Bukhara, 200114, Uzbekistan; panoev_abdullo @mail.ru https://orcid.org/0009-0001-2398-3068

Relevance: frequency control is saving because it improves the efficiency of the induction motor by rectifying the speed of the induction motor and reduces power loss. It is shown how to start and control the equipment for grinding feed using a frequency converter, which is installed between the machine and the motor and controls the speed of the motor. Previously, front gearboxes were used to change the speed of the electric motor, which, in turn, led to various difficulties. If it is necessary to reduce or increase the number of revolutions of the electric motor due to the peculiarities of the production technology, the use of additional mechanisms in the electric drive, in turn, led to an increase in the power of the electric motor. With the help of frequency converters, the speed can be directly controlled by changing the frequency of the electric motor. One of the advantages of this method is that since current and torque are closely related, the frequency converter can reduce the starting current when starting the motor. When starting, the motor starts smoothly, which saves energy during startup.
Aim: justification of energy savings due to control of static and dynamic modes of asynchronous motor of feed grinding devices.
Methods: methods of frequency control, experimental and comparative analysis were used.
Results: frequency control has enabled a 17% saving in electricity consumption, adjustment of the speed of the asynchronous motor, smooth start and stop of the electric drive, and reduction of power waste of the asynchronous motor.
Key words: energy saving, electric drive, frequency converter, optimal control, energy criteria, operating mechanisms, energy efficiency, control systems, efficiency and power factor.

1. Kirish (Introduction)

Bizlarga ma’lumki hozirgi vaqtda Respublikamizda qishloq xo‘jaligi sohasi borgan sari takomillashib, rivojlanib bormokda. Hozirgi kunda qishloq xo‘jaligida qo‘llanilayotgan yem maydalash qurilmalaridan foydalanish hamda unga bo‘lgan ehtiyojlar yildan-yilga oshib bormoqda. Ma’lumki elektr stansiyalar tomonidan ishlab chiqariladigan elektr energiya iste’molining 70 – 80 foizi elektr motorlariga to‘g‘ri keladi [2-15]. Shu sababli bugungi kunda, yem maydalash qurilmalarida qo‘llaniladigan asinxron elektr motorlarini ekspluatatsiya qilish jarayonida ularning samarali ishlashini ta’minlash, energetik qurilmalarning elektr energiya iste’moli rejimlarini zamonaviy avtomatlashtirilgan elektr tizimlar yordamida boshqarishni takomillashtirish, yem maydalash qurilmalarining asinxron motorlarining ish jarayonida sodir bo‘ladigan qisqa tutashuvlarni oldini olish, energetik qurilmalarning ta’miri uchun ketadigan sarf-xarajatlarni sezilarli darajada kamaytirish, qolaversa elektr energiyadan oqilona foydalanish hamda energiya va resurslarni tejashga alohida e’tibor qaratilmoqda. Shuning uchun ham yem maydalash qurilmalarini ekspluatatsiya qilish jarayonida energiya tejamkor usullar orqali ekspluatatsiya qilish hozirgi kunning dolzarb muammolaridan biri hisoblaniladi [6-13].

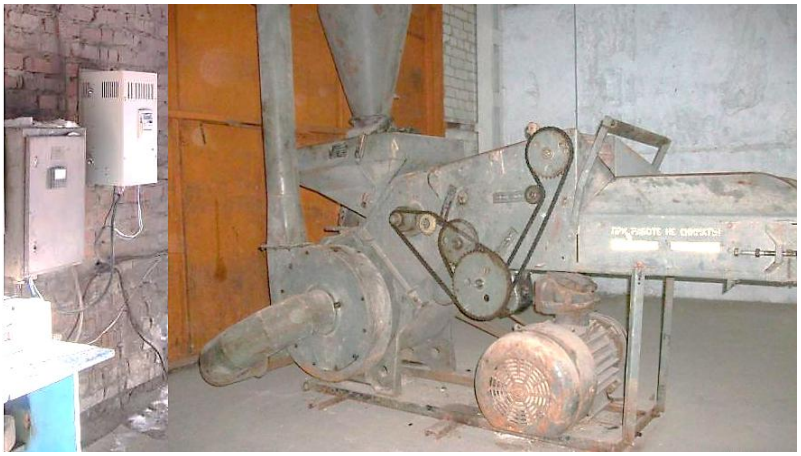
2. Usullar va materiallar (Methods and materials)

Hozirgi kunda “Buxoroparranda”AJ korxonasi misolida qo‘llanilib kelinayotgan Ukraina davlatida ishlab chiqarilgan КДУ-2,0; tipdagi universal yem maydalash qurilmasini oladigan bo‘lsak, bunda bu yem maydalash qurilmasining asinxron motorini bir necha usullar yordamida yurgizish mumkin. Bu universal yem maydalash qurilmasi bilan makkajo‘xori urug‘i, beda poyasi, bug‘doy somoni, bug‘doy, tariq, arpa, makkajo‘xori poyasi, g‘o‘zapoya, makkajo‘xori so‘tasini maydalashimiz va boshqa barcha qishloq xo‘jaligida yetishtiriladigan urug‘larni ham maydalash imkoniyatiga ega.

Bu universal yem maydalash qurilmasidan foydalanganimizda, maydalash qurilmasining asinxron motorida juda katta tok sakrashlari hosil bo‘ladi, uni ishga tushirish toki yoki tormozlangan rotordagi tok deb nomlanadi, bundan tashqari yemlarni yoki poyalarni birdaniga ko‘p ketib qolgan vaqtda, maydalagichning asinxron motorining aylanish tezligi pasayib, yuklamasi oshib ketishi natijasida motorning ishlash muddati qisqaradi. Universal yem maydalagichning asinxron motori chulg‘amlari qizishi natijasida kuyish holatlari va

reaktiv quvvat iste'mol qilishiga, elektr energiyasining juda ko'p isrof qilinishiga olib keladi. Universal yem maydalash qurilmasining asinxron motorini ishga tushirish jarayonida, ishga tushirish toki nominal tokidan 5-10 barobar yuqori bo'ladi [1-14]. Qisqa muddat ta'sir qiladi, tezlashib olganidan so'ng esa, asinxron motordagi tok minimal qiymatga tushib ketadi. Shuning uchun bu universal yem maydalash qurilmasini ekspluatatsiya qilish jarayonida, qurilmaning asinxron motorini ishga tushirish tokini kamaytirish, aylanish tezligini yuklamaga mos ravishda barqaror ish rejimida ishlashini ta'minlash, reaktiv quvvatini qoplash, ta'minot kuchlanishini stabillashtirish uchun hamda elektr energiyasini tejash maqsadida, ishga tushirishning quyidagi usullaridan foydalaniladi.

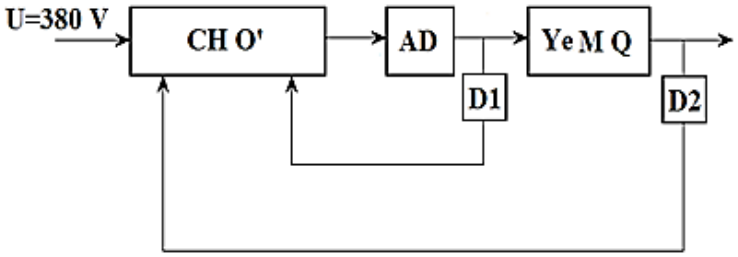
Shu usullardan biri bu universal yem maydalash qurilmasining asinxron motorini tezligini chastota o'zgartgich yordamida boshqarish usuli hisoblaniladi [4-8]. Bu universal yem maydalash qurilmasini ishga tushirish va boshqarishda chastota o'zgartgich yordamida amalga oshiriladi, u avtomat va asinxron motor orasida o'rnatiladi va asinxron motorning aylanish chastotasi chastota o'zgartgich orqali boshqariladi, qo'shimcha tarzda elektr energiya tejalishiga olib keladi [3-11]. O'tkazilgan tajribalar 1-rasmda ko'rsatilgan.



1-rasm. Universal yem maydalash qurilmasining asinxron motorini chastota o'zgartgich orqali boshqarish
Figure 1. Controlling the asynchronous motor of a universal feed grinder using a frequency converter

Bunda universal yem maydalash qurilmalarining asinxron motorini ishga tushirish va boshqarishda chastota o'zgartgich yordamida amalga oshiriladi. Tezligi chastotani o'zgartirib rostlanadigan asinxron elektr yuritmalarni statik rejimlarida elektr energiyadan iqtisod qilish bilan bir qatorda dinamik rejimlarida ham elektr energiyadan samarali foydalanish mumkin [5-10]. Universal yem maydalash qurilmalarining asinxron motorini to'g'ridan to'g'ri-tarmoq kuchlanishini boshqarmasdan ishga tushirish vaqtida ishga tushirish tokining nominal stator tokiga nisbatan 5 – 10 marta katta bo'lishi stator chulg'amida elektr energiya isrofini oshib ketishiga olib keladi. Agar asinxron motor va ishchi mexanizmlarning inersion momenti katta bo'lsa, o'tish jarayoni juda uzoq davom etadi [1-15]. Natijada stator chulg'ami izolyasiyasining ruhsat etilgan haroratidan yuqori darajada qizishiga olib kelishi va izolyasiyaning ishdan chiqishiga olib keladi. Shuning uchun ham universal yem maydalash qurilmalarining asinxron motorlarini ekspluatatsiya qilish jarayonida asinxron motorining aylanish tezligini chastotani o'zgartirib rostlanadigan asinxron motorlarni ishga tushirishda chastotani ma'lum qonuniyat bo'yicha boshqarib ishga tushirish, stator tokining o'ta oshib ketishidan saqlaydi va shunda yem maydalash qurilmalarining asinxron motori issiqlik rejimi bo'yicha normal ishga tushiriladi [7-12]. Ma'lumki, universal yem maydalash qurilmalarining asinxron motorini to'g'ridan-to'g'ri ishga tushirish vaqtida katta elektr magnit momentlari va toklar yuzaga keladi. Elektr magnit momentlarning katta amplitudali siltanishlari asinxron motor stator chulg'amida xavfli dinamik yuklanishlarni hosil qilishi mumkin va shuningdek, elektr yuritmaning kinematik zanjirlarida mexanik zo'riqishlarni yuzaga keltirishi ham mumkin [8-11]. Shuning uchun ham universal yem maydalash qurilmalarining asinxron motorini ishga tushirish va to'xtatishlarning silliq kechishini ta'minlashda, ya'ni katta dinamik zo'riqishlarni paydo

bo‘lishiga yo‘l qo‘yilmaslik asixron motorining ishlash muddatini uzaytiradi [1-15]. 2-rasmda universal yem maydalash qurilmasining asinxron motorini chastota o‘zartgich orqali boshqarishning yopiq funksional sxemasi ko‘rsatilgan.

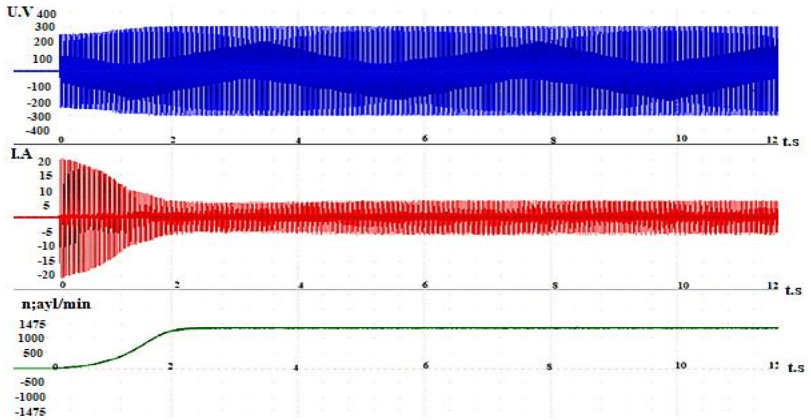


2-rasm. Yem maydalash qurilmalarining asinxron motorini chastotali boshqarishning yopiq funksional sxemasi: CHO‘- chastota o‘zgartgich; AD- asinxron dvigatel; YeMQ - yem maydalash qurilmasi; D1-D2- tezlik datchigi

Figure 2. Closed functional diagram of frequency control of an asynchronous motor of a feed grinding device: CHO'- frequency converter; AD- asynchronous motor; EMX - feed grinding device; D1-D2- speed sensor

3. Natijalar va muhokama (Results and discussion)

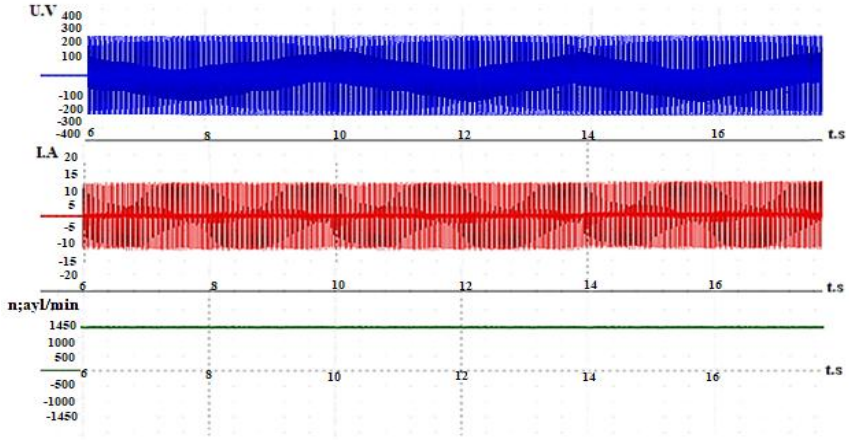
Biz universal yem maydalash qurilmalarining asinxron motorida tajriba tadqiqotlar o‘tkazish jarayonida energiya tejamkorligiga erishish mumkinligini aniqladik [9 - 15]. Bunda birinchi holatda universal yem maydalash qurilmasining quvvati P=2,2 kVt, aylanish tezligi n=1475 ayl/min bo‘lgan asinxron motorining salt ishlash rejimidagi ishga tushurishdagi faza kuchlanish, tok, tezlik ossillogrammalari olingan (3-rasm).



3-rasm. Yem maydalash qurilmasining quvvati P=2,2 kW, aylanish tezligi n=1475 ayl/min bo‘lgan asinxron motorining salt ishlash rejimidagi faza kuchlanish, tok, tezlik ossillogrammalari

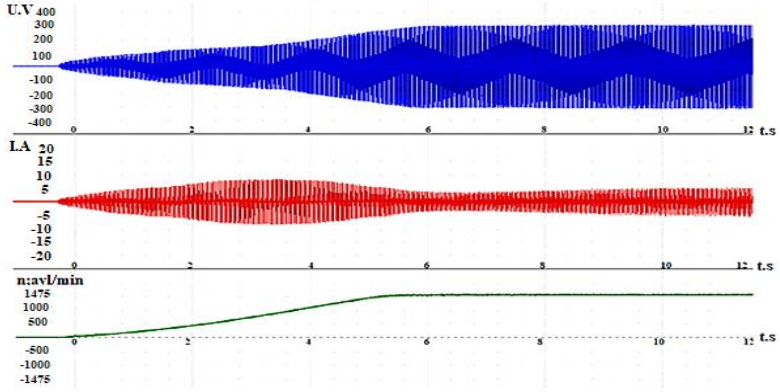
Figure 3. Oscillograms of phase voltage, current, and speed in the sole operation mode of an asynchronous motor with a power of P=2,2 kW and a rotation speed of n=1475 rpm of a feed grinding device

Bundan shuni ko‘rish mumkinki bu rejimda yem maydalash qurilmasining asinxron motorida energiya iste’moli meyorida iste’mol qilayotganligini ko‘rish mumkin. Keyingi ossillogrammada xuddi shu kuchlanishdagi va xuddi shu quvvatdagi universal yem maydalash qurilmalarining asinxron motorini yuklama rejimida ishlash jarayonidagi faza kuchlanish, tok, tezlik ossillogrammalari ko‘rsatilgan (4-rasm).



4-rasm. Yem maydalash qurilmasining quvvati P=2,2 kW, aylanish tezligi n=1475 ayl/min bo‘lgan asinxron motorining yuklama rejimidagi faza kuchlanishi, tok, tezlik ossillogrammalari
Figure 4. Oscillograms of phase voltage, current, and speed in the load mode of an asynchronous motor with a power of P=2,2 kW and a rotation speed of n=1475 rpm of a feed grinding device

Bu ostsillogrammalardan shuni ko’rish mumkinki bu rejimda universal yem maydalash qurilmalarining asinxron motoridagi faza kuchlanish qiymati tushib ketganligini, tok qiymati esa oshib ketganlgini, tezlik qiymati esa pasayganligini ko’rish mumkin. Bu esa universal yem maydalash qurilmalarida qo’llanilayotgan asinxron motorlarini ekspluatatsiya qilish jarayonida energiya sarfi juda ko’p sarflanilayotganligini ko’rsatmoqda. Universal yem maydalash qurilmasi barqar rejimda ishlamayotganligidan dalolat beradi. Bunda ya’ni universal yem maydalash qurilmalarining asinxron motorida energiya iste’moli meyorida emas [10-15]. Shu sababli elektr energiyasi juda ko’p sarf bo’layotganligini bilish mumkin. Keyingi 5-rasmdagi ostsillogrammada xuddi shu kuchlanishdagi va xuddi shu quvvatdagi universal yem maydalash qurilmalarida qo’llanilayotgan asinxron motorning chastotali ishga tushurish faza kuchlanishi, tok, tezlik ostsillogrammalari keltirilgan.



5-rasm. Yem maydalash qurilmasining quvvati P=2,2 kW, aylanish tezligi n=1475 ayl/min bo‘lgan asinxron motorining yuklama chastota o‘zgartgich ulangan hol uchun faza kuchlanishi, tok, tezlik ossillogrammalari
Figure 5. Oscillograms of phase voltage, current, and speed of an asynchronous motor with a power of P=2,2 kW and a rotation speed of n=1475 rpm of a feed grinding device with a load frequency converter connected

Bundan shuni ko‘rish mumkinki grafikda yuqori garmonikalar yo‘qolganligi va faza kuchlanishining shakli sinusoidaga yaqin bo‘lganligi aniqlandi. Natijada energiya iste’moli kam sarflanganligidan dalolat beradi.

4. Xulosa (Conclusion)

“Buxoroparranda”AJ korxonasi misolida qo‘llanilib kelinayotgan Ukraina davlatida ishlab chiqarilgan КДУ-2,0; tipdagi universal yem maydalash qurilmasining asinxron motorini ekspluatatsiya qilish jarayonida statik va dinamik rejimini optimal boshqarilishiga

erishildi, ya'ni chastotaviy boshqarish orqali sarflanayotgan elektr energiya iste'molining 17% tejalishiga, asinxron motor tezligini rostlashga, elektr yuritmani silliq ishga tushirib, to'xtatish orqali elektr yuritma FIK ni oshishiga va asinxron motorning quvvat isrofini kamaytirishni ta'minlanishiga erishildi.

Yem maydalash qurilmasining asinxron elektr yuritma chastota o'zgartkichida tezlikni rostlash jarayonida kuchlanishni rostlash vektorli usulda amalga oshirilishi, tezlikni aniq darajada bo'lishini ta'minlaydi. Elektr yuritmaning ishonchli ishlashini, chastotaning kichik qiymatlarida momentni oshirishini va dinamik isroflarning kamayishi shartlari to'liq bajarilishiga erishildi.

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