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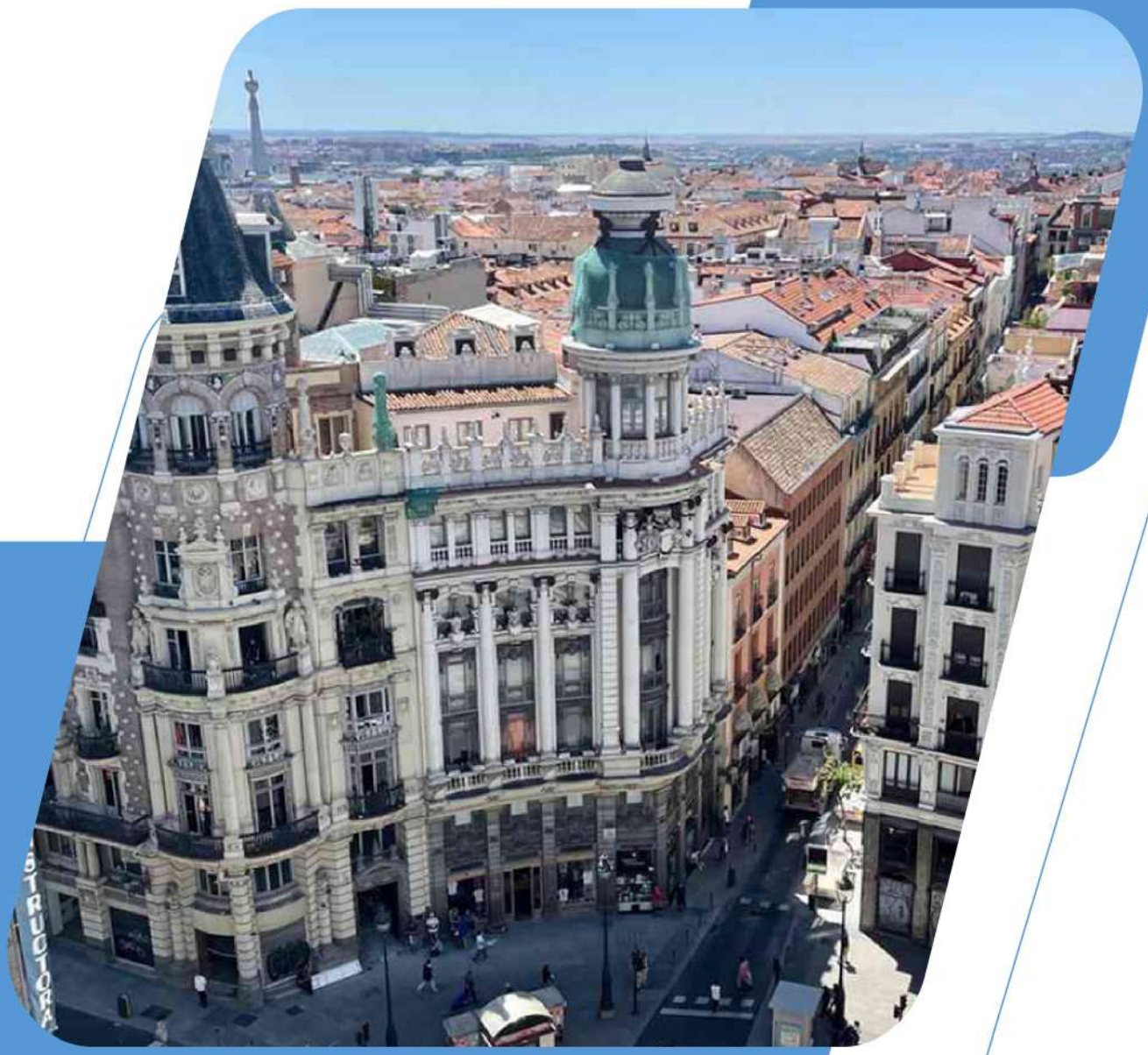

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Content

Agricultural sciences

ANALYSIS OF THE DEVELOPMENT OF DOMESTIC REINDEER HUSBANDRY

Satayeva Zhuldyz
Zhetimkarinov Erlan
S. Seifullin Kazakh Agrotechnical Research University
LLP "Pulse N"

Reindeer (Cervidae) are animals found primarily in Eurasia, North America, South America, and southwest Africa. Like caribou, antlers are found in male reindeer but not in females, and are shed and regenerated periodically each year. This unique model of organ regeneration in animals has attracted worldwide attention [1-3].

New Zealand is the largest producer of antler velvet, producing 450–500 tonnes of red deer velvet annually. China produces 400 tonnes of antler velvet annually, which is made primarily from sika deer. Russia produces 80 tonnes a year, and the US and Canada produce around 20 tonnes a year. Korea is the largest exporter of antler velvet, with sales of around US$1.6 billion [4].

In Kazakhstan, the most suitable place for keeping marals-reindeer in captivity is the eastern region of Katon-Karagaysky district, the foot of Mount Belukha, where the Kazakh part of the Altai Mountains is located.

Breeding of deer and marals for the production of antlers (the antlers of young marals and sika deer used to make medicines) and other products has been practiced in Eastern Kazakhstan for over a century and a half. Eastern Kazakhstan has long been considered a fertile land for breeding marals. Maral breeding is, without exaggeration, a national brand for the country. Everyone knows about the magical properties of antler preparations, but many do not realize that maral breeding today is far from a profitable business, very energy-intensive, costly, and rather works for the future. Industrial maral breeding in Kazakhstan is going through hard times. Prices for maral antlers on export markets remain low, and the costs of breeding these noble deer account for more than half of the revenue from the sale of antlers. The industry, which is positioned as Kazakhstan's national brand at foreign exhibitions, survives only thanks to tourists.

Scientists have confirmed that the young cut antlers of these deer contain a real elixir of health. In Kazakhstan, people drink blood from the antlers, make wraps, antler baths, balms, antler inhalations, and take pantohematogen. The antlers themselves are boiled, dried, and used to make medicines and biologically active additives.

According to the National Statistics Bureau, a total of 8.6 thousand deer – marals bred in peasant farms were registered in Kazakhstan in 2021. Of these, 94.4%, or just over 8 thousand animals, were in the East Kazakhstan region. There are 18 maral farms in the region that breed red deer. They produce 5 tons of antlers per year (5.3 tons in total in the republic). The largest maral farm in the east is considered to be Katon-Karagaysky Oleniy Park LLC.

Other well-known farms in the region are the «Damir», «Maraldy», «Bayan», «Dolina Tsary», «Dolgoletiya Center», «Zhanat», «Maralenok», «Bagration-2», etc. Almost every maral farm has its own antler treatment centers, guest houses, and actively attracts tourists and those wishing to undergo a health course. This trend — the transition from the production, raw materials direction of maral breeding to tourism — has been observed in the region for several years now.

New farms were created not only in the Katon-Karagaysky district of the East Kazakhstan region – a traditional place for breeding marals, but also in the Akmola, Almaty, Pavlodar, Karaganda and Aktobe regions.

The main problems that local maral breeders face today are low prices on the world market, weak selection and breeding work, an underdeveloped market for the sale of antler products and, most importantly, the lack of state support in the form of subsidies for breeding maral and increasing the productivity and quality of maral products.

One of the main reasons for the low profitability of the raw materials cluster is the low export price of antlers. If in the early 2000s the cost of a kilogram of antlers was 1 thousand US dollars, then in the last five years it has been only 200-280 US dollars. In Soviet times, the product was sold for 1000-1500 dollars per kilogram. Sales went mainly to South Korea, Japan and China. Keeping marals is expensive, as they need free grazing, a large fenced area, feeding, selection and much more. Equipment and own

mini-production are needed to process the valuable pantocrine substrate.

The second reason for the backwardness of the industry is the poorly developed infrastructure of health departments and the lack of good roads. The main problems are financial instability, caused by the instability of the markets for the sale of antler raw materials, and a lack of investment, since the main investors are the reindeer herding farms themselves.

According to industry experts, the profitability of maral breeding remains within 8-10%. Because of this, reindeer breeding in Kazakhstan has been subsidized by the state for many years [5].

In Kazakhstan, each resident receives only 1.2 grams of medicinal products from maral breeding per year, while in Southeast Asia the norm is 100 grams per person per year. The magical properties of various tinctures and baths based on boiled antlers are especially appreciated in Japan, China and Korea. This is where 70% of reindeer breeding products go.

So far, the bulk of Altai antlers is supplied to South Korea as raw materials. Only five enterprises are engaged in their processing in the republic, which produce liquid pantohematogen, balms and dietary supplements. Due to poor awareness, the product is in little demand among the local population, so only 10-12% of the produced antlers go to the domestic market.

Improving the conditions and volumes of subsidies for the construction of new and expansion of existing maral farms, increasing productivity and product quality, conducting selection and breeding work, purchasing breeding stock of maral, breeding record-breaking stags, using artificial insemination, feed production, purchasing new equipment for cutting antlers, an antler preservation workshop, a finished product warehouse, and a freezer can ensure an increase in antler production by 30% or more.

With the improvement of infrastructure, hotel-type health centers will be created in picturesque remote places of Kazakhstan, and investments will be attracted through the sale of tourist vouchers [6].

It is well known that antlers are a recognized raw material for obtaining medicines and the only complex of animal origin in the world that has a powerful preventive, healing effect. The use of drugs based on products of antler deer breeding increases the body's energy, and also slows down the aging process. East Kazakhstan maral breeders propose to include antler-containing drugs produced in the region in the national drug formulary of our country.

Treatment with blood and antlers of deer is used in the treatment of mental and physical fatigue, helps to strengthen the body's compensatory capabilities during hard work and sports activities. Accelerates recovery after surgeries and infectious and other chronic diseases. Increases the stability of the nervous system in asthenic conditions and chronic fatigue. Helps with neuroses, vitamin deficiencies, encephalopathies of various origins. Enhances hematopoiesis in anemia [7].

Deer antlers are considered the key to human health and longevity. There are legends about their miraculous properties, but maral breeders assure that these are not just legends, but a fact confirmed by science. It turns out that clinical studies of people employed in industrial metallurgical production were conducted jointly with the National Center for Hygiene and Occupational Pathology. For a month, they underwent procedures at a sanatorium in VKO. A clear improvement in health was noted, the number of diseases decreased by 23%, and the effect of the procedures lasted for a year [8].

In the 18th century, when the territory of modern Kazakhstan was part of Russia, trade relations were formed between Russia and China, in which trade in maral products was of considerable importance. It was the Chinese who were the first to show great interest in maral antlers due to their ancient knowledge of their beneficial properties. The Chinese willingly paid high prices for unossified antlers of maral, red deer and sika deer. This trend and the profit from the sale of antlers by the 19th century led to an extraordinary scale of maral and deer hunting, the most ruthless methods of deer capture were used.

Having exterminated a terrifying number of deer and marals, hunters who wanted to profit from selling antlers left themselves no choice but to start breeding animals. Thus, in the 1830s, the beginning of catching and breeding animals was laid, taking care of their health. The first maral breeders appeared. Breeding antler deer became a very profitable agricultural lot, and it began to be increasingly practiced both in Altai and in Eastern Kazakhstan. Preparations based on maral antlers in Kazakhstan are produced in Eastern Kazakhstan, where maral breeding is still a traditional economic activity. It is given great attention by local authorities, who are trying to preserve and revive the long-standing traditions of the region. Today, maral breeding products have not lost their popularity [9].

In recent years, people have become increasingly aware of the importance of diet for health, which has contributed to the popularity of dietary supplements among consumers. Deer antlers have been used as a health food and medicine in China, Japan, and Korea for thousands of years. As the only fully regenerable mammalian organ, deer antlers have attracted interest as an animal-derived medicine that

can be obtained without harming the animal [10].

Recent studies have isolated various biologically active compounds from deer antlers, such as peptides, lipids, polysaccharides, proteins, nucleotides, glycoproteins and trace elements [11]. However, velvet antler protein has received only limited attention as a potential bioactive resource. Studying the bioactivity of velvet antler protein is important for expanding its application in functional foods and nutraceuticals.

Therefore, it is worth paying attention to deep scientific research of unique compounds, antlers of domestic maral-deer to develop new high-quality safe products for human health.

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Medical sciences

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REHABILITATION OF ONCOLOGICAL PATIENTS: ACTUAL QUESTIONS AND WAYS OF THEIR IMPLEMENTATION

Arman Khozhayev
Professor of the Department of Oncology named after S.N. Nugmanov, Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan
Gulmira Yessenbulatova
Head of the Clinical Diagnostic Laboratory of the Almaty Oncology Center, Almaty Oncology Center, Almaty, Kazakhstan
Takhir Sabirov
Oncologist-mammologist, Enbekshikazakh District Hospital № 1 of Shelek Village, Almaty region, Kazakhstan
Zarina Toilybaeva
Oncologist, Almaty Oncology Center, Almaty, Kazakhstan
Anastassiya Belilaya
General practice physician, City Center for Primary Health Care, Karaganda, Kazakhstan
Nurken Nurseit
Physician expert, City polyclinic №4, Almaty, Kazakhstan
Zaure Kairatova
Anesthesiologist-resuscitator, Regional Children's Clinical Hospital, Almaty, Kazakhstan

Abstract

This scientific publication describes modern directions of rehabilitation of cancer patients with various localization of the tumor process. The currently available methods of rehabilitation treatment and scientific directions that require further research to improve the quality of life of this contingent of patients are described. The use of a comprehensive program of medical rehabilitation in cancer patients will restore their vital conditions as much as possible and will optimize the processes of physical, psychological and social adaptation of these patients, which is the main task of oncology and rehabilitation today.

Keywords: *oncology, rehabilitation, quality of life.*

Today, high rates of incidence of malignant tumors and a priori aggressive treatment methods and, often, the prevalence of the oncological process itself lead to disability, requiring rehabilitation measures. In this regard, such a section of clinical oncology as the rehabilitation of cancer patients must be on the same level with modern treatment, diagnosis and prevention of cancer [1,2].

It is important to especially emphasize that rehabilitation measures begin not after the patient develops various kinds of physical and psycho-emotional dysfunctions as a result of specialized treatment and (or) complications of the tumor process, but already from the moment the diagnosis of a malignant neoplasm is made. At the same time, patients registered with an oncologist often experience various kinds of functional disorders that affect their quality of life and ability to work. For example, physical disorders may include fatigue, decreased muscle strength, cognitive dysfunction, paraesthesia, or eating problems, while mental symptoms may include anxiety, depression, fear of relapse, or insomnia. In this regard, the role of rehabilitation doctors and the importance of specialists with the skills of professional assessment and therapy in oncology services in this situation can hardly be overestimated [3].

One of the important aspects of complex rehabilitation of cancer patients is the use of drug correction of the psycho-emotional state of cancer patients, which previously received little attention. It is clear that oncologists and rehabilitation specialists take on this difficult role, but in some, quite common cases, additional drug support for the patient's psyche is required [4,5].

Thus, Taiwanese researchers Cheng-Hsu Wang et al. [6] not only analyzed, but also proved that the need for psychotropic drugs depends on the nosological form of the tumor. They analyzed data from 35,137 cancer patients from Taiwan's National Health Insurance database over 2.5 years. Among those patients who survived for at least 6 months, every fifth (20.9%) used psychotropic drugs: patients were most often prescribed sedatives (14.3%), then antidepressants (5.5%), anxiolytics (3.6%) and antipsychotics (2.7%). Lung cancer, prostate cancer and oral cancer showed a statistically significant association with regular drug use during the first six months after diagnosis. And among patients who survived for at least 2.5 years, 4.8% still use psychotropic medications on a regular basis.

Catherine L. Granger et al. [7] found through a systematic review of articles using the electronic databases Medline, Cinahl, Embase, Scopus and Cochrane that despite evidence and existing guidelines for physical activity in patients with lung cancer, it is hardly implemented in clinical practice. This systematic review of the literature showed that the challenges of adequate physical rehabilitation of patients with lung cancer are multifaceted and involve various factors. These include patient-level factors such as symptoms, comorbidities, sedentary lifestyle, mood and fear, and environmental factors. These factors should be taken into account to determine and develop a treatment and rehabilitation program for these patients.

In addition, very little attention is often paid to the fact that the main moral burden when caring for cancer patients falls, of course, on their loved ones. And, unfortunately, according to Swedish researchers Ji J. et al. [8] spouses of cancer patients who provide care are at increased risk of coronary heart disease and stroke. This is necessary to know for the correct approach to correcting the psychological state of not only the patient himself, but also their relatives (family rehabilitation).

At the same time, Badr H. et al. [9] found a low level of self-efficacy and a high level of distress when independently caring for patients with advanced lung cancer. The authors, based on experimental studies in which 39 patients took part, developed a program to coordinate care and train care skills for such patients. The program was based on self-determination theory. Participants reported significant reductions ($p<0.0001$) in depression, anxiety, and caregiving burden, increased caregiver competence, and caregiver autonomy to provide care compared to usual care.

Similar results were obtained in their study by Kim Y. et al. [10]. The authors note that the difficulty of psychological adaptation of relatives in families in which there is a cancer patient and the lack of social support are the main predictors of the development of major depressive disorders, even 3 years after diagnosis. At the same time, programs for adaptation to long-term care are crucial for the possibility of long-term (5-year results were taken into account) active care for the patient.

In addition, El-Jawahri A. et al. [11] found that patients' inadequate perception of their prognosis regarding cancer affects many of their decisions about medical care. However, the relationships between prognostic perception, quality of life, and patient mood itself are not yet fully understood. They stated the fact that, although patients wanted to know detailed information about their illness, half incorrectly perceived the fact that the prognosis in their situation was favorable. Of the 50 patients included in the study, 38 (76%) wanted to know as many details as possible about their diagnostic procedures and treatments. However, 25 of 50 patients (50%) stated that their goal was to "cure cancer," and only 10 of 49 patients (20%) reported that they had completely "put their fate in the hands of their oncologist." Patients who accepted their illness as a death sentence reported lower quality of life ($p=0.005$) and higher levels of anxiety ($p=0.003$) compared to those who did not perceive themselves as terminally ill. The authors established a direct connection between accurate prognostic perception and the quality of life of patients. Therefore, interventions aimed at improving understanding of disease prognosis provide adequate psychosocial support for these people.

Any methods, as we all understand perfectly well, should be used to alleviate the condition of cancer patients and restore their well-being. Such methods include art therapy, which, of course, belongs to non-traditional methods of influence, but with a comprehensive program of restorative treatment it shows its effectiveness.

Lee J. et al. [12] decided to evaluate the effect of art therapy using paintings by famous artists on the manifestation of long-term chronic stress (distress) in cancer patients receiving radiation therapy. The level of anxiety, depression and symptoms associated with the manifestation of the cancer itself were assessed. The authors conducted a prospective study that included 24 cancer patients with various forms of malignant neoplasms who received radiation therapy. Art therapy took place in two parts, including 4 sessions of a famous painting course and 4 sessions of works of art of the creative generation; these sessions were held twice a week for four weeks. Distress was assessed using the Hospital Anxiety and Depression Scale (HADS), the Hamilton Depression Rating Scale (HDRS), and the Edmonton Symptom

Assessment Scale (ESAS) at three assessment points: before the start of art therapy, after the fourth session, and then after the eighth session. art therapy. It was found that of the 24 patients included in the study, 20 patients (83%) completed all eight sessions. At the same time, the authors note a significant and even significantly significant decrease in indicators of depression and anxiety on all scales used in the study.

It should be noted that a number of nosological forms of malignant tumors and crippling surgical interventions used in these diseases, such as enucleation of the eye, removal of the obturator apparatus of the rectum, breast extirpation lead to the deepest physical, psychological and social disability of patients. Laryngeal cancer is one of these localizations of the oncological process.

A very interesting and important study on this subject was carried out by Millgård M., Tuomi L. [13]. The study aimed to investigate the short-term and long-term effects of voice rehabilitation in patients treated with radiotherapy for laryngeal cancer as measured by both the acoustic measure smoothed cepstral peak prominence (CPPS) and perceptual measures. A secondary aim was to investigate the relationship between acoustic and perceptual measures. In total, 37 patients received voice rehabilitation post-radiotherapy and 37 patients constituted the irradiated control group. Outcome measures were mean CPPS for connected speech and ratings with the auditory-perceptual Grade, Roughness, Breathiness, Asthenia and Strain (GRBAS) scale. Outcome measures were analyzed 1 (baseline), 6, 12, and 24 months post-radiotherapy, where voice rehabilitation was conducted between the first two time-points. Additional recordings were acquired from vocally healthy participants for comparison. As a result, CPPS values of the voice rehabilitation group and vocally healthy group were not significantly different at 24 months post-radiotherapy. Ten out of 19 patients who received voice rehabilitation yielded a CPPS value above the threshold for normal voice 24 months post-radiotherapy, compared to 11 out of 26 in the irradiated control group. No statistically significant correlations were found between CPPS and perceptual parameters of GRBAS. Based on the results obtained, the authors conclude that voice rehabilitation for irradiated laryngeal cancer patients may have positive effects on voice quality up to 24 months post-radiotherapy. The relationship between CPPS and GRBAS as well as the applicability of CPPS for evaluation over several points of measurement needs to be studied further.

In their paper, Zhu X. et al. [14] emphasize that dysphagia is a common complication in patients with laryngeal cancer after surgery and radiotherapy. The aim of the study was to study the impact of swallowing training administered in combination with nutritional intervention on the nutritional status and quality of life of laryngeal cancer patients with dysphagia after surgery and radiotherapy. Sixty-six patients with laryngeal cancer who developed dysphagia were randomly divided into control group and intervention group (n = 33 in each group). Patients in both groups received total laryngectomy and prophylactic radiotherapy and were provided routine health counseling and swallowing training. Patients in the intervention group were additionally provided with nutritional intervention. All patients were evaluated using video fluoroscopic swallowing examination (VFSE), Patient-Generated Subjective Global Assessment on nutritional status (PG-SGA) score, and Quality of Life Questionnaire-core 30 (QLQ-c30) score immediately after radiotherapy and 3 months later. The results were as follows: prior to swallowing training, there was no significant between-group difference with respect to VFSE evaluation, PG-SGA score, or QLQ-c30 score. Both groups showed improvement in these measures at 3 months after radiotherapy; however, the improvement in the intervention group was significantly better than that in the control group. The researchers conclude that swallowing training combined with nutritional intervention can improve swallowing function, nutritional status and the quality of life of laryngeal cancer patients with dysphagia after operation and radiotherapy.

As noted by Salerno G. et al. [15], total laryngectomy represents the surgical procedure necessary for the treatment of some advanced neoplasms of the hypopharyngeal-laryngeal district and involves strong functional, physical and emotional repercussions. In their study, our colleagues examined how rehabilitation techniques used to improve the communication needs of patients who have undergone laryngectomy affect their perception of quality of life. The questionnaires "V-RQoL" and "SECEL" were administered to 45 patients divided into four groups on the basis of the type of vicarious voice: group TE (27 patients), group E (7 patients), group EL (2 patients), group NV (9 patients). Patients using electrical or tracheo-esophageal prostheses reported a better quality of life than patients with an erythromophonic voice. Regarding postoperative satisfaction, the group with esophageal voice was the most satisfied. The authors emphasize the importance of preoperative counseling to make the patient as aware as possible of his future condition.

Retinoblastoma is an intraocular cancer of infancy and childhood, which has been treated with radiation therapy and chemotherapy. Radiation on growing patients can cause deterioration in

maxillofacial growth and development that leads to severe skeletal discrepancies between the maxilla and mandible, and dental problems such as crossbite, openbite, and hypodontia. Kim S.H. et al. [16] presented a case of a 19-year-old Korean man with chewing disability and dentofacial deformities. He had undergone enucleation of the right eye and radiation therapy of the left eye due to retinoblastoma 100 days after birth. Subsequently, he received cancer therapy for the secondary nasopharyngeal cancer at the age of 11 years. He was diagnosed with severe skeletal deformity including sagittal, transverse, and vertical growth deficiency of the maxilla and midface, and with class III malocclusion, severe anterior and posterior crossbite, posterior openbite, multiple missing upper incisors, right premolars, and second molars, and impaction of the lower right second molars. To restore impaired functions and esthetics of the jaw and dentition, the orthodontic treatment combined with two jaw surgery was performed. At the end of surgical orthodontics, dental implants were placed for prosthetic treatment of missing teeth. Additional plastic surgery for zygoma elevation was done with calvarial bone graft followed by fat graft. Facial esthetics and occlusal functions of patient were favorably enhanced with the improvement of skeletal discrepancy and the rehabilitation of maxillary dentition by prosthetic work. At the 2-year follow-up, the skeletal and dental relationships and implant prosthetics were well maintained. The authors conclude as follows: in an adult patient with dentofacial deformities caused by early cancer therapy in the head and neck area, interdisciplinary interventions including additional plastic surgery of zygoma depression and prosthetic work of missing teeth as well as surgical-orthodontic treatment could establish favorable facial esthetics and oral rehabilitation.

The case of eyeball prosthetics was presented in their study by Goiato M.C. et al. [17]. Male patient, 60 years old, sought care at the Oral Oncology Center of the São Paulo State University "Júlio de Mesquita Filho", for the rehabilitation of the orbital cavity with an acrylic eye prosthesis. This prosthesis was made with thermopolymerizable acrylic resin and hand painted iris with oil paint on cardboard. The prosthesis was installed after finishing and polishing and the hygiene and general care instructions were explained. Colleagues focus on the fact that the lack of an eye has an immediate and long-term impact on a patient's life. In the present case, the patient was satisfied with the aesthetics and comfort of the prosthesis, which demonstrates the success of the treatment.

As Rokohl A.C. et al. [18] show, a smooth supply with a visually appealing prosthetic eye after enucleation is not just a cosmetic solution, it is also a key factor in successful social and psychological rehabilitation. The authors submitted an overview of the current state of medical and ocular care regarding prosthetic eyes in Germany. It focuses mainly on the newest clinical results, daily care, complications, and psychological aspects of wearing prosthetic eyes. As a result of the latest clinical data and a current review of the PubMed literature, it was found that in Germany, enucleated patients normally get a double-walled, hollow prosthetic eye made of cryolite glass, and patients with a microphthalmic or phthisic eye receive a thin single-walled prosthesis. Anophthalmic patients wearing cryolite glass prosthetic eyes seem to be more satisfied with their appearance and the look of their prostheses than polymethylmethacrylate (PMMA) prosthetic eye wearers. Cryolite glass prosthetic eyes must be renewed at least each year, while PMMA prostheses need to be polished once a year and renewed after five years of wearing. Among children, the fit of the prosthetic eye must be checked, based on growth, semi-annually. A slightly higher risk of breakage of cryolite glass prostheses is, for most patients, not a great disadvantage in everyday life. Ocularists and ophthalmologists should determine an individual cleaning regime, together with the patient, that is dependent on the material of the ocular prosthesis and other external factors. Complications, such as allergic, giant papillary, viral and bacterial conjunctivitis and blepharoconjunctivitis sicca must be treated at an early stage to allow for a prosthetic eye. In the case of inflammation-caused socket shrinkage or post-enucleation socket syndrome, surgical interventions are needed to re-enable the use of a prosthetic eye. Since the health of the remaining eye is the major psychological burden of prosthetic eye wearers, good ophthalmological care and medical screenings are essential elements. In conclusion, the researchers conclude that a smooth supply with a prosthetic eye, adequate and early treatment of possible complications and attention to psychological aspects is essential for successful long-term rehabilitation of enucleated patients.

As well as patients with previous localizations of the oncological process, patients with colorectal cancer with colostomies need mandatory rehabilitation measures.

Thus, Yang P. et al. [19] set themselves the goal of to systematically evaluate the effect of collaborative nursing on self-care ability of postcolostomy patients with colorectal cancer (CRC). PubMed, Web of Science, Embase, China National Knowledge Infrastructure, and Wanfang databases were searched to collect relevant literatures on randomized controlled trials of postcolostomy patients with CRC. The search period was started from 2010 to 2021. Statistical analysis was performed on the

data extracted from the comprehensive meta-analysis with STATA 16.0 analysis software. As a result, it was found that the incidence of adverse reactions in the control group was higher than that in the treatment group. Seven studies included the preintervention self-care concept and preintervention self-care skills. Six studies included preintervention self-care responsibility and preintervention exercise of self-care agency (ESCA) scale. In the comparison among the concept of self-care after intervention, self-care skills, self-care responsibility, and ESCA scale, all of them had higher scores in the treatment group than in the control group ($p<0.05$). It fully explains that collaborative nursing can significantly improve the evaluation indicators of patients' self-care ability and reduce patient complications. In summary, the authors conclude that the application of collaborative nursing in the nursing work of patients with CRC after colostomy can significantly reduce the incidence of adverse nursing reactions.

The aim of the work is Yu S., Tang Y. [20] to explore the impacts of comprehensive care on psychological emotion, postoperative rehabilitation and complications of colorectal cancer patients after colostomy. From August 2018 to February 2020, a total of sixty colorectal cancer patients undergoing colostomy in our hospital were collected and randomly assigned to a control group to receive conventional care and a research group to receive comprehensive care, with 30 patients in each group. The two groups of patients were compared for postoperative recovery, complications, adverse psychological emotions, self-care ability, quality of life, and nursing satisfaction. The first time of exhaust, food intake and the recovery of bowel sound in the research group were markedly earlier than those in the control group. Besides, the research group had notably lower incidence of postoperative complications, lower self-anxiety scale (SAS) and self-depression scale (SDS) scores at discharge, and higher average self-care ability than the control group, as well as higher quality of life score and nursing satisfaction. At the end of the work, it was concluded that comprehensive care intervention can promote postoperative recovery of colorectal cancer patients after colostomy, relieve their negative emotions, reduce postoperative complications, improve quality of life and nursing satisfaction, which are all important and make this type of care worthy of promotion in clinical practice.

A study by Wang S.Y. et al. [21] examined the effects of a multimedia patient education intervention on improving self-care knowledge and skills in patients with colorectal cancer who underwent colostomy surgery. A quasi-experimental design was adopted to measure the self-care knowledge and skills of patients with colorectal cancer before and after surgery. The experimental group ($n = 33$) received a multimedia patient education intervention, whereas the control group ($n = 30$) was provided conventional instructions. Results were evaluated using analysis of covariance. On the day prior to discharge from hospital, the experimental group exhibited significantly greater improvement in self-care knowledge than did the control group. The experimental group also exhibited significantly greater improvement in self-care skills than did the control group on the day of gas passage, the day prior to discharge from hospital, and during the first clinic visit after discharge from the hospital. In other words, multimedia patient education intervention yielded greater improvement in self-care knowledge and skills than did conventional instruction. The authors state that multimedia patient education is an adequate educational tool for patients with colorectal cancer who have undergone colostomy.

Now, regarding the rehabilitation of patients with breast cancer.

The leading method of treating malignant neoplasms, including breast cancer, is surgical. As Chan K.S. points out. et al. [22], functional results are increasingly important in breast cancer, as survival and prognosis for this pathology improve over the years. Since more than half of diagnosed breast cancer cases occur in middle-aged women between 45 and 64 years of age, it is appropriate to ensure preservation of upper extremity function as this group of patients may be the primary caregivers for their families, lead active lifestyles, and are at the peak of their careers. Additionally, most previous studies have shown that Asians may have higher body fat percentages, lower bone mass, and lower levels of physical activity than Western populations. These factors may influence functional outcomes in patients with breast cancer. The authors conducted a single-center prospective cohort study with a follow-up period of 6 weeks after surgery. The main inclusion criteria were patients over 21 years of age who underwent 44 radical surgical interventions - wide sectoral resection - 16 (36.4%) and mastectomy - 28 (63.6%). The main exclusion criteria were patients with pre-existing neurological or rheumatological comorbidities affecting upper limb function, or previous trauma that resulted in upper limb deformity. Patients who had undergone mastectomy with reconstruction were also excluded. The patients underwent early rehabilitation from the 1st day after surgery, including a standardized set of exercises for the shoulders and upper extremities. Active shoulder flexion and abduction range of motion and disability scores were assessed 1 week before surgery and then at weeks 2 and 6 postoperatively. This pilot study in an Asian cohort showed that patients were able to regain active range of motion of shoulder

flexion and abduction at 6 weeks postoperatively, but had a worse disability score, especially in the axillary lymph node dissection subgroup after sentinel lymph node examination. Recommendations include the use of active early rehabilitation methods for breast cancer patients, however, as the authors note, longer follow-up is required to assess long-term functional results.

The modern direction in medical rehabilitation of patients with breast cancer, as well as in their treatment today, is the individualization of the treatment and rehabilitation program. As Olsson Möller U. et al. note in their publication [23], it is well known that women suffer from the negative consequences of breast cancer treatment and that their very important needs during rehabilitation interventions are often not met. At the same time, up to 43% of these women are at risk of developing chronic distress, requiring comprehensive treatment. However, it is unknown how to identify and meet the needs of these women early, leaving them with a low chance of optimal rehabilitation. The authors plan to conduct a three-arm randomized controlled trial and aim to develop a model and evaluate the effect of individualized screening-based rehabilitation after primary treatment for breast cancer. The rehabilitation program will be based on self-reported data, focusing on physical and psychological outcomes, as well as treatment satisfaction at baseline at 2 weeks, 3, 6, 9 and 12 months. The assessment will also include economic aspects of health, based on register data and information from patients and their relatives during the rehabilitation process. In addition, optimal threshold levels of negative behaviors will be explored as an indicator of the need for extended rehabilitation. It is planned to identify potential new problems and rehabilitation needs of patients during the 1-year follow-up period. The researchers note that this study will provide important knowledge regarding the effectiveness of screening to identify needs for individualized, standardized, evidence-based rehabilitation after primary breast cancer treatment.

Much work regarding the development of a rehabilitation program for patients with breast cancer has been carried out by Spanish scientists and clinicians Barnadas A. et al. [24]. As the researchers emphasize, the gradual increase in incidence associated with the aging population and the implementation of screening programs, together with lower mortality rates from breast cancer, has led to an increase in the number of surviving patients with this pathology. The treatment used leaves physical, psychological and psychosocial consequences that can manifest and persist even years after completion of treatment and can interfere with the well-being of breast cancer patients and their reintegration into normal social and professional activities. Complications of the underlying disease and concomitant pathology require joint monitoring by specialized medical institutions and primary health care services. The authors have compiled guidelines aimed at ensuring joint and coordinated monitoring of these patients by these medical services. The guideline addresses health problems arising from treatment, with recommendations for a therapeutic approach that individualizes treatment, as well as suggestions for coordinated joint monitoring by primary and secondary care. In addition to organizational issues, the guide provides general recommendations for breast cancer patients: 1) avoid excess weight, 2) healthy diet and exercise, 3) quit smoking, 4) moderate alcohol consumption, 5) possible use of additional treatment methods, for example, such as acupuncture, 6) awareness of symptoms indicating a possible relapse or recurrent tumor, 7) adherence to prescribed anti-estrogenic hormone therapy for a long period (5-10 years), 8) return to work.

In addition, one of the modern methods of restorative treatment of cancer patients includes a method such as neuromuscular electrical stimulation (NMES) [25]. It may be a pragmatic short-term alternative to voluntary exercise in patients who are currently undergoing or have recently completed treatment for cancer. In this study, the authors assessed the impact of a personalized and progressive NMES exercise intervention, designed with the early rehabilitation period in mind, on patients' physical performance and quality of life. This manipulation was found to improve performance on the 30-second sitting test (STS), the 6-minute walking test (6 MW), and global quality of life using the EORTC QLQ C-30 questionnaire. Benefits gained included improved muscle strength and greater confidence when walking. The authors recommend further evaluation of this technique in a further controlled prospective study.

In recent years, the term "multimodal" has been increasingly used in clinical research, which means, according to Wiktionary, involving or using several methods or modes of implementation. When analyzing a review of the literature related to multimodal rehabilitation of cancer patients, it should be noted that the overwhelming number of scientific works are devoted to the use of rehabilitation measures at the stage of preparing patients for specialized treatment, be it surgery or courses of drug or radiation therapy.

Guinan E.M. et al. [26] note in their work that the inflammatory changes themselves and the

disruption of redox processes after radical surgery for esophageal cancer significantly affect both the quality of life and the survival of patients. In this regard, an integrated approach to the rehabilitation of these patients, including special exercises and a certain diet, can reduce the negative manifestations of the treatment. However, the authors note that the results will be further examined in a larger randomized controlled trial. In addition to the impact of these manifestations on the survival of patients, the economic side of the full rehabilitation of these patients will also be studied.

Bolshinsky V. et al. [27], based on an analysis of studies on multimodal rehabilitation programs before surgery for gastrointestinal tumors, conducted a systematic literature search using Medline, PubMed, Embase, Cinahl, Cochrane and Google Scholar databases. Study quality was assessed using the Cochrane Risk of Bias Tool (randomized trials) and the Newcastle-Ottawa Quality Assessment Scale (cohort studies). Of the 544 studies identified, 20 were included in the qualitative analysis. The authors found that although small studies have found encouraging results, larger prospective studies using uniform objective risk stratification and structured interventions with prespecified clinical and economic endpoints are needed to determine the definitive value of prehabilitation programs.

Summing up the analyzed works on rehabilitation measures in cancer patients with various nosological forms of malignant neoplasms, we can draw a definite conclusion that a multifaceted approach is required when conducting rehabilitation treatment in these patients, aimed at compensating for impaired body functions, improving the quality of life, reducing the severity of disability and prolonging active life. The process of recreating the vital status of patients is multidimensional and requires an integrated approach to restore the physical, psycho-emotional and social conditions of patients. At the same time, almost all authors agree on one thing: further multicenter randomized studies are needed to develop standardized approaches to conducting rehabilitation measures in cancer patients.

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ORTHODONTIC NEEDS FOR TREATMENT AT COMMUNITY LEVEL - PRELIMINARY STAGE

Eric-Cristian Cirica[1]
Agnes Katalin Lackner[2]
Andrei Kozma[3,4]
[1]*Private Dental Practice, Bucharest, Romania,*
[2] *PhD student; Medical University Wien, University Dental Clinic, Department of Paediatric Dentistry,*
[3] *CSI, Dr.habil. Phd, MMD, DrHC; „Alessandrescu-Rusescu"National Institute for Mother and Child Health Bucharest, Romania /*
[4] *member of the Academy of Romanian Scientists*

Abstract

The various pathologies that can be detected by the orthodontist, the reluctance to treatment and the medical condition of the patient are just some of the problems that can arise when initiating the orthodontic treatment plan.

The present article aims at obtaining the necessary information within the community needed for the implementation of the optimal treatment protocol.

To establish the target groups, two questionnaires were distributed both physically and online: one for patients who required orthodontic treatment without having had the orthodontic treatment in the past, and one for those during treatment.

Both questionnaires are divided into two sections to facilitate the processing and understanding of the collected data. The first section of both questionnaires contains the GDPR agreement and questions about personal data, with the following sections showing differences for the target group to which they refer to.

The first set of questionnaires, with responders requiring orthodontic treatment as the target group, gathered 70 responses, 10 of which cannot be counted in this study due to poor completion by patients, resulting in an completion rate of 86.7%. In the first group of participants, there is a clear separation by age groups (the first two predominating), namely: 7-17, 18-24, 25-30 and 31-50 years old.

The participants reported painful episodes in 75% of cases after the adjustment session, 50% reported functional difficulty during meals, 62.5% of them experience a significant increase in dental mobility and 25% experience difficulty while brushing their teeth.

The data collected differs significantly from other national and international studies. The aesthetic needs of the women who participated do not outweigh the functional needs compared to other studies in the field. The frequency of requesting orthodontic treatment among women decreases from 70% to 48% (63% if we also take into account the participants in the second group).

Factors such as cost and availability influence 20% of the decision to follow the treatment, while cultural and social attitudes do not seem to significantly influence the decision of respondents to seek an orthodontic treatment path.

Quite a lot of problems have come to light as a result of the two questionnaires: lack of access to information when it comes to the need for orthodontic treatment, the level of hygiene at community level and the negative feelings towards the medical team.

Keywords: orthodontic treatment, socio-demographic aspects, quality of life, radiological

Introduction

It is important to distinguish between the need for orthodontic treatment and the demand for orthodontic treatment. The need for orthodontic treatment is defined as the urgent need for orthodontic intervention, evaluated professionally by a specialist; the lack of orthodontic treatment can affect the functioning of the masticatory system. The request for orthodontic treatment is a subjective desire for self-perceived need of orthodontic treatment - usually for aesthetic or social reasons. It is important to note that the demand for orthodontic treatment is not always consistent with the need for treatment, since factors such as cost, availability and cultural attitudes may influence an individual's decision to seek

care. In the literature, it is reported as ranging from 8.4 to 49% [1].

An objective understanding of the patient's view of his health can be achieved through patient-reported outcomes, which have also received increased attention in the past years in pediatric dentistry as it supports patient-centered care. [2]

Factors such as gender, age, treatment duration, compliance and treatment improvement also appear to contribute to satisfaction. Patient satisfaction is important for ensuring patient adherence to orthodontic treatment. In previous studies, different factors were analyzed and different tools were used to assess satisfaction after orthodontic treatment. Patients' dental attitudes have changed over time. In the last decade, the number of patients seeking orthodontic treatment has increased considerably with socioeconomic development and the change of views on physiognomy. [3]

While quality of life generally refers to the perceptions of individuals on their positions in life in the context of the cultural and value systems in which they live and in relation to their goals, expectations, standards and concerns.

The American Dental Association reported that 70% of women seek or require orthodontic treatment, mostly for aesthetic reasons. This observation is consistent with that of Shaw, who, as early as 1981, demonstrated that women were more unhappy with the appearance of their teeth and perceived the need for orthodontic treatment more often than men. [4]

Socio-demographic aspects must be included in health studies, as they help to understand inequalities when it comes to access to information, education and healthcare services, especially specialist treatments. [5]

The right timing for orthodontic intervention has aroused intense debate, the definitive orthodontic treatment is most often initiated in the case of late mixed dentition or early permanent dentition. The specific implementation of simple interception measures is important and cost-effective, with the general practitioner perfectly placed to identify and occasionally correct occlusion problems in a timely manner. [6]

Materials and Method

To establish the target groups, two questionnaires were distributed both physically and online: one for patients who required orthodontic treatment without having had the orthodontic treatment in the past, and one for those during treatment. Both questionnaires are divided into two sections to facilitate the processing and understanding of the collected data.

The first section of both questionnaires contains the GDPR agreement and questions about personal data (full name, gender, age, region, area, occupation, contact details), with the following sections showing differences for the target group they refer to.

The second section for patients requiring orthodontic care contains questions related to their medical history (diet, allergies, general and dental pathologies, current medication, frequency of visits to the dentist and to a radiological control and the appearance and functionality of the masticatory system), while the second section for respondents wearing braces contains a set of questions aimed at clarifying their clinical situation (difficulties caused by said braces, the presence of pain or complications and previously performed surgical measures).

Results

The first set of questionnaires, with responders requiring orthodontic treatment as the target group, gathered 70 responses, 10 of which cannot be counted in this study due to poor completion by patients, resulting in an completion rate of 86.7%. In the first group of participants, there is a clear separation by age groups (the first two predominating), namely: 7-17, 18-24, 25-30 and 31-50 years old.

The visit to the dentist for a check-up is, according to the collected questionnaires, often carried out in a period of 6 months - 1 year. Although the dentist suggests visiting a radiological center every 6 months (or, in the case of current treatments requiring frequent radiological investigations, less than 6 months), a large portion of the respondents never go for a radiological control. In the case of the presence of feelings caused by the orthodontic treatment, the first group of respondents expressed mostly negative feelings, such as fear, and discomfort. (Table 1.)

Table 1.

Questions about frequency of dental regular check-ups and radiological investigations

QUESTIONS	*ANSWERS*			
	Every 5 years	*Every year*	*Every 6 months*	*Never*
1. How often do you go to a dental check-up?	*14*	*20*	*22*	*4*
2. How often do you go to a radiological examination?	*14*	*18*	*4*	*24*

The reasons for visiting a doctor or a radiological center are also varied: for the question about

dental control, the habit of visiting a doctor prevails, followed by the appearance of health problems, while the question about the radiological examination has most of the answers based on the doctor's request to visit a radiological center (Table 2).

Table 2.

Questions about the reason behind dental regular check-ups and radiological investigations

QUESTIONS	ANSWERS			
	Regular check-up	Health problems	At doctor's recommendation	No reason
1. Why do you go to a dental check-up?	28	25	0	7
2. Why do you go to a radiological examination?	4	12	30	14

When self-assessing the level of general and dental personal hygiene (Figure 1), respondents gave 63% positive responses, only 3% of the eligible answers were negative ("Unsatisfactory").

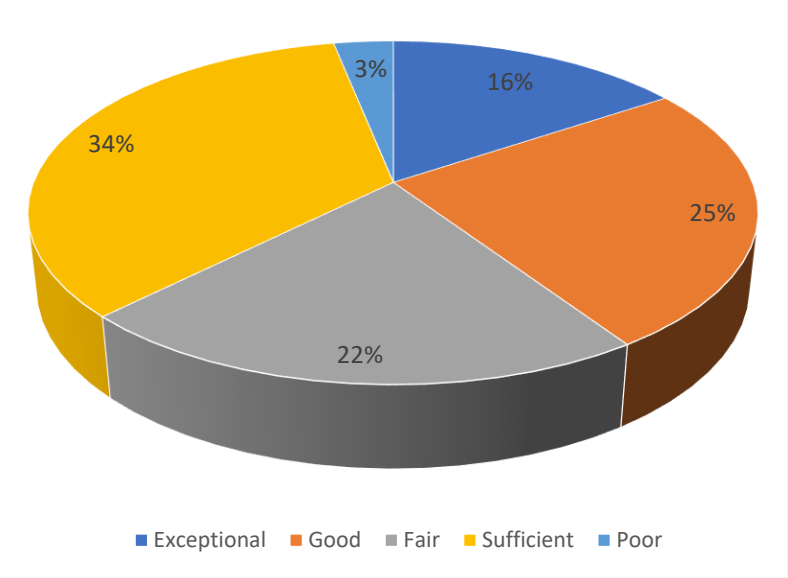

Figure 1. General and dental personal hygiene in group I

The second set of questionnaires, the one for the group of respondents who are during orthodontic treatment obtained 24 answers. 37.5% of respondents specified having required tooth extractions to obtain sufficient space on the arch, while 12.5% (33% of those with the above mentioned extractions) required bone grafts to repair the defects encountered. The participants reported painful episodes in 75% of cases after the adjustment session, 50% reported functional difficulty during meals, 62.5% of them experience a significant increase in dental mobility and 25% experience difficulty while brushing their teeth.

In the last section of the questionnaire, containing questions about the perceived progress or success of the treatment, 12.5% of respondents consider the current treatment plan ineffective (Table 3). Patients during treatment specified fear, anxiety, and anxiety as their main feelings in relation to orthodontic care. Only one respondent offered a positive perspective in relation to the visit to the orthodontic specialist.

Table 3.

Questions related to ongoing orthodontic treatment

QUESTIONS	ANSWERS		
	Yes	No	Don't know
1. In your case, have teeth been extracted at any stage of treatment?	9	12	3
2. In your case, were bone grafts required?	3	18	3
3. In your case, were complex surgical maneuvers required (orthognathic surgery, gingivectomy, tissue repositioning)?	6	18	0
4. Do you encounter difficulties while brushing your teeth? (Hygiene may be poor due to the presence of braces, some areas have become difficult to reach.)	6	18	0
5. Do you encounter difficulties during meals? (The braces limit the diet, variety of meals, consistency of food consumed, etc.)	12	12	0
6. Do you feel considerable pain after each check-up?	18	6	0
7. Do you feel considerable dental mobility after each monthly check-up?	15	6	3
8. Do you think your teeth have maintained their position despite the ongoing treatment?	3	18	3
9. Do you think that the orthodontic treatment does not progress towards the desired result?	3	21	0

The second group is composed entirely of female respondents, from the region of Muntenia, urban environment, with a self-assessment of general and dental hygiene ranging between "Sufficient" and "Exceptional" in equal proportions, negative responses not being found at any respondent.

The medical assessment that followed confirmed the authenticity of previously stated answers. Respondents specified the frequency of daily dental hygiene, obtaining a perfect percentage in this category as well (The frequency of brushing was multiple times a day). The initiation period of treatment was framed within three main time periods, namely: middle school, high school and after the age of 18 (Figure 2).

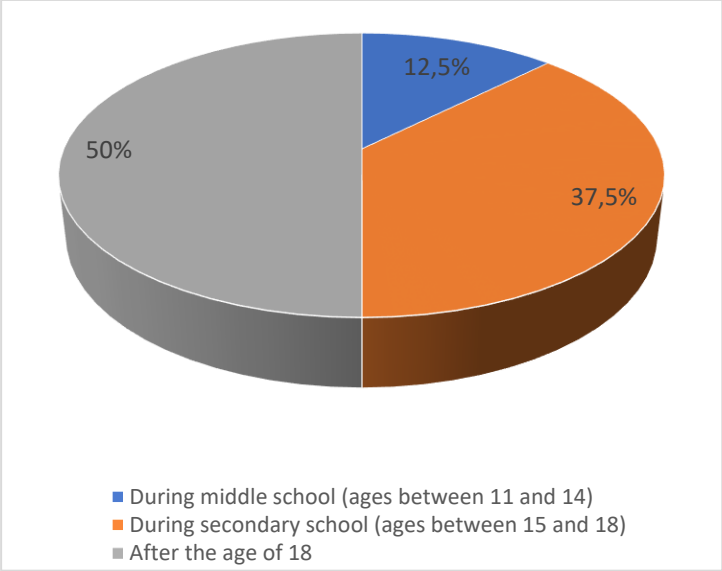

Figure 2. Initiation period of orthodontic treatment in group II participants

68% of the respondents of the first group belong to the female gender, the final average, also taking into account the participants in group 2, being 80%. 48% of the women in the main group are dissatisfied with the appearance of their teeth and want to improve their personal aesthetic appearance (the related question receiving answers related to the color, positioning and appearance of their teeth) and, to a small extent, requested periodontal treatment for reducing gingival bleeding.

Despite the results presented above, 58% of participants do not know the solution provided by orthodontic treatment in their case, and 57% do not take orthodontic treatment into account (overlap of statistics equally in patients who knew about orthodontic treatment, as well as in those who did not know). 20% of the participants incorrectly estimated, in the absence of knowledge in the field, the minimum required time and the minimum to average cost for an optimal orthodontic treatment.

Discussions

The data collected differs significantly from other national and international studies. The aesthetic needs of the women who participated do not outweigh the functional needs compared to other studies in the field. The frequency of requesting orthodontic treatment among women decreases from 70% to 48% (63% if we also take into account the participants in the second group).

Factors such as cost and availability influence 20% of the decision to follow the treatment, while cultural and social attitudes do not seem to significantly influence the decision of respondents to seek an orthodontic treatment path.

Conclusions

Quite a lot of problems have come to light as a result of the two questionnaires: lack of access to information when it comes to the need for orthodontic treatment, the level of hygiene at community level and the negative feelings towards the medical team.

The discrepancy between the frequency of visiting the dentist and the frequency of visiting a radiological examination presents a problem with serious consequences in the effectiveness of the treatment for future braces wearers. Also, the lack of a comprehensive analysis on the patients pertaining to the first selection group, the lack of obligation to present themselves at regular dental and radiological check-ups and the lack of specialized information on the possibility of orthodontic treatments can lead in the near future to difficult cases that require long-term multidisciplinary collaboration.

Except for the specialty aspects, courses or explanatory materials can be distributed and used to educate the patient in school and professional environments to improve the orthodontic treatment

request rate and success. Implementation of a comprehensive treatment protocol and the formation of a specific guide in order to help coordinate the treatment according to the pathologies encountered are the objectives of the next stage.

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Physical sciences

NEW SOURCES OF INEXHAUSTIBLE ENERGY

Alakbarov Shahin Shamshad oglu
Ph.D., Associate Professor
Baku State University

Abstract

This paper provides information on three systems that can, in principle, be used as an inexhaustible source of energy.

Theoretical calculations show that in the ideal (without losses and without friction), as well as in the real case, there are systems in which cyclic processes in these systems are accompanied by the release (excess) of energy.

In the first example proves that in gases that obey the Bolsmann distribution, the energy required to raise a mass of gas to a certain height is less than the work (internal energy) that the gas can do when expanding in this height. The mass of gas that has done the work at the expanding is released at this height, and this mass of gas returns to the bottom (initial state) of the large volume taken, as a result of the Bolsmann redistribution. Thus, in these systems, under certain conditions, the movement of a gas mass along a closed trajectory in a gravitational field is accompanied by the release of a certain amount of excess energy in each cycle.

The second example is based on the effect of reverse osmosis. Here it is proved that due to the difference in densities, the height of the free level of the solvent becomes greater than the height of the free level of the solution at high heights of the solution (a solution of salts with a high density is more suitable) and solvent. By limiting the height of the free level of the solvent (by making a hole in the wall of the vessel), it is possible to make the pressure of the solution on the semiconductor membrane located at the bottom of the vessel greater than the pressure of the solvent. At this time, due to the effect of reverse osmosis, the solvent molecules in the solution pass through the semipermeable membrane and enter the solution, and spontaneous circulation of the solvent occurs in the system under consideration.

In the third example it is proved that in gases that obey the Bolsmann distribution it is possible to create such systems that in these systems, when is separated by a partition with holes at the ends a gas with a small molar mass (this gas has a small atomic radius) and a mixture of the same gas with a gas of a large molar mass (this gas has a large atomic radius), spontaneous circulation of the gas with a small molar mass occurs in such a system.

Keywords: *gas, excess energy, osmotic pressure, water, aqueous solution, semipermeable membrane, energy.*

It is known that at present most countries of the world are experiencing great difficulties due to the energy crisis [1,2] and many specialists are looking for ways out of this energy crisis [3-5]. At present, the methods of obtaining energy known to science either pose a threat to the living world or disrupt the ecological balance on Earth, destroy the living world (it is enough to recall the accidents of nuclear power plants, hydroelectric power plants, in coal mines, explosions of hydrocarbons in public places). Solar and wind energy, which is rapidly developing today, also causes great damage to the living world and the environment (this includes environmental pollution and soil erosion).

Theoretical calculations show that in the ideal case there are systems in which cyclic processes in these systems are accompanied by the release (excess) of energy.

This work provides information on three systems out of several that can, in principle, be used as an inexhaustible source of energy.

Despite the possibility of solving the problems under consideration for different and general cases, the presented problems are solved in a simpler and more particular case.

The first system.

Let us imagine that on Earth in a gravitational field a sufficiently large volume forms a closed system, inside which there is an ideal gas (or real gases He, Ne, Ar), and the temperature in this system is the same and constant in all places. The pressures, and accordingly, the density of the gas are subject to

the Boltzmann distribution depending on the height.

Let us imagine that a closed vessel in this system moves along a closed circuit, i.e. a closed vessel with gas of mass m, pressure P_0, volume V_0, and temperature T, first rises from a height $h = 0$ to a height h without changing the volume (let us assume that the piston has the ability to be fixed in the cylinder). At a height h, the gas, expanding to a volume V_h, does work until the pressures inside and outside the vessel are equalized (at a height h, the gas pressure P_h outside the vessel is less than inside it). After doing the work, the same vessel (piston and cylinder) goes down in a separated state (Fig. 1). The calculations do not take into account the mass of the vessel, since when raising and lowering, due to the mass of the vessel, the same work with different signs is done.

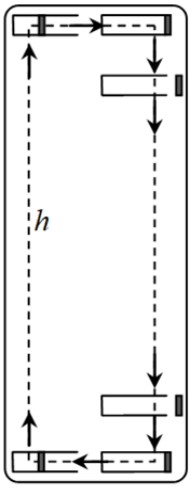

Fig.1

Let us calculate the work of lifting a vessel with gas of mass m, pressure P_0, volume V_0, and temperature T from a height $h = 0$ to a height h, taking into account that the vessel (the given mass of gas) is acted upon by gravity and the Archimedes force. Thus, the total force acting on the given mass of gas is equal to:

$$F = mg - F_A = mg - \rho_h V_0 g = \rho_0 V_0 g - \rho_h V_0 g \qquad (1)$$

Here g – is the acceleration due to gravity, F_A – is the Archimedes force, ρ_0 – is the gas density at a height $h = 0$, ρ_h – is the gas density at a height h, V_0 – is the volume of the vessel containing the gas under pressure P_0.

It is known that:

$$\rho_h = \rho_0 e^{-\frac{\mu g h}{RT}} \qquad (2)$$

Here μ – is the molar mass of the given gas, R – is the universal gas constant.

Taking into account expression (2) in (1)

$$F = \rho_0 V_0 g - \rho_0 V_0 g e^{-\frac{\mu g h}{RT}} = \rho_0 V_0 g \left(1 - e^{-\frac{\mu g h}{RT}}\right) = mg\left(1 - e^{-\frac{\mu g h}{RT}}\right) \qquad (3)$$

The work of the force of determined expression (3)

$$A = \int_0^h F(h)dh = \int_0^h mg\left(1 - e^{-\frac{\mu g h}{RT}}\right)dh = mgh - \frac{mRT}{\mu}\left(1 - e^{-\frac{\mu g h}{RT}}\right) \qquad (4)$$

It is known that at a height h the gas pressure inside a closed vessel is greater than around it. If the gas is allowed to expand isothermally to equilibrium pressures inside and around the closed vessel, then the expanding gas can do work

$$U = \int_{V_0}^{V_h} P(V)dV = \int_{V_0}^{V_h} \frac{mRT}{\mu}\frac{dV}{V} = \frac{mRT}{\mu} ln\frac{V_h}{V_0} = \frac{mRT}{\mu} ln\frac{P_0}{P_h} = \frac{mRT}{\mu} ln\frac{P_0}{P_0 e^{-\frac{\mu g h}{RT}}} = mgh \qquad (5)$$

Here V_h – is the volume of gas after expansion to pressure P_h at height h.

After the work is done, the same vessel (piston and cylinder) goes down in a separated state (in this case, when the vessel is lowered, no work is done) and at the bottom the vessel goes into its initial state (position). In this process, the excess energy and efficiency are according to expressions (4) and (5):

$$E = U - A = \frac{mRT}{\mu}\left(1 - e^{-\frac{\mu g h}{RT}}\right) = P_0 V_0\left(1 - e^{-\frac{\mu g h}{RT}}\right) \qquad (15)$$

$$\eta = \frac{U}{A} = \frac{mgh}{mgh - \frac{mRT}{\mu}\left(1 - e^{-\frac{\mu g h}{RT}}\right)} = \frac{1}{1 - \frac{RT}{\mu g h}\left(1 - e^{-\frac{\mu g h}{RT}}\right)} \qquad (16)$$

Taking $\mu g h = \alpha RT$ in expressions (15) and (16), we obtain:

$$E = U - U = P_0 V_0\left(1 - e^{-\frac{\mu g h}{RT}}\right) = P_0 V_0(1 - e^{-\alpha}) \qquad (17)$$

$$\eta = \frac{U}{A} = \frac{mgh}{mgh - \frac{mRT}{\mu}\left(1 - e^{-\frac{\mu g h}{RT}}\right)} = \frac{1}{1 - \frac{RT}{\mu g h}\left(1 - e^{-\frac{\mu g h}{RT}}\right)} = \frac{1}{1 - \frac{1 - e^{-\alpha}}{\alpha}} = \frac{\alpha}{\alpha + e^{-\alpha} - 1} \qquad (18)$$

From expression (18) it is evident that (provided $\alpha > 0$), $\eta \gg 1$ at $\alpha \ll 1$, $\eta = e = 2{,}718$ at $\alpha = 1$, $\eta \geq 1$ at $\alpha \gg 1$. The dependence of η on α for this case is shown in Fig.2.

We considered the case when the temperature T in a large volume is constant. Here it was assumed that the amount of heat released during gas compression (at a height of $h = 0$ the gas is compressed spontaneously due to the Boltzmann distribution) is absorbed directly during expansion by the gas inside the vessel. Thus, the decrease in temperature inside the vessel can be neglected and the temperature inside the large volume can be considered constant. Such conditions can be satisfied for slow processes. This will not affect the parameters η and , however, the power output from this system will be greatly reduced.

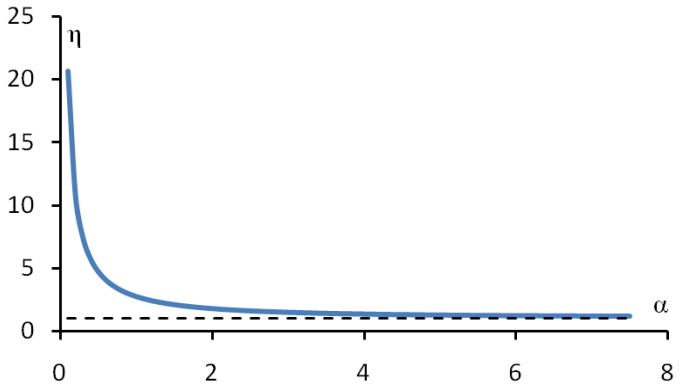

Fig.2

The second system.

The production of excess energy in these systems is based on the reverse osmosis effect. In this effect, due to the pressure exceeding the osmotic pressure, the solvent molecules pass through a semipermeable membrane from the solution into the solvent.

In this example, at large heights of the column of solution and solvent (water), the level of the solvent becomes higher than the level of the solution due to the difference in density of the solution and solvent. In this case, the solvent (water) can do work (this is excess energy), falling from a large height onto the solution, the level of which is lower than the level of the solvent. The solvent (water), poured into the solution, reaches the semipermeable membrane due to diffusion, and after that the solvent molecules pass from the solution into the solvent through the semipermeable membrane, since the pressure of the solution on the semipermeable membrane is greater than the pressure of the solvent.

Suppose that one arm of the U-shaped tube is filled with a solvent (for example, water), and the other - with a solution (for example, an aqueous solution of salt). The arms of the U-shaped tube are separated by a semipermeable membrane located at the bottom of the tube (Fig. 3). In this case, water molecules can pass through the semipermeable membrane, but salt molecules cannot.

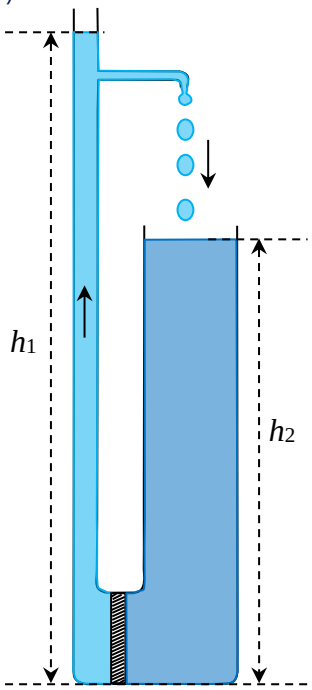

Fig.3.

The osmotic pressure P_{os} is expressed by the formula [6,7]:

$$P_{os} = iCRT \qquad (19)$$

where i– is the isotonic coefficient of the solution, which for most salts takes values from 1 to 2 depending on the degree of dissociation, C– is the molar concentration of the solution; R– is the universal gas constant; T – is the thermodynamic temperature of the solution.

To simplify the problem, we will take water as the solvent and a salt with a high density, which dissociates into two ions when dissolved in water.

In our case (Fig.3), taking into account the osmotic pressure, the pressure of the solution and the solvent, we can write:

$$P_1 + P_{os} \leq P_2 \qquad (20)$$

Here, P_1 – is the pressure of the water column, P_{os} – is the osmotic pressure, P_2 – is the pressure of the solution column.

Since:

$$P_1 = \rho_1 g h_1 \qquad (21)$$

Here, ρ_1 – is the density of water, g – is the acceleration of gravity, h_1 – is the height of the water column.

$$P_2 = \rho_2 g h_2 \qquad (22)$$

Here, ρ_2 – is the density of the solution, g – is the acceleration of gravity, h_2 – is the height of the solution column.

The density of a dilute solution can be determined as follows:

$$\rho_2 = \frac{m_1+m_2}{V_1+V_2} \qquad (23)$$

Here, m_1 and m_2 – are masses, V_1 and V_2 – are volumes of water and salt, respectively.

In expression (23), V_2 can be ignored compared to V_1.

$$\rho_2 = \frac{m_1+m_2}{V_1} = \frac{m_1}{V_1} + \frac{m_2}{V_1} = \rho_1 + \frac{m_2}{V_1} \quad (24)$$

m_2 in expression (24) can be determined from the expression for the amount of substance (for salt) $\nu_2 = \frac{m_2}{\mu_2}$:

$$m_2 = \mu_2 \nu_2 \quad (25)$$

Taking into account expression (25) in expression (24) we obtain:

$$\rho_2 = \rho_1 + \frac{m_2}{V_1} = \rho_1 + \frac{\mu_2 \nu_2}{V_1} = \rho_1 + \mu_2 \frac{\nu_2}{V_1} = \rho_1 + \mu_2 C \quad (26)$$

Here we took into account that $C = \frac{\nu_2}{V_1}$.

Taking into account expression (26) in expression (22) we obtain:

$$P_2 = \rho_2 g h_2 = (\rho_1 + \mu_2 C) g h_2 = \rho_1 g h_2 + \mu_2 C g h_2 \quad (27)$$

To obtain excess energy in expression (20), the pressure of the solution P_2 acting on the semipermeable membrane must be greater than the sum of the osmosis pressures P_{os} and the water column P_1 (i.e. $P_1 + P_{os}$). In this case, water molecules must pass from the solution to the solvent (water) through the semipermeable membrane due to the reverse osmosis effect.

Thus, in accordance with the above, the condition $h_1 > h_2$ must be satisfied.

Let us assume that:

$$h_1 = n h_2 \quad (28)$$

In expression (28) we assume that $n > 1$.

Taking into account expressions (19), (21), (27), (28) in expression (20) we obtain:

$$\rho_1 g n h_2 + iCRT \leq \rho_1 g h_2 + \mu_2 C g h_2 \quad (29)$$

from here

$$h_2 \geq \frac{iCRT}{g[\mu_2 C + \rho_1 (1-n)]} \quad (30)$$

In this system, the generated energy (surplus energy) ΔE can be defined as

$$\Delta E = \Delta m g (h_1 - h_2) \quad (33)$$

Here Δm – is the mass of water that passes through the semipermeable membrane from the solution into the solvent (water). This value depends on a number of factors, such as the throughput of the semipermeable membrane, the difference in heights of the solution and water, the rate of water diffusion in the solution, the height of the solution, the cross-section of the solution, temperature, etc.

Thus, water, doing extra work, enters the solution, reaches the semipermeable membrane due to diffusion and passes through it. As a result, water circulates in the system (U-shaped tube).

For a semipermeable membrane with a fairly large cross-section (surface), the value of Δm mainly depends on the rate of water diffusion in the solution.

The amount of substance (water) transferred through the solution due to diffusion is calculated using the Fick formula [8,9]:

$$\Delta m = D \frac{C_2 - C_1}{l} S \Delta t \quad (34)$$

Here, D – is the diffusion coefficient, C_1 and C_2 – are the molar concentrations of salt in water and solution, respectively, l – is the distance between waters with salt concentrations C_1 and C_2, S – is the cross-section of the solution through which diffusion occurs, Δt – is the diffusion time. Considering $C_1 = 0$ (there is no salt in the water), $C_2 = C$ (the molar concentration of the solution), $l = h_2$ (the height of the solution column), we obtain:

$$\Delta m = D \frac{C}{h_2} S \Delta t \quad (35)$$

Taking into account expressions (28), (30) and (35) in expression (33)

$$\Delta E = \Delta m g (n h_2 - h_2) = DCS \Delta t g (n-1) \quad (36)$$

The efficiency η of this system:

$$\eta = \frac{\Delta m g h_1}{\Delta m g h_2} = \frac{h_1}{h_2} \quad (37)$$

Taking into account expression (28) in expression (37)

$$\eta = \frac{h_1}{h_2} = \frac{n h_2}{h_2} = n \quad (38)$$

The third system.

Let us imagine that on Earth in a gravitational field a sufficiently large volume forms a closed system, and this volume is divided into two parts vertically by a partition that has holes in the upper and lower parts (Fig. 4). The sizes of the holes are such that helium (He) atoms can pass through the holes,

but xenon (Xe) atoms cannot. The radius of xenon (108 pm) is greater than the radius of helium (31 pm). The pressures of these gases obey the Boltzmann distribution depending on the height. In this example, thermal effects are not taken into account.

Let us assume that He is on the left side of the partition, and Xe is on the right, and in the initial state at the bottom (h = 0) of the volume the pressures of these gases are equal. In this case, the pressure of He in the uppermost part (h = h) of the volume must be greater than the pressure of Xe, since the molar weight of Xe is greater than the molar weight of He. In this case, some of the He atoms must pass to the right part through the holes in the upper part of the partition, where Xe is located. In this case, the He pressure in the left part of the partition will decrease slightly, and in the right part, the pressure of the Xe and He gas mixture will increase slightly, as well as at the bottom of the volume. In the right part of the partition, the He atoms will reach the bottom of the volume due to diffusion. The He atoms must move to the left part of the partition, since at the bottom of the volume, in the right part, the pressure of the Xe and He gas mixture is greater than the He pressure in the left part of the partition. Thus, spontaneous He circulation occurs in this volume, which is accompanied by the release of energy. This is the "excess energy".

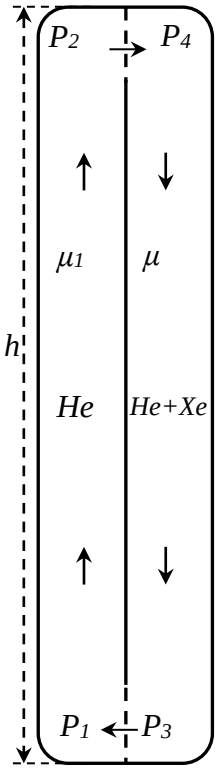

Fig.4

Let us adopt the following notation:

On the left (let's conventionally designate 1), at the bottom, at the bottom of the volume, the pressure of pure helium $P_0^{(1)}(He) = P_1$ *at h = 0; at the top of the volume, the pressure of pure helium* $P^{(1)}(He) = P_2$ *at h = h. The molar mass of helium* $\mu(He) = \mu_1$.

In the right (let's conventionally designate 2) part of the volume there is a mixture of xenon (Xe) and helium (He) gases. The pressure of the mixture of Xe and He gases in the lower part of the volume $P_0(Xe + He) = P_3$ *at h = 0, in the upper part* $P(Xe) = P_4$ *at h = h. The molar mass of xenon* $\mu(Xe) = \mu_2$, *the average molar mass of the mixture of xenon and helium gases* $\mu(Xe + He) = \mu$.

Taking into account the above:

$$P_2 = P_1 e^{-\frac{\mu_1 g h}{RT}} \quad (39)$$

$$P_4 = P_3 e^{-\frac{\mu g h}{RT}} \quad (40)$$

Here, $g = 9{,}81\ \text{м/с}^2$ *is the acceleration due to gravity,* $R = 8{,}31\ \text{J/mol·K}$ *is the universal gas constant, and the average molar mass of a mixture of xenon and helium gases is determined by the expression*

$$\mu = \mu_1\varphi_1 + \mu_2\varphi_2 \quad (41)$$

where, φ_1 *- is the volume fraction of helium,* φ_2 *- is the volume fraction of xenon.*

Taking into account expression (41) in expression (40)

$$P_4 = P_3 e^{-\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}} \quad (42)$$

On the other hand, the following condition must be met in this system.

$$P_2 - P_4 = P_3 - P_1 \quad (43)$$

Taking into account expressions (39) and (42) in expression (43)

$$P_2 - P_4 = \frac{P_4}{e^{-\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}}} - \frac{P_2}{e^{-\frac{\mu_1 g h}{RT}}} \quad (44)$$

or

$$\frac{P_2}{P_4} = \frac{1+e^{\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}}}{1+e^{\frac{\mu_1 g h}{RT}}} \quad (45)$$

According to our conditions, in expression (45)

$$e^{\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}} \gg 1, \qquad e^{\frac{\mu_1 g h}{RT}} \gg 1 \quad (46)$$

Taking into account expression (46), we can write expression (45) as:

$$\frac{P_2}{P_4} = \frac{e^{\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}}}{e^{\frac{\mu_1 g h}{RT}}} \quad (47)$$

or

$$P_4 = \frac{P_2 e^{\frac{\mu_1 g h}{RT}}}{e^{\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}}} \quad (48)$$

Taking into account expression (39) in expression (48)

$$P_4 = \frac{P_1}{e^{\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}}} \quad (49)$$

The excess energy generated can be calculated using the formula

$$\Delta E = \Delta P \cdot \Delta V \quad (50)$$

Here, ΔP – is the difference in pressure on opposite (left and right) sides of the partition in the upper or lower part of the volume, ΔV – is the volume of helium passing through the holes in the partition.

For the upper part of the volume

$$\Delta P = P_2 - P_4 \quad (51)$$

Taking into account expression (48) in expression (51)

$$\Delta P = P_2 - \frac{P_2 e^{\frac{\mu_1 gh}{RT}}}{e^{\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}}} \quad (52)$$

or taking into account expression (39) in expression (52)

$$\Delta P = P_1\left(e^{-\frac{\mu_1 gh}{RT}} - e^{-\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}}\right) \quad (53)$$

ΔV – the volume of helium passing through the holes in the partition, can be calculated using the formula

$$\Delta V = S \cdot v \cdot \Delta t \quad (54)$$

Here S – is the total cross-section of the partition holes in the upper or lower part of the volume, Δt – is the time, v – is the flow rate of helium passing through the partition holes, which can be determined by Bernoulli's law.

$$v = \sqrt{\frac{2\Delta P}{\rho_2}} \quad (55)$$

Here ρ_2 – is the density of helium in the upper part of the volume, determined by the formula

$$\rho_2 = \rho_1 e^{-\frac{\mu_1 gh}{RT}} \quad (56)$$

Taking into account expressions (53), (54), (55) and (56) in expression (50), we can calculate the excess energy (power) generated per unit of time using the formula

$$N = \frac{\Delta E}{\Delta t} = P_1\left(e^{-\frac{\mu_1 gh}{RT}} - e^{-\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}}\right) \cdot \sqrt{\frac{2P_1\left(e^{-\frac{\mu_1 gh}{RT}} - e^{-\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}}\right)}{\rho_1 e^{-\frac{\mu_1 gh}{RT}}}} \cdot S \quad (57)$$

The efficiency of this system can be calculated as follows.

$$\eta = \frac{P_2 \cdot \Delta V}{P_4 \cdot \Delta V} = \frac{P_2}{P_4} = \frac{e^{\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh}{RT}}}{e^{\frac{\mu_1 gh}{RT}}} = e^{\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh-\mu_1 gh}{RT}} \quad (58)$$

For such systems, we can calculate φ_1 and φ_2, the volume fraction of gases (helium and xenon) in the gas mixture (on the right side of the volume). For this, we write expression (47) in a different form

$$\frac{P_2}{P_4} = e^{\frac{(\mu_1\varphi_1+\mu_2\varphi_2)gh-\mu_1 gh}{RT}} \quad (59)$$

or

$$\frac{RT}{gh} ln\left[\frac{P_2}{P_4}\right] + \mu_1(1-\varphi_1) = \mu_2\varphi_2 \quad (60)$$

It is known that,

$$\varphi_1 + \varphi_2 = 1 \quad (61)$$

Taking into account expression (61) in expression (60)

$$\frac{RT}{gh} ln\left[\frac{P_2}{P_4}\right] + \mu_1\varphi_2 = \mu_2\varphi_2 \quad (62)$$

From here

$$\varphi_2 = \frac{RT}{(\mu_2-\mu_1)gh} ln\left[\frac{P_2}{P_4}\right] \quad (63)$$

Fig. 5 and Fig. 6 show the dependences of the pressures of pure He and a mixture of Xe and He gases (in Fig.5 μ=12.4 and in Fig.6 μ=12.2).

The results of all ongoing processes, including energy processes in the described and other similar systems, depend on the type and parameters of these systems, on the conditions set, and also on how the process itself occurs.

It should be noted that it is impossible can not to say in advance how many types of such systems exist. But it should be noted that calculations have been made and real operating designs of several installations (engines) with an efficiency greater than 2 have been designed, in which each cubic meter of these installations can produce mechanical energy in unlimited quantities (with a capacity from 1 W to 250 kW).

The results obtained can be useful in creating new energy sources, as well as in solving some global problems related to energy, ecology and economics.

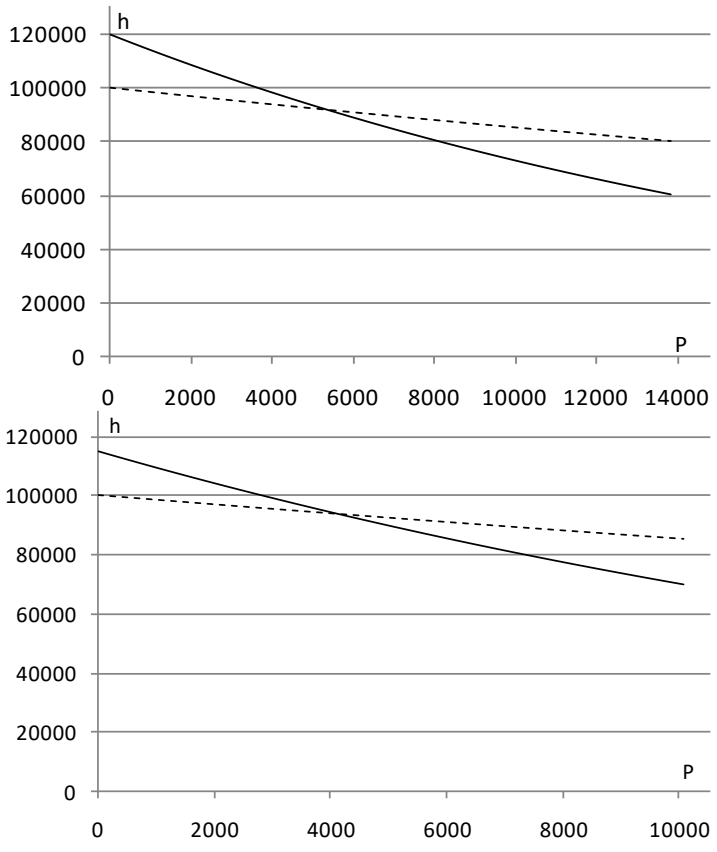

Fig.6

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Technical sciences

THE IMPACT OF THE EXPANDER-GENERATOR UNIT ON THE EFFICIENCY OF BOILER INSTALLATIONS WHEN HEATING PIPELINE GAS WITH THE FLUE GASES OF A GAS TURBINE UNIT

Mukolyants Arsen
Tashkent State Technical University named after Islam Karimov
Ergasheva Dilbar
Tashkent State Technical University named after Islam Karimov
Nizomov Jonibek
Tashkent State Technical University named after Islam Karimov

ВЛИЯНИЕ ДЕТАНДР-ГЕНЕРАТОРНОГО АГРЕГАТА НА ЭФФЕКТИВНОСТЬ РАБОТЫ КОТЕЛЬНЫХ УСТАНОВОК ПРИ ПОДОГРЕВЕ МАГИСТРАЛЬНОГО ГАЗА ДЫМОВЫМИ ГАЗАМИ ГАЗОТУРБИННОЙ УСТАНОВКИ

Мукольянц Арсен
Ташкентский государственный технический университет им. И. Каримова
Эргашева Дильбар
Ташкентский государственный технический университет им. И. Каримова
Низомов Жонибек
Tashkent State Technical University named after Islam Karimov

Abstract

The article discusses the use of an expander generator unit in boiler plants, the high energy efficiency of which is determined by the fact that the expander is not a heat engine, to ensure the operation of which it is necessary to give part of the supplied heat to a cold source. In an expander generator set, almost all the heat supplied to it (with the exception of mechanical losses) can be converted into electrical energy. One of the factors influencing the efficiency of the expander generator unit is the choice of a heat source for heating the gas before the expander and the method of heating. Various heat flows can be used to heat the gas, for example, in a heating boiler room, gas heating in front of the expander can be carried out by exhaust gases from boilers, direct mains water, flue gases from a gas turbine installation installed in the boiler room and using a heat pump installation.

Аннотация

В статье рассматривается применение детандер-генераторного агрегата на котельных установках высокая энергетическая эффективность которого определяется тем, что детандер не является тепловой машиной, для обеспечения работы которой необходимо часть подведенной теплоты отдавать холодному источнику. В детандер-генераторном агрегате почти вся подведенная к нему теплота (за исключением механических потерь) может быть преобразована в электрическую энергию. Одним из факторов, влияющих на эффективность детандер-генераторного агрегата, является выбор источника тепла для подогрева газа перед детандером и способ подогрева. Для подогрева газа могут быть использованы различные потоки теплоты, так, например, в отопительной котельной подогрев газа перед детандером может осуществляться уходящими газами котлов, прямой сетевой водой, дымовыми газами установленной в котельной газотурбинной установки и с помощью теплонасосной установки.

Keywords: *boiler plant, expander-generator unit, gas heating, gas turbine installation, flue gases of a gas turbine installation, heat of flue gases, generated electricity.*

Ключевые слова: *котельная установка, детандер-генераторный агрегат, подогрев газа, газотурбинная установка, дымовые газы газотурбинной установки, теплота дымовых газов, вырабатываемая электроэнергия.*

Введение. *При оценке эффективности применения детандер-генераторных агрегатов необходимо исходить из того, что они используются в уже существующей системе*

газоснабжения и проанализировать все изменения, происходящие с потоком газа по сравнению с исходным, уже существующим вариантом газоснабжения. При этом необходимо также учитывать, какое влияние оказывает использование детандер-генераторного агрегата (ДГА) на работу газопотребляющего оборудования. Это вызвано тем, что полная энергия, которую поток газа отдает в топке котла или печи, определяется не только теплотой его сгорания, но и физической теплотой топлива [1,2]. Следовательно, если газ после ДГА сразу направляется на сжигание, то эффективность использования ДГА для получения электроэнергии следует определять с учетом того, как он повлияет на технико-экономические показатели, в частности на расход топлива всей установки в целом по сравнению с тем, когда снижение давления газа происходило за счет дросселирования потока [3,4].

При анализе показателей работы котельной в качестве критерия будем рассматривать КПД нетто котельной $\eta_{\text{КОТ}}^{\text{н}}$. *Это связано с тем, что один из основных показателей работы котельных - КПД котельной брутто* $\eta_{\text{КОТ}}^{\text{БР}}$ *определяемый, как отношение теплоты, полученной сетевой водой, к теплоте, отданной топливом, полно характеризует котельную с "тепловой стороны", с точки зрения использования теплоты топлива, но не учитывает расход электроэнергии на собственные нужды, что является необходимым условием в случае включения ДГА в схему котельной, т.к. вырабатываемая электроэнергия может покрыть существенную часть этих нужд [5,6].*

Основная часть. *Для решения задачи принимается условие равенства тепловых нагрузок* $Q_К$ *котельной установки до и после включения ДГА.*

Для учета расхода электроэнергии использовать следующую формулу:

$$\eta_{\text{К}}^{\text{н}} = \frac{Q_{\text{к}}}{(B_{\text{Т}} \cdot Q_{\text{Н}}^{\text{С}} + N_{\text{СН}})} \qquad (1)$$

или для котельной:

$$\eta_{\text{КОТ}}^{\text{н}} = \frac{Q_{\text{к}} - Q_{\text{СН}}}{(B_{\text{Т}} \cdot Q_{\text{Н}}^{\text{С}} + N_{\text{СН}})}. \qquad (2)$$

В этом случае потребленная электроэнергия (полученная от стороннего источника) рассматривается как часть подводимой энергии и все определяется собственными характеристиками оборудования котельной.

При таком подходе величина $\eta_{\text{КОТ}}^{\text{н}}$ *позволит учесть и энергетические затраты на собственные тепловые и электрические нужды, и экономию от применения детандер-генераторного агрегата.*

В случае применения ДГА, когда вся вырабатываемая установкой электроэнергия расходуется на собственные нужды котельной, формула (2) приобретает следующий вид:

$$\eta_{\text{КОТ}}^{\text{н}} = \frac{Q_{\text{к}} - Q_{\text{СН}}}{(B_{\text{Т}} \cdot Q_{\text{Н}}^{\text{С}} + N_{\text{СН}} - N_{\text{ДГА}})}. \qquad (3)$$

Один из способов подогрева газа - использование дымовых газов газотурбинной установки (ГТУ).

При этом возможны два следующих варианта:

а) мощность ГТУ такова, что вся теплота дымовых газов идет на подогрев газа перед детандером;

б) мощность ГТУ больше необходимой для подогрева газа и избыточная теплота с дымовыми газами направляется в топку котла.

В работе рассмотрен вариант, при котором вся производимая установкой электрическая энергия идет на покрытие собственных нужд котла.

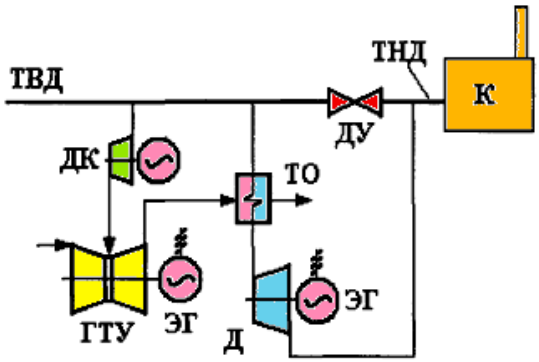

Рис.1. Принципиальная схема установки с подогревом газа дымовыми газами ГТУ. ТВД, ТНД - трубопроводы высокого и низкого давления; ДУ - дросселирующее устройство; ТО - теплообменник подогрева газа; Д - детандер; ДК – дожимной компрессор; ЭГ - электрический генератор; К - котёл

Мощность ГТУ, необходимую для подогрева газа перед ДГА, считая, что энтальпия газа на входе в ДГА h_0 может быть не равна энтальпии газа на выходе из детандера h_2 определим из:

$$N_{\text{ГТУ}} = B_{\text{ГТУ}} \cdot (Q_{\text{Н}}^{\text{С}} + h_0 - h^0) \cdot \eta_{\text{ГТУ}} . \quad (4)$$

Теплота, содержащаяся в дымовых газах ГТУ:

$$Q_{\text{ДГ}} = B_{\text{ГТУ}} \cdot (Q_{\text{Н}}^{\text{С}} + h_0 - h^0) \cdot (1 - \eta_{\text{ГТУ}}) . \quad (5)$$

Требуемая теплота дымовых газов ГТУ с учетом теплоты уходящих газов:

$$Q_{\text{ДГ}} = Q_{\text{ПОВД}} \cdot \frac{t_{\text{ДГ}} - t_{\text{ХВ}}}{t_{\text{ДГ}} - t_{\text{УХ}}} . \quad (6)$$

Теплота, $Q_{\text{ПОВД}}$ которую необходимо подвести к газу, определяется соотношением:

$$Q_{\text{ПОВД}} = B_{\text{Т}} \cdot (h_1 - h_0) . \quad (7)$$

Используя формулы (4), (5), (6), получим необходимую мощность ГТУ для обеспечения требуемой теплоты дымовых газов:

$$N_{\text{ГТУ}} = Q_{\text{ПОВД}} \cdot \frac{t_{\text{ДГ}} - t_{\text{ХВ}}}{t_{\text{ДГ}} - t_{\text{УХ}}} \cdot \frac{\eta_{\text{ГТУ}}}{1 - \eta_{\text{ГТУ}}} . \quad (8)$$

Расход топлива на ГТУ $B_{\text{ГТУ}}$ может быть определен по формуле:

$$B_{\text{ГТУ}} = \frac{N_{\text{ГТУ}}}{(Q_{H}^{C} - h_0 - h^0) \cdot \eta_{\text{ГТУ}}} . \quad (9)$$

Так как энтальпия газа после детандера h_2 не равна энтальпии на входе в газораспределительный пункт (ГРП) $h_0 \neq h_2$, то изменится расход газа, идущий в котел:

$$B_{\text{Т}}^{1} = B_{\text{Т}} \cdot \frac{Q_{\text{Н}}^{\text{С}} + h_0 - h^0}{Q_{\text{Н}}^{\text{С}} + h_2 - h^0} . \quad (10)$$

Изменение расхода газа на котел $\Delta B_{\text{Т}}$ определяется только изменением физического тепла топлива и определяется из выражения:

$$\Delta B_{\text{Т}} = \frac{B_{\text{Т}} \cdot (h_0 - h_2)}{Q_{\text{Н}}^{\text{С}} + h_2 - h^0} . \quad (11)$$

Следовательно, мощность ГТУ составит:

$$N_{\text{ГТУ}} = B_{\text{Т}} \cdot \frac{Q_{\text{Н}}^{\text{С}} + h_0 - h^0}{Q_{\text{Н}}^{\text{С}} + h_2 - h^0} \cdot (h_1 - h_0) \cdot \frac{t_{\text{ДГ}} - t_{\text{ХВ}}}{t_{\text{ДГ}} - t_{\text{УХ}}} \cdot \frac{\eta_{\text{ГТУ}}}{1 - \eta_{\text{ГТУ}}} , \quad (12)$$

а общая мощность ГТУ и ДГА $N_{\text{УСТ}}$:

$$N_{\text{УСТ}} = B_{\text{Т}} \cdot \frac{Q_{\text{Н}}^{\text{С}} + h_0 - h^0}{Q_{\text{Н}}^{\text{С}} + h_2 - h^0} \left[(h_1 - h_0) \cdot \frac{t_{\text{ДГ}} - t_{\text{ХВ}}}{t_{\text{ДГ}} - t_{\text{УХ}}} \cdot \frac{\eta_{\text{ГТУ}}}{1 - \eta_{\text{ГТУ}}} + (h_1 - h_2) \right] . \quad (13)$$

Увеличение расхода топлива $\Delta B_{\text{УСТ}}$ *составит:*

$$\Delta B_{\text{УСТ}} = B_{\text{ГТУ}} + \Delta B_{\text{К}} =$$

$$= B_{\text{Т}} \cdot \frac{Q_{\text{Н}}^{\text{С}} + h_0 - h^0}{Q_{\text{Н}}^{\text{С}} + h_2 - h^0} \left[(h_1 - h_0) \cdot \frac{t_{\text{ДГ}} - t_{\text{ХВ}}}{t_{\text{ДГ}} - t_{\text{УХ}}} \cdot \frac{\eta_{\text{ГТУ}}}{1 - \eta_{\text{ГТУ}}} \cdot \frac{1}{(Q_{\text{Н}}^{\text{С}} + h_0 - h^0) \cdot \eta_{\text{ГТУ}}} + \frac{h_0 - h_2}{Q_{\text{Н}}^{\text{С}} + h_0 - h^0} \right]. \quad (14)$$

Расчет произведен для следующих условий: давление газа перед ДГА 0,5 МПа, давление газа после ДГА 0,15 МПа, температура газа перед ДГА 278 К, $Q_{\text{Н}}$ *=11805 ккал/кг, производительность котла 116 МВт, собственные нужды котельной установки 1048 кВт,* $t_{\text{ДГ}}$ *= 673 К,* $t_{\text{УХ}}$ *= 373 К,* $t_{\text{ХВ}}$ *= 293 К, КПД*$_{\text{ДЕТАНДЕРА}}$ *= 0,9, КПД*$_{\text{ГТУ}}$ *= 0,25.*

Результаты расчета представлены в таблице 1.

Таблица 1.

t_1, °C	T_1, K	T_2, K	$N_{\text{уст}}$, кВт	$B_{\text{т}}$, кг/с	ΔB, кг/с
5	278,15	218,03	321,789	2,564	0,0065
10	283,15	221,95	340,913	2,565	0,0070
20	293,15	229,78	379,589	2,566	0,0081
30	303,15	237,62	418,851	2,567	0,0092
40	313,15	245,46	458,634	2,568	0,0104
50	323,15	253,30	499,084	2,569	0,115
60	333,15	261,14	540,211	2,570	0,0127
70	343,15	268,98	582,061	2,571	0,0138
80	353,15	276,81	624,695	2,573	0,0150
90	363,15	284,65	668,030	2,574	0,0162
100	373,15	292,49	712,118	2,575	0,0175
110	383,15	300,33	757,003	2,576	0,0187
120	393,15	308,17	802,695	2,578	0,0200
130	403,15	316,01	849,193	2,579	0,0213
140	413,15	323,85	896,516	2,580	0,0226
150	423,15	331,68	944,654	2,581	0,0239

На рис. 2, 3 показаны графики зависимости мощности ДГА и ГТУ от температуры подогрева газа перед ДГА. Таким образом мощность ДГА и ГТУ зависит от температуры подогрева газа.

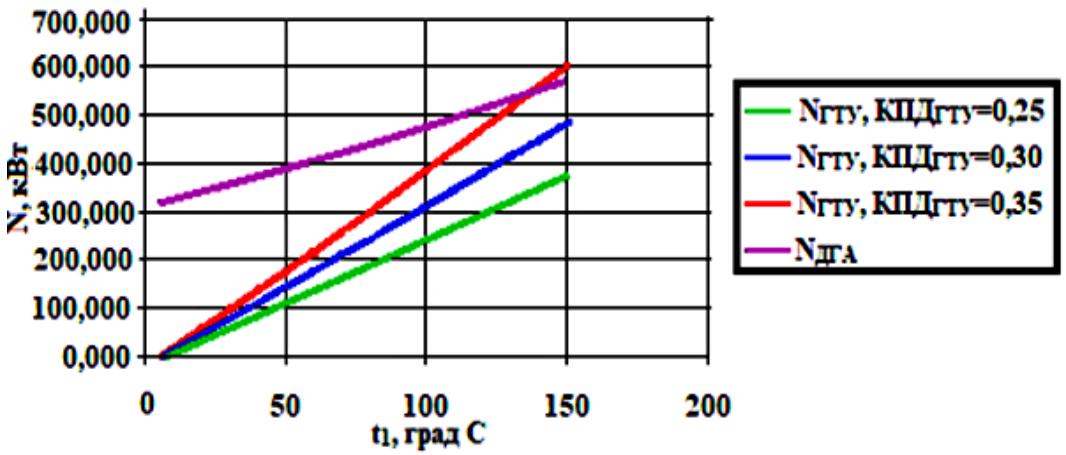

Рис.2. Мощность ДГА, ГТУ при различных температурах подогрева газа и КПД ГТУ

На рис.4 показана зависимость расхода топлива через ДГА и на ГТУ.

Из графика видно, что расход топлива на ГТУ достаточно мал и составляет менее 1.16% от расхода топлива на котел. При этом, при увеличении температуры подогрева газа перед ДГА расход газа на котел уменьшается на 0,036% на каждые 10°С (из-за роста температуры газа после ДГА).

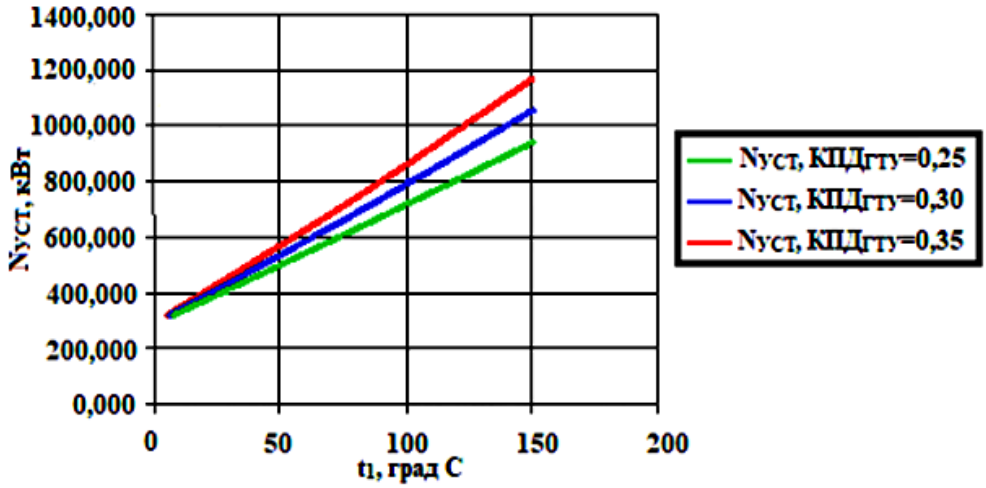

Рис.3. Мощность установки в целом при различных температурах подогрева газа и КПД ГТУ

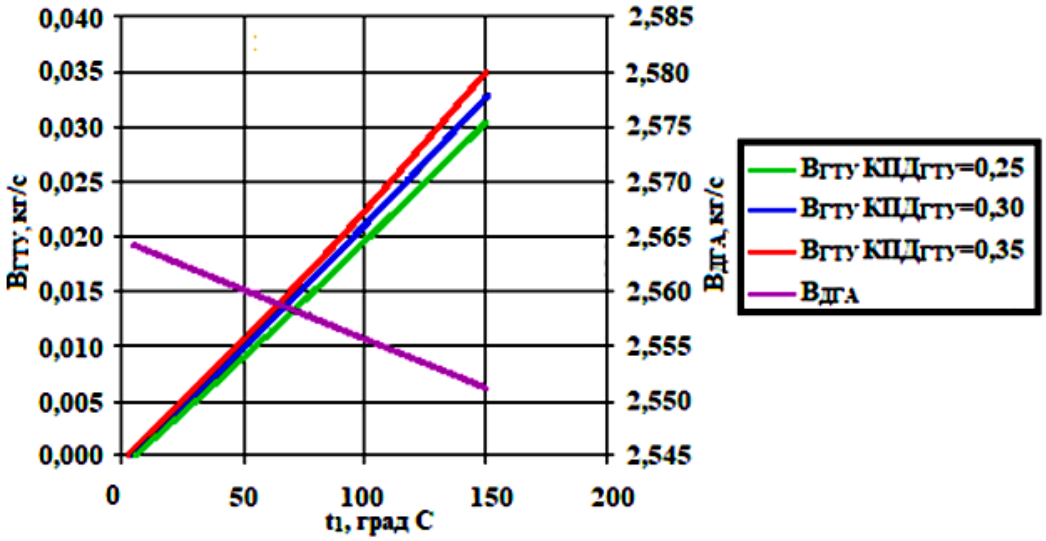

Рис.4. Расход газа через ДГА при различных температурах подогрева газа и КПД ГТУ

Вывод. *Следует отметить, что 1 кВт·ч вырабатываемой на ДГА электрической мощности стоит в несколько раз дороже, чем 1 кВт·ч затрачиваемый для подогрева газа перед ДГА. При этих условиях вариант с подогревом газа при помощи ГТУ является приемлемым.*

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