Miscellaneous

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The Ancient "Actors" of the Mining - Metallurgical Beginning

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ABSTRACT: In the paper is treated the problematic of ancient human developments in rock and mineral elaboration and on the mining - metallurgical "producers" of used .stones and metals. Based on data from the earliest *prearic* and *uric* language, it has been separated the terms used for such "producers". Mankind activated in different works is qualified as "rock-man", "work-man" and lor mining and metallurgical activities as "fire-man". An intensive activity of "fire-man" in groups and tribes is developed at the last millenaries BC over the Old World (Asia, Africa and Europe).

1 INTRODUCTION

/./ *First steps of the human activities in contact with rocks and minerais*

It is generally observed that the nature of the humankind development, in its pre-historical and historical evolution had mainly the orientation from East lands to West lands (in Asia, Africa and Europe). Also the contact and treatment of rock materials and the interesting for minerals and ores had the same course and development in selecting and using them.

Indeed, it is very difficult to fetch any information Irom the historical descriptions on (he antiquity for human persons that had operated in selection and treating of stones in *paleolitic* and *neolitic* ages. Nowadays, we have almost nothing described as "finders" of the gems and "acting man" with different used stones. The situation is not better with the "actors" as "searchers", "exploiters" of the metal ores and "operators" in melting, moulding and casting of different useful metal objects. Indeed, groups of "specialized" men existed and were activated as a driving force of the antique human civilization, and their effects are also used, frequently in actual developments.

The archaeology and the archaeologists observe and distinguish that there were different "actors" of the developments in material elaborations and their creative force in modeling and constructing. Often being present between their ruins, express their astonishment for the ex-constructions, buildings and other works of art in earth, in stone and in metal, which were worked with a virtuous simplicity and with a splendid greatness of the Old World miracle. But on the work operations and the masters of working used, only a confuse reflex may be from the shade of the past.

The same is and for all others that created the tools of development in hunting, stock-breading, agriculture, and habitation centers building and so on. Their masters are plunged in a death - like silence.

1.2 The traces of civilizing "actors" at the substratum of different languages (in an unique monosyllabic state)

For better information about the antiquity and their human "actors", as it is described, legends and myths and other people's narrations are used. Facts from burial grounds and ruins are gathered and interpreted. But. all such an accumulation cannot present the true of the happiness and the personages of the past.

In fact, another source of information isn't unveiled: the human memory, living memory, transmitted by languages. Each actual language is evolved in lime and may have a lot of information from the past of the generations. Different stages have been passed in forming of the actual language and at the components of the actual speaking. So, parts of the earliest speaking may be isolate as "fossilized" words within the syllables of actual used as fundamental words.

A research work on the existing of the monosyllabic compositions within the words of different languages is done (realized) and astonishing results are taken out, particularly for the solid nature conceptions and human activities practiced. It is also concluded that such an initial form of speaking was extended al the *arte* and *prearic* tribes in Central Asia about ten millennia ago. By time are created composition stages of speaking in different languages at human groups forming the speaking of peoples so called of indoeuiopcans. Semitic, camitic and Mongolian languages, actually diffused over all the world.

Table 1

- Human Family:		
Woids	Composed Word	Meaning
Ma	â - M a = am(a) = AM	Motlıeı. Gıand mother
Ta	â - T a = at(a) = AT	Father. Grand lather
	fi - i r = a(Dr=AR	Youns man (son)
	â - i i = Kıla = Io	Young woman (gul)
Ei		Men (plural)
Ba	Later word (Babylonian)	Fathei
Na		Familial gioup (plural We)
Nature Elements		
UÜ		Water
Fıı (Vu. Pu - latei diminutive valiants)		Fire (great fire) Fne (small file)
Ko		Rock, stone
Dhé		Ground
Ei		Wind, air
Ri		Water How. River
El. Ell		Sun (later God)
Actions (verbs)		
K»		going, moving away
ko		looking for. search for
bâ		do. make
»a. ka		hold. own. have
bi		sprout
bı		fall
di		know
Food		
el	â - (e)I = al	food (fruits, plant, seed)
	go - cl = el so	moving food (animal, lowl. bud)
	am - cl = amel. In different later expressions may be also el=al=ol=ul	milk
SettJin.il		
	â - na = ana	oui place, land
	(i)s - ta - (a)n(a) = sum	tribe settlement (father land)
	bâ - 11(a) = ban	dwelling
Divinity		
Di		god
De		goddess
Human activities		
	û - (i)r = ur	river - man
	ar - h(â) = arb laıeı expiessed in different fioms as- rab. lab. lav	work - man
	â - (e) l - b â = alb(a)	food-maker (farmer)
	b(â) - ar = bar (singular)	herdsman
	b(â) - er = bei (plural)	herdsmen

I..i Basic word -forming of the ancient past

The "tracks" of the very ancienl word-forming, as it is mentioned are at the respective actually used languages, bul not only. A great number of the loponomic and hydronomic nominations, names of gods and heroes of the mythic legends, dwelling centers and chief-towns, regions, nations and also actual states, continents and seas may be given their right meaning. For our interesting, also a lot of names considered derived from the old non used Greek and Latin languages had another real meaning from (he very ancient past including the named rocks, ores and minerals. More detailed information on the problematic are in the work prepared for publishing in Albanian and tilled "Shtigje te lashtesisc xehlare", that in English may be "Throw the ancient M.M. developments of the Old World".

In the limited conditions of the paper we may preseni the following list of determined words and their actual meanings, grouped in:

- Existing or being (third person)
û. as, es. is, os, us = is. are (different variants evolved in time)

The "actors" of the solid nature are, by time, differenced in three groups:

a) The group of stone-searchers:

Kö - (i)r = kër —* stone marker (searcher)
K(o) - **ir** = kir — • searcher (lr)
Ko - (a)r = kor — • Ar - searcher
K(o) - **ur** = kur — • Ur - searcher

b) The group of ore searchers and elahorators

F(u) - **ir** = Fir —» Fire man (miner and metal worker)
Fu - **ar** = Far
Fu - **ur** = Fur

By time in different antic populations the consonant "F" is changed in "P", for limited "fires", in "V". So. there are used the compositions:

F(u)ir^Fir=Pir = Vir
F(u)ar — • Far = Par = Var
Fu ur —» Fur = Pur = Vur

The group searchers are named differently as individual independent and dependent searchers-workers. Basically their dependence was from the family or tribe head (Ma, Ta). So, are observed different compositions:

Fir - at. Pir -am etc.

c) The workmen's of gold searching and extracting

From *uric* regions arc called, by their name "ar" as nobleman, but when in later times (3000 - 2000 BC) when the gold was evaluated as a precious metal (foremost by Egyptians, that it considerate as long living God-blood), the nomination changed in:

Ko - El ~ Kel or Kol (individual) and
Ko - El - T(a) = Kelt or in similar variants.

It must be known that the Old World had a great spreading of such "actors" in all the continents, where were considered "first man" of the tribe, of dwelling centres and of the primitive state forming populations. Examples may be the words:

First = F(u) - **ir** - (i)s - t(a) = Fire man's Father
Paris = **Fu** - **ar** - **is** = Far - is = Fire man's is

In Albanian is the word "I Par" = First. A historical fact is that an lllyrian tribe named Pirusta was activated in Mirdita region copper and gold mining and metallurgy. The people were forced by Roman occupiers to deport in Romania at the Carpal Mountains as miners for gold mining. They were:

Pirusta = **Fir-usta** —• Maslers in Mining

It's true also that different Firemen tribes from five to three millenniums ago, in all continents, were famous builders of new towns, ways, bridges and fords. The greatest buildings and statues of the past, are erected by them including the antic Egyptian pyramids. But which is the meaning of their denomination:

- For Rodi Colossus:

Ro-Di Ko-Al-os = Protector God of Gold Searcher is

- For Pyramid:

Pir-Am-Ida = Firemen Mother's mountain of Gods

It is also known that, in the Ancient Egypt, for many centuries, many Pharaoh Dynasties reigned, but what means their common name?

Far - **ra** - on = Firemen King's Womb is.

2 MINERAL AND METAL TERMS

It seams that mineral and metal terms in actual scientific used form are from new modern conceptions, but all may be an occasional impression. In a monos\ll ihk inil\/i ui. m i* lı IM <L\ impies):

Figure I. Dibra Crystal (Gypsum)

a} For minerals

Kristal (Crystal) = **Ko** - **ir** - **is** - Ta - AL = The Father Sun (God) of the Search man is (Fig. I).

Elmaz = El - Ma - Az = The Sun (God) of the Eastern Great Mother is.

Diamond - Is a conception of later ages.

Samfir = **Is** - **Am** -**Fu** - **Ir** = Fireman Mother's is...

Kuarc (Quartz) = **Ko-Vu-Ar-At-is** = Search Fireman's Father is...

Opal = **A-Fu-al** = Fire-feeder is or Sun-Fire is.

b) For metals

The terms formulated in different times, in diverse actual languages are:

Gold

In Albanian AR = **â-ar** of Ars is:

Persian ZÄR = **as-ar** oi Ars is:

Turkish ALTIN = â-EI-Ta-ân = Father-Sun's Land is

Hungarian ARANY = **ar-an-i** = Ars Young Mother's Land is

Russian ZOLLOT = **as-AL-AT** = Father-Sun's is

Czech ZLAT = **as-AL-AT** = Father-Sun's is

English, German GOLD = **go-(E)l-D(i) =** God Sun is

French OR **= ar-â =** of Ars is

Italian ORO = **ar-â =** of Ars **ıs**

Greek FLORI **= Fu-El-Ari** = Ars Sun Fire is

Copper

In Albanian BAKER = Ba-Ko-Er = Searchmen Father's i

Table 2 The word "Iron" in different languages

English	Albanian	Turkish	Persian	Slavic	German	Hungarian	Italian	French
Iron	Hekur	Demir	Ahin	Zelezo	Eisen	Vas	Ferro	Fér

Turkish BAKIR = **Ba-Ko-Er** = Searchmen Father's is

English COPPER = **Ko-Fu-Er** = Searchmen-Miners is

German KUPFER = **Ko-Fu-Er** = Searchmen Miners is

French CUIVRE = **Ko-Fu-Er** = Searchmen Miners is

Albanian REMA = **Ré(Ra)-Ma-â** = King's Mother is

Italian RAME = **Ré(Ra)-Ma-â** = King's Mother is

Hungarian RÉZ = **Re-az** = King's is

Russian, Czech MJEDJ = **ıMâ-di** = Mother's God (or Savant) is

In a particular form during the first millennium BC, the component "MED" is a boasted part of human names in Arabian and Greek language, surely connected with the surprising effects of metals.

At least, the term METAL is a quite common name for many actual languages, excluding Persian, Czech and Hungarian language that had latest evolutions. So, from a decomposition of the word, we may have:

METAL = **Am-Et-AL** = of Mother's King Father, conception that was diffused also at the Hittite Kingdoms.

For other metals, as **Iron** of the latest antic age, the respective term in different languages is conditioned clearly from the time and land it was produced (Table 2).

If we pursue, step by step the development of human civilization from the east toward the west, it may be slightly noted that the developments of course they are connected with the extension of the *prearic* and *aric* movements according to the orientation of young alpine mountain ranges from the SE Asiatic to the Central and SW Europe. The reason, close by the favourable climate was the presence of an abundant source of minerals for the humankind needs. This fact support the logic of such a development and naturally the exit from Anatolia to the next continents (Africa and Europe) was a natural gale very appropriate for more important and advanced developments in time in mining and metallurgy. It is sufficient a visit at the Museum of the Anatolia civilizations in Ankara to be convinced for such a priority. Independently of the no presence there of the citations for "Ko-ir", "fuir" and other terms for the "actors" of the ancient mining and metallurgy, there arc present their advanced works, as bounding steps of the human history.

Except the over mentioned ancient conceptions on mineral and mining works, there is a treasure of toponyms and hydronyms of the mineral and metal-giver lands all over the Old World as fossilized traces of the ancient human thinking and speaking. Knowing and analyzing its compositions, we may be have a complete complex vision about the earliest human civilization development, where the confirming "actors" and "authors" appears with their force and greatness.

Let wish that the future give for all peoples the right image of getting up, step by step on the stairway of the human civilization. Humankind must see more clearly his past, to pass more normally his future beins; Hows.

3 CONCLUSIONS

1. Humankind's developments of the antique prehistoric and historic limes and the respective Human Civilizations are narrowly connected with Human activities on the solid part of the nature.

2. The start of the known developments was firstly reflected at the central Asiatic lands by the *pre-aric* and *aric* tribes and peoples. They were also in an advancing movement oriented especially according to the extension of the tertiary mountain ranges mainly from the Asiatic South-East to the North-Wesl and further to Caucasian and Anatolian lands penetrating in North Africa and all the Europe.

3. The more advanced antique activities in mining and metallurgy were manifested in Caucasian and

Anatolia regions that proceeded in time and in technology.

4. The human "actors" in elaborating stones and ores evolved also in time. They are differentiated in "searchers" called "Kor", "Kir" and rarely "Kur", in lire-men oriented in pottery and mining-metallurgy, called "Far", "Fir" and partly "Fur" and. al last, "gold searchers" and "operators" named "Kol" or "Kel". Their activity was known over all the Old World during many millenniums individually and in groups guided by their "Fathers" "Is Ta" or "Usta", which frequently were also the leaders of the antique society as "Kings", in building and managing of City-Statcs.

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Economic Criteria of Ore Deposits Mined with Consolidated Stowing

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ABSTRACT: In the paper worked out approach is presented which allows solving a problem of determination ol" optimal characteristic properties of filling mass (its compressive strength, shrinkage and so on). This approach takes account of both geomechanical characteristics and economic criteria.

I INTRODUCTION

Mining method with consolidating stowing was widely propagated for thick ore deposits mining in the Republic of Kazakhstan at the end of the 20.h century. Bui in new economic conditions different variants of this mining method became very expensive, especially because of large consumption of structural cement per I nv[1] of tilling mixture. Level of ore losses and ore dilution depends on compressive strength of filling mass, and compressive strength, in turn, depends on cement consumption. Consequently, criterion for determination of optimal characteristic properties of filling mass is a balance of profit at the expense of decreasing of cement consumption per 1 nr[1] of filling mixture and loss of additional ore losses and ore dilution.

2 DETAILS OF PROBLEM

When mining of thick ore deposits by room and pillar method with consolidating stowing it is necessary to determine normative compressive strength for particular mining-and-gcological conditions. Filling mass interacts with surrounding rock mass, changing its stressed-dcforming condition and increasing its support ability. Studying of behaviours of this interaction and worked out compositions of tilling mixtures with necessary properties we may act on a "weak" element of a system, which is in limiting condition. For milling by room and pillar method such element is ore pillar (or a group of pillars) which is extracted in the final (urn. So, a problem of determination of normative characteristics of tilling may be formulated as: strength characteristics and deformation properties of filling must ensure maximum concentration of stresses in pillars, extracting in the final turn, not to go over the permissible limit.

Economic factor plays an important role in determination of normative characteristic of filling's compressive strength. It is known that in cost of filling operations more than 50% falls at costs on filling materials and cement consumption is the main factor, defining both costs of filling mixtures and level of ore losses and ore dilution. So, normative compressive strength (a'_a) must be not only technologically justified but economically expediency. That is why the following additional condition is taken into account:

$$a_n \quad SCT,;(C,,L>,,'VC,,„) \qquad (1)$$

where; C_n, optimal value of normative filling strength, depending on its cost c, , economic damage at the expense of ore losses and ore dilution $U_rL),i$ and binding agent (cement as a rule) consumption c_{ha} .

Economic loss at the expense of ore losses may be considered as received less profit. Economic loss at the expense of ore dilution we may consider as unproductive costs for extracting of additional volume of barren rock, poor ores and broken filling material and also costs connecting with decreasing of ore quality. On the basis of carried out analysis we may establish a fact that changing of a level of ore losses has less influence on profit than changing of a level of ore dilution.

When using of mining method with consolidating stowing changes of strength characteristics and cost of filling mixtures may be carried out by variation of cement consumption. In this case when decreasing cement consumption per 1 nr of tilling mixture.

compressive strength decreases, because it bears an exponential f relationship to cement consumption. Correspondingly ore losses and ore dilution increase and it causes economic loss. So, economically expedient condition of cement consumption decreasing is the following - economy at the expense ol'decreasing of cemeni consumption (E_c) must not be less than damage at the expense of additional ore losses and ore dilution:

$$E_c \geq D_l + D_d \quad (2)$$

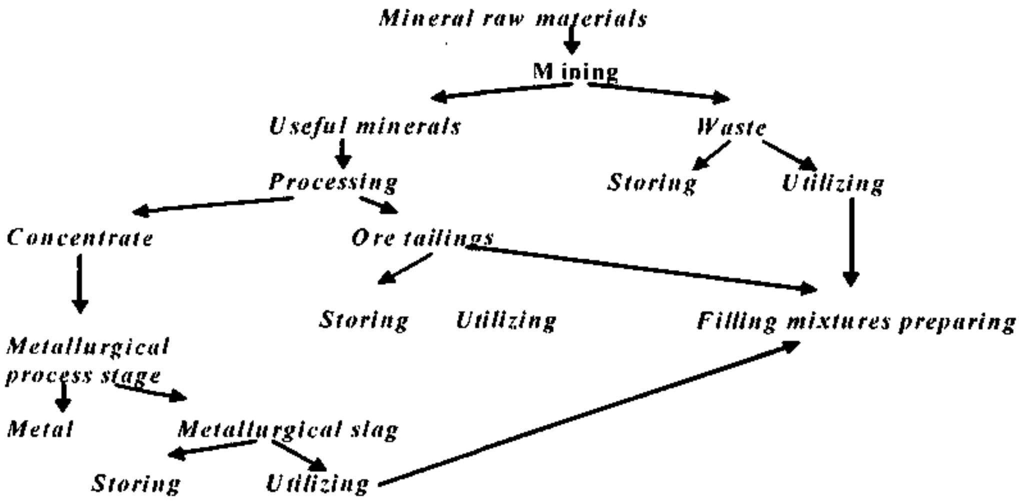

Figure I Scheme of solid waste of mining, processing and metallurgical utilization

To decrease the costs of filling mixture, it is possible to prepare multi-component filling mixtures at the basis of solid waste using. Today level of waste processing accounts 4.9%*of rocks, 3% of waste of coal processing, 3.7%' of ash, 9% of waste of phosphorous production. Investigations showed that industrial solid waste (rocks, "ore tailings, ash. metallurgical slag) may be used for producing of special sorts of cement for filling mixtures preparing. It will decrease costs of fiiline operations and increase profitability of a number mining enterprises of the Republic of Kazakhstan. Negative influence of enterprises of mining-and-metallurgical complex on environment is one of the very important economic and social problems. That is why it is necessary to introduce ecologically clean technologies, providing full utilization of industrial waste. Scheme of one of such variants of mineral raw materials using is presented in Figure 1.

Solid waste using for filling mixtures preparation may be considered as a measure for improvement of ecological situation in mining regions and at the same time economical factor, increasing effectiveness of ore extraction by mining methods with consolidating stowing using. Technological indexes of mining systems with consolidating stowing depend on both of cement consumption and composition of filling mixtures. Working out and using different compositions of filling mixtures for different mining-and-gcological conditions at the same deposit we may ensure safe technological requirements of ore extraction with optimal economic indexes and receive maximum profit per I ton of mined ore.

3 CONCLUSIONS

Determination of normative compressive strength of filling must be carried out in the following sequence:

Stressed-deforming condition of rock mass is evaluated with due account of dynamics of mining operations development, mining-and-geological and mining-and-technical characteristic properties of a deposit for determination of the "weakest" element, depending on stability of a system as a whole:

Condition is determined for saving the stability of this element, taking account of its interaction with physical-mechanical properties of filling;

Values of deformation and strength characteristics of filling arc determined, which should conform to given gcomechanical requirements and are practically normative characteristics;

Compositions of filling mixtures with given physical-mechanical characteristics are worked out and selected and economic expediency of their utilization is evaluated.

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Pecularities of Regulation of Nature-Using in Mining Regions of Kazakhstan

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ABSTRACT: Development of economy of the Republic of Kazakhstan is based on development of mineral raw materials basis. In new economic and ecological conditions it is very important forming of the system of regulation of nature-using for subjects of mining production. Elements of this system are presented in the paper.

I INTRODUCTION

Mineral resource, including power-generating fuel, ferrous and non-ferrous metals, oil-chemical mineral raw materials, mineral raw materials for industry of structural materials and agronomic-industrial complex, which are necessary for life's work of society, influence the level of economic development of any country as a whole. Today the main factors of humanity development are studying of ensuring of life's work of society and forecasting of its needs in mineral resources. In the end mineral resources are the basis, characterizing economic, social, ecological problems of progress of modern economy.

As known, total volume of moved rock mass all over the world is more then 100 milliard tons. Technical-in-genesis mass (artificially formed mass, including overburden rocks, ore tailings and metallurgical slag) specifically effect on biosphere of regions. Areas of alienated and broken lands reach several thousand hectares for some kinds of mining enterprises. Substantial losses are characteristic for mining complex, connecting with low level of complex processing of mineral raw materials. In the former USSR up to 5 milliard tons of overburden rocks, 0.7 milliard tons ore tailings, 0.15 milliard tons of ash were stored, and only 2 percents of them were utilized.

2 DETAILS OF STUDY

In a process of integration of the Republic of Kazakhstan in world economic society the special place is given to mining-and-metallurgical complex, as the main branch of industry, having powerful export potential. For the nearest future mineral raw materials will be the basis *o(our* economy. Total volume of investments to 2005 will be more than $2 milliard. The increase of volume in production of mining-and-metallurgical complex will be 17 % for non-ferrous metals, 7.5 % for ferrous metals, 36.8 % for iron ore and 70 % precious metals. Sustainable development of mining-and-metallurgical complex proposes the following problems: taking inventory of natural-resource potential of the mining enterprises and the related branches; determination of standards on multi-component mineral raw materials in evaluating the reserves of deposits; bringing competitiveness to mining raw materials and producing their products, solving problems associated with sale of metals produced; analysis and using of accumulated wastes as one of reserves of strengthening of mineral raw materials basis; value estimation of wastes as a potential mineral raw material for the following using; justification of optimal variant of complex using of multi-component ores.

The last decade economic condition of Kazakhstan practically full depends on results of mining and processing of geo-resources. However it is necessary to establish a fact that positive improvement is absence in the country in a field of ecological safety when exploiting bowels of the Earth. Development of specific nature-conservation measures is caused by specific nature of mining production, mining resources, peculiarities of mined part of bowels of the Earth and territory of location of a source of the resources. Taking place changes of mining parts of bowels of the Earth, very substantial in a form and in a scale, have no systematic registration and estimation. Forms of displaying of global ecological problems as a result of exploitation of resources of bowels of the Earth arc numerous and varied. As a result of these changes historical pollunon takes place with annual their increase by 1 milliard tons. Waste forming in mining industry is (in milliard tons): in non-ferrous metallurgy - 6.9: in ferrous metallurgy - 3.6; in heating power engineering- 1.35. From total 21 milliard tons of accumulated waste about 5.2 milliard tons are toxic waste. Volumes and structure waste of mining industry is presented on Figure 1.

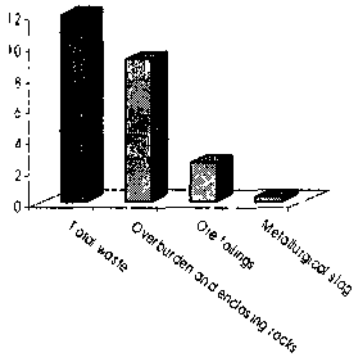


Figure 1. Volume and structure of mining waste production

The most part of waste of mining-and-metallurgical enterprises is potential mineral raw materials for increasing of production of non-ferrous and precious metals, rare elements. From total volume of waste about I89f are waste, including lead and its compounds, *2%* includes arsenic and its compounds, more than 36 mill.t of waste include radio-active matters: more than 5H mill.t are phosphorous-containing waste and 1.2 mill.I are waste, including fluorine compounds and so on. Branch proportion of discharges of pollutants is presented on figure 2.

As we can see from Figure 3 volume of discharges of stationary sources of pollution in the last years decreases but it is connected with decrease of production in the country and not with improving of ecological situation in the country.

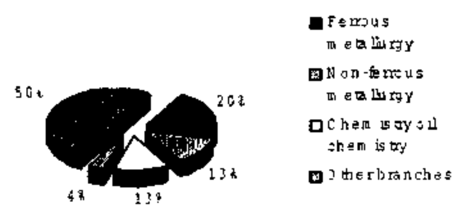


Figure 2. Share of branches of industry in total discharges of pollutants

As it is well known ensuring of ecological safety consisted in decreasing of a level danger of mining waste. But today, in our opinion, we must say about ecological orientation of mining industry: decreasing of per unit consumption of resources of production, due account of deficit and limit of many kinds of resources, rehabilitation of lands and parts of bowels of the Earth, which were broken by mining operations in mining regions. It is possible when working out of unified strategy ensuring of ecological safety of running in and exploiting of resources of a region, because modern practice of nature using gives evidence of ecologically dangerous consequences, for example, teehnical-in-genesis earthquakes take place in regions of oil-mining in Western Kazakhstan. The main principles of this strategy are:

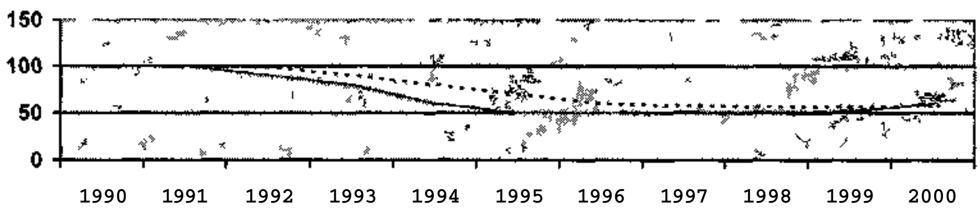
- ensuring of life's work of society depends first of all on ecological consequences of its activity;
- ecological safety is possible when joint studying of all stages and processes of mining production: search and exploring of resources - mining - processing - utilization of waste - liquidation of consequences of mining operations;
- ensuring of ecological safety is possible when effective regulation interaction and interconnections in specific ecological-economic system, arising when running in and exploiting of resources of a region.

Function of this system is based on normative-legal supplying of using of bowels of the Earth, economic mechanism of regulation of nature using, creation of scientific-technical and industrial-technological programs on ecological safely, ecological audit and control, licensing and so on. This strategy causes working out a system of ecological safety ensuring when running in and exploiting ot resources of a region, the main principles of which are:

- determination of normative of ecologically permissible running out and using of nature-resource potential of a region, due account of ecological balance in a region;
- improving of ecology of an area and saving of life quality in a region of resources running in (Figure 4).

Becoming sharp of conflict in a system "human-socicty-natuie" shows that the further economic growth in conditions of limit and deficit of many kinds of nature resources must cause to global catastrophe. And it may be marked by three intersecting factors - economy, resources and ecology. Conception of sustainable development was a attempt of a search a way to working out of common to all system of behavior. Solving of ecological problems has two approaches: global and regional.

Studying analysis and stable evaluations ol eco logical ptessuie ot technical systems on envuonment weie loimed and opeiate al inteistate and global levels However mechanism ol envuonment piolection is showed thiough specilic subject That is why subjects must guaiantee ensuring ol ecological safety in a iegioii It as a whole environment piolection is a point ot state iank sepaiate piactical prob lems must be solved in those regions where they ause and where there is necessaiy information about pollution Coming liom such inlormation measures aie woiked out toi improving ot sanitary conditions ot envuonment All industnal-economic activity in any region must be coordinated with common stial egy ot pollution prevention Stabilization and im piovement ol ecological situation aie possible when loiming ot state ecological policy taking account ol social-economic development ot regions then eco nomic signilicancc peispectives ot development and ecological condition



Figuie •? Dependence ot decreasing volumes of pollutant dischaiges on decreasing pioduclion

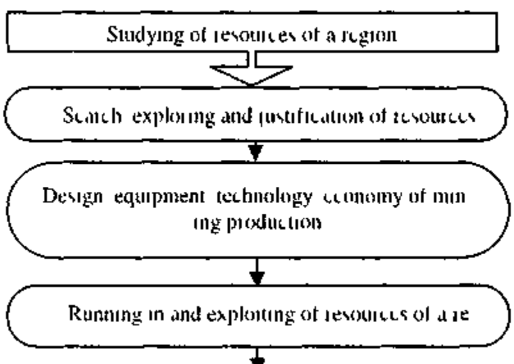


Figure 4 Scheme ol ensunng ol ecological salety in mining regions

Studying analysis and stable evaluations ot ecological pressure ol technical systems on environment were loimed and operate at intei state and global levels However mechanism of environment protection is showed thiough specilic subject That is why subjects must guaiantee ensunng of ecological safety in a region If as a whole envuonment piotection is a point ol state rank separate piactical pioblems must be solved in those regions where they anse and where there is necessaiy inhumation about pollution Coming liom such intoimation measures are woiked out toi impioving ol sanitaiy conditions of envuonment All industrial-economic activity in any region must be cooidmated with common strat egy ol pollution prevention Stabilization and im piovement ol ecological situation are possible when foiming of state ecological policy, taking account ol social-economic development ol regions then economic significance peispectives ol development and ecological condition

The main elements of this system in oui opinion are the following estimation ot real ecological situation in a region taking account ot histoucal and modem pollution for example, solid waste coirec tion ol si/e of payments tor pollution ol envuonment ol regions with due account ot ecological conditions in any region Realization of these main principles ot the system is based on an arrangement ol mining regions by ecological condition The cutenon tor the arrangement is quality ot human lite In establishing ot regional evaluation ot condition ot envuonment the lmpoitanl place is given to working out ot ecological-economic registration document ot icgion/enteiprise It represents real pollution ot bio sphere especially toi mining regions souices ot pollution and then chaiacteustics levels of using of nature resources levels and volumes ot development of blanches ol economy ol mining regions, ditleientialing ot zones of a region with due account of the region's economic activity and ecological load

Market respects and different forms of property dictate necessity of working out of normative evaluations of ecological limits, including:

- ecological limits - pollution of biosphere of mining regions by different kinds of waste: determination of ecologically permissible limits of nature using in mining regions;
- economic limits - rational, possible and necessary for mining regions structure of branches of economy with due account of food, ecological and economic safety,
- solving problems of possibility of carrying out and limiting of economic activity in mining regions.
- Offered by us estimation of effect of mining industry on environment proceeds from the following principles:
- analysis, estimation and taking account of existing condition of environment in mining regions with due account of historical pollution;
- estimation of stability of elements of biosphere (atmosphere, soils, lands, bio-resources) to forecasting lechnical-in-gencsis effects of mining enterprises on environment:
- complex approach to evaluation of tcehnical-ingenesis influence on biosphere of all operating economic objects in mining regions;
- taking into account social, economic factors and parameters of development of mining regions with analysis if their economy and consequences of operating of enterprises and productions, located in this area, demographic situation and health of population.

Mining practice must include prevention of negative ecological consequences, liquidation and decreasing their danger. Modern conditions of environment require creation of scientific principles of control by ecological situation. The important attention is paid to studying of possibilities of arising of ecological danger in mining regions because of activity of technical-in-genesis geo-systems, working out of methods of evaluation of ecological situation, methods and measuring devices for control of ecological parameters, creation of standard ecological systems, which confirm to normative of nature using. All negative influences on ecological systems of mining regions effect immediately on parameters of ensuring of life's work of bio-resources (Figure 5).

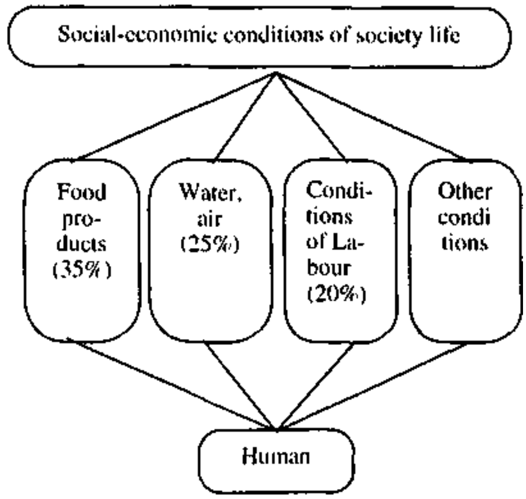


Figure 5. Forming of conditions of life's work.

3 CONCLUSIONS

In difficult ecological-economic conditions for mining regions of Kazakhstan it is necessary and very important forming of system of regulation of nature using by subjects of mining production. The main elements of this system, in our opinion, arc the following: estimation of real ecological situation in any mining region; taking account of historical and modern pollution, for example, solid mining waste; correction of size of payments for pollution of environment with due account of ecological conditions in any region. Realization of these main principles of the system is based on an arrangement of mining regions by ecological condition. The criterion for the arrangement is quality of human life in mining regions in accordance with the main parameters of human life's work in a zone of location of subjects of mining industry.

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Determination of Thermal Conductivity of Building Stones from P-Wave Velocity

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ABSTRACT: One aspect of energy efficiency is the improved insulation of buildings by using stones of a low thermal conductivity. In cold climates this results in reduced heating requirements, whilst in equatorial regions air conditioning energy consumption is decreased. Determination of the thermal conductivity of a natural stone plays an important role when considering its suitability for energy saving insulation. Thermal conductivity of rocks changes with rock type since rocks have variable and different mineral constituents. Secondly the porosity, natural water content and density is also very important property, which affects the thermal conductivity. In the study its found that laboratory determined P-wavc velocity of the rock samples which is a function of total porosity affects the thermal conductivity. So thermal conductivity values of natural stones found to be directly proportional to their P-wave velocities and there exists a good correlated relationship between them. So by measuring sonic velocity of a rock one can guess its thermal conductivity with a close approximation.

I INTRODUCTION

Encıgy efficiency is a subject that needs to be considered in building industry. To an increasing extent, energy usage, and more particularly, energy wastage is receiving close examination at present (Hasan 1999). By using natural stones of a low thermal conductivity improves insulation of buildings by giving energy efficient solution. The hot plate method (BSI 1986) is typical of the steady state method of thermal conductivity measurement. The thermal conductivity is determined from measurements of the temperature gradient in the stone and the heat input (ASTM 1990).

Guarding or correcting for heat losses is essential, as well as accurate measurements of the heat flux. With low conductivity stones, the necessary steady stale conditions take a long time to achieve. Heat conduction obeys to Fourier's law. Equation (I) derived from Fourier's law, which is used for heat conduction (Incropera & Dewitl 1990).

$$k = -\frac{q_x}{(dT/dx)} \quad (1)$$

In the formula (I), q_x is the heat flux (W/m^2) and its the heat transfer rate in the x direction per unit area perpendicular to the direction of transfer. It is proportional to the temperature gradient, dT/dx. dx is the thickness of the wall in x direction. The proportionality constant k is known as the thermal conductivity (W/mK) and is a characteristic of the wall material. The minus sign shows that heat is transferred in the direction of decreasing temperature. It follows that, for a prescribed temperature gradient, the conduction heat flux increases with increasing thermal conductivity. Considering the physical mechanism associated with conduction in general, the thermal conductivity of a solid is larger than that of a liquid, which is larger than that of a gas. For example (Incropera & Dewilt 1990);

- fireclay brick has a thermal conductivity of 1.7 W/mK,
- water at 30()°K has a thermal conductivity of 0.613 W/mK.
- ice at 273°K has a thermal conductivity of 1.8« W/mK.
- air at 3()0°K has a thermal conductivity of 0.026 W/mK,

As shown above when water becomes ice its thermal conductivity increases three times. This trend is due largely to differences in intcrmolccular spacing for the two slates. The thermal conductivity briefly is a transport properly, provides an indication of the rate at which energy is transferred by the diffusion process. So it depends on the physical structure of matter, atomic and molecular, which is related to the state of the matter.

/./ *Insulation systems*

Thermal insulations are comprised of low thermal conductivity materials combined to achieve an even lower system thermal conductivity. In fiber, powder, and Hake type insulations, the solid material is finely dispersed throughout an air space. Such systems are characterized by an effective thermal conductivity, which depends on the thermal conductivity and surface radiative properties of the solid material, as well as the nature and volumetric fraction of the air or void space. A special parameter of the system is its bulk density (solid mass/total volume), which depends strongly on the manner in which the solid material is interconnected and the percentage of pores in the solid. Therefore porosity is a determinative parameter of the thermal conductivity.

If bonding or fusing portions of the solid material forms small voids or hollow spaces, a rigid matrix is created. When these spaces are sealed from each other, the system is referred to as a cellular insulation. Most of the lymra limestones are an example of such rigid insulations. Evacuation of the air in the void space will reduce the effective thermal conductivity of the system. On the other hand the presence of water in the pores will increase the effective thermal conductivity.

The internal structure of a natural stone having open and closed pores in its texture effects to its heat transfer. The heat transfer inside such a stone may have several mode of heat conduction such as: conduction through the solid materials: conduction or convection through the air in the void spaces: and. if the temperature is sufficiently high, radiation exchange between the surfaces of the solid matrix. The effective thermal conductivity accounts for all of these processes. The values for selected insulation systems are summarized in Table 1.

Table 1 Theimophy.sical properties of building and insulating materials and nicks ai 300 Kdnciopera &Dewm 1990)

	Density, p (kü/m'l	Thermal conduetivity. UW/mK)
Coneietei stone mix 1	2300	1.40
Cement mortal	1S60	0.72
Perine	105	0 053
Wood (pine)	540	0.17
Plvwood	545	0 12
Rock		
Oiamre (Barre)	2630	2.79
Limestone. (Salem)	2320	2 15
Maible(llalstiin)	26X0	2 SO
Quarmte. Sioux	2640	5 3«
Sandstone. Berea	2150	2 90

1.2 Other relevant properties

In heat transfer, it is necessary to use many properties of matter. These properties are generally referred to as thermo physical properties and include two distinct categories, transport and thermodynamic properties. The transport properties include the diffusion rate coefficients such as k. the thermal conductivity (for heat transfer), and v, the kinematic viscosity (for momentum transfer). Thermodynamic properties on the other hand pertain to the equilibrium .state *of* a system. Density (p) and specific heat (C„) are two such properties used extensively in thermodynamic analysis. The product pC_p (J/m'K), commonly termed the volumetric heat capacity, measures the ability of a material to store thermal energy. Because substances of large density are typically characterized by small specific heats, many solids and liquids, which are very good energy storage media, have comparable heat capacities (pCp > I MJ/nr K). Many natural stones are also very good energy storage media, in this aspect. Because of their very small densities, however gases are poorly suited for thermal energy storage (pCp = 1 kJ/nı K)

In heat transfer analysis, the ratio of the thermal conductivity to the heat capacity is an important property termed the thermal diffusivityce, which has units of m^2/s:

$$\alpha = \frac{k}{\rho C_p} \qquad (2)$$

It measures the ability of a material to conduct thermal energy relative to its ability to store thermal energy. Materials of large a will respond quickly to changes in their thermal environment, while materials of small a will respond more sluggishly, taking longer to reach a new equilibrium condition (Incropera&Dewiti 1990).

2 THE PROPERTIES OF NATURAL STONES

The mineralogy, grain size and porosity are the intrinsic properties controlling rock strength. The rocks containing quartz as the binding material are the strongest followed by calcite, ferrous minerals; rocks with clayey binding material are the weakest (Clauser and Huenges 1995). In general, the higher the quartz content, the greater is the strength (Price 1960). The strength of rocks is greater for finer grained rocks (Brace 1961). Compressive strength decreases with increase in porosity (Price 1960), (Smorodinov et al. 1970) . Solidified volcanic ashes such as tuff stones, and briquettes made from pumice, are used in Turkey in buildings as an insulating material. These kinds of building stones have large percentage of porosity. On the other hand porous materials arc good insulators of heat and sound. The thermal properties of a natural stone depend primarily on;

- Its mineral composition and constitution

- Its structural and textural features. These include mineral size fine grained or coarse grained, mineral shape and the presence of pores. Also the presence of micro cracks.
- The amount of pore water present.
- The condition it is in, when tested (e.g.. temperature, water content).

In bulk specimens of intact rock the mechanical properties depend not only on the properties of the individual minerals, but also upon the way in which the minerals are assembled. The relevant information is given by a full pétrographie description, which includes the mineral composition of crystals, grains, pores and cracks. The degree of isotropy or anisotropy is also important and varies with the size of the body of rock under consideration. For example, in schist, gneiss, and other foliated rocks, the constitutive properties vary with direction even at the microscopic scale, and to the extent that the mechanical properties even of a small specimen are affected. However, in sedimentary rocks, which are generally laminated, the rock within a lamina may be relatively isotropic, where as at a scale that includes the separation between lamina, the same rock may be relatively anisotropic. On the other hand, other rocks may be strongly anisotropic even within very thin sheets. Primary anisotropy, brought about by preferential orientation during crystallisation, or by recrystallisation during sedimentation or melamorphic processes, may be distinguished from secondary anisotropy, brought about by geologic deformation of the rock.

The number of specimens to be tested should be large enough to obtain an absolute value. But to limit the testing costs without sacrificing the reliability of results, it is necessary to ascertain the minimum number of specimens to be tested. In determining the number of specimens to be tested, account must be taken of the variability of test results and the desired accuracy and reliability of the mean value. (Yamaguchi 1970) analysed this problem by using a statistical technique "Decision of the sample number" after carrying out experiments for compressive and tensile strengths on three kinds of rock, granite, andésite and sandy tuff. He concluded that testing ten specimens could give 90% confidence level in determining the strength of rock. Therefore to lest about ten samples would be enough to accept the result with high confidence.

2. / *Mechanical significance of porosity and density data*

The presence of pores in the fabric of a rock material decreases its strength, and increases its deformabilily. A small volume fraction of pores can produce an appreciable mechanical effect.

Information on the porous nature of rock materials is frequently omitted from petrological descriptions, but is required if these descriptions are to be used as a guide to mechanical performance. Sandstones and carbonate rocks in particular occur with a wide range of porosities and hence of mechanical character; igneous rocks that have been weakened by weathering processes also have typically high porosities.

Most rocks have similar grain densities and therefore have porosity and dry density values that are highly correlated. A low-density rock is usually highly porous. It is often sufficient, therefore, to quote values for porosity alone. But a complete description requires values for both porosity and density.

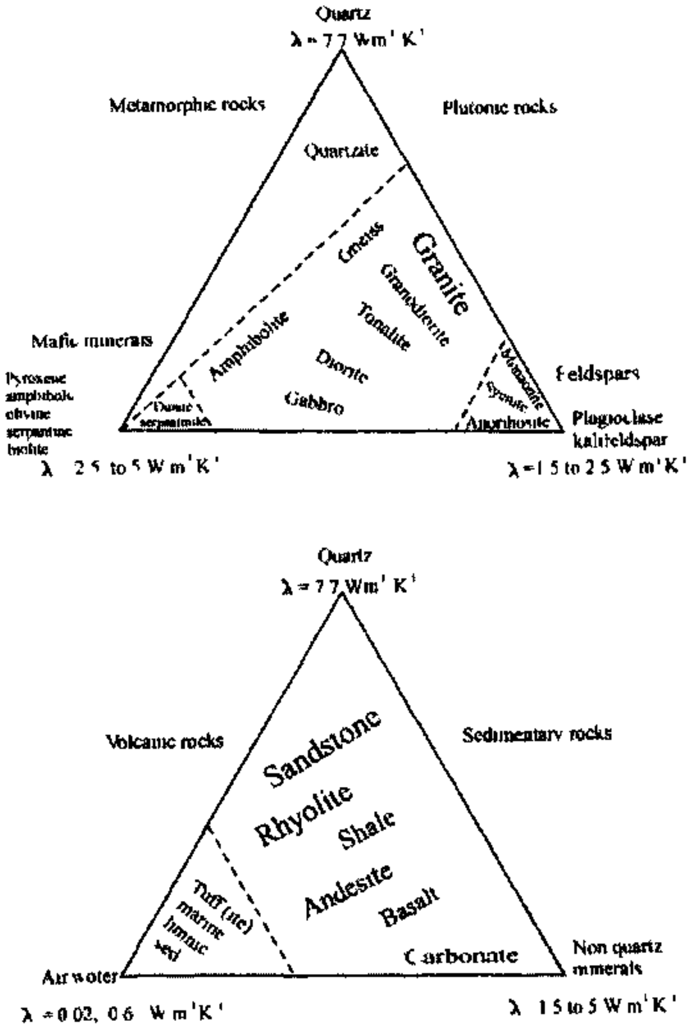
Samples were cut into cubes from several rock lumps. The lump sizes are chosen to be large to minimize the effect of experimental error.

Bulk density determination is carried out according to ISRM Committee or Laboratory Tests, suggested methods for determining physical properties such as porosity or density (ISRM 1972). Grain density is taken as density of solid component of the sample. Buoyancy method is used to determine bulk volume using Archimedes principle, from the difference between saturated-surface dry and saturated-submerged sample weights. Grain mass or the mass of solid part of the sample is obtained by oven drying at a temperature of 105 °C.

Porosity calculated from bulk volume and grain volume using the pulverization method. This gave total porosity. Therefore pore volume obtained includes that of closed pores as well as open pores. The ratio of volume of interconnected pores called open pores to bulk volume of the sample only gives effective porosity value, which can be determined from water absorption quantity.

3 THERMAL CONDUCTIVITY OF ROCKS AND MINERALS

Clauser & Huenges (1995) illustrated the various factors that influence thermal conductivity in rocks and minerals in two ternary diagrams as shown in Figure I. The diagrams relate different types of rocks with those factors that have the most pronounced effect on their thermal conductivity. Figure la is for melamorphic and plutonic rocks. Figure lb is for volcanic and sedimentary rocks. The différent rocks are representative for various classes of rocks within each group, thus representing the total spectrum of thermal conductivity in each group. Feldspars having low thermal conductivity and low variability are not further classified. The position of a rock's name in the compositional triangle indicates in a qualitative way its thermal conductivity.



h»uie I Theinnil conduct.vit> ot basic lock-loiming mmeials and compositional lelal.o.islup with locks (A) Meiamorphic and plûtonıc locks (B) Volcanic and sedimentary locks Foi Volcanic and sedimenlaiy locks the th.ıd mineral P j · ª ^ ^ ' ^ " ' ^ due to tht gieat importance ot poiosity toi the theimal conductivity ol these locks (Clausei & Huenges I99*i)

Meiamorphic and plntonic rocks are made up ot quart? teldspais and mafic minerals, and the content ol mmeials horn these thtee groups basically determines a lock's theimal conductivity since these locks display a much smallei porosity Quaitz content determines conductivity since low conductivity associated with low quaitz-contcnt in metamoiphic tocks In volcanic and sedimentary locks the thud mineral component is leplaced by air and water as the high vaiiabiiity ot poiosity in these locks is a major factor controlling their theimal conductivity Especially tor sedimentary locks the controlling lactors on thermal conductivity aie poiosity and ongin ot particular sediment As tat as origin is concerned chemical sediments, mainly formed by precipitation of dissolved minerals or by compaction of organic material, and low porosity (< about 30%) physical sediments formed by compaction and cementation of clastic material have relatively high thermal conductivities. In contrast, high porosity (> about 80%) mainly marine physical sediments display a distribution which is biased towards low conductivities (Clauser & Huenges 1995).

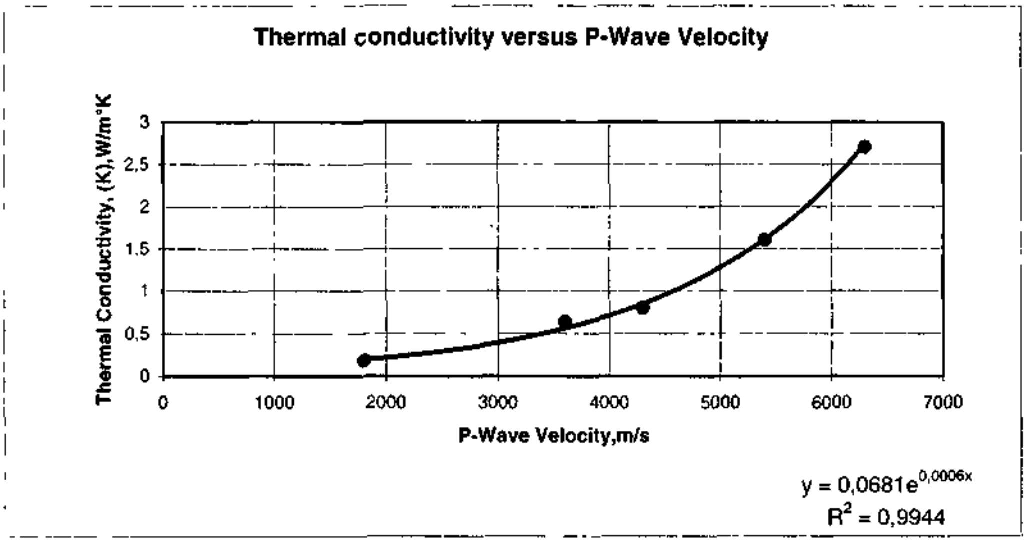
4 TESTS CONDUCTED IN THE LABORATORY

Tests conducted in the laboratory on specially prepared rock samples to determine a relation between thermal conductivity and their physico-mechanical properties. The types of rocks chosen are mainly used in building construction as a structural element or cladding inside and outside walls. Thermal conductivity tests conducted on 50 cm x 50 cm in 3 cm thick plates al a temperature of 300 K. P-wave velocity is measured on oven dried prismatic samples of 5 x 5 x 16 cm in dimension by Pundit apparatus. All the rock specimens were oven dried in all tests. Bulk density is found from bulk volume. The bulk volume of regular specimens is calculated using Archimedes principle, from the difference between dry and submerged sample weights. During the tests a thermostatically controlled, ventilated drying oven capable of maintaining a temperature of 105 °C for a period of at least 24 h is required. After determination of bulk volume and grain mass, the oven-dry sample is pulverized and its grain volume is determined by displacement of an equivalent volume of water in a volumetric flask (picknometer). Porosity calculated from bulk volume and grain volume by this method is termed total porosity, since the pore volume obtained includes that of "closed" pores. Porosity values given in Table I are total porosity values including open and closed pores. Cubic specimens with side length 4 cm. and 10 cm. are tested for compressive strength tests. Tests carried out in accordance with procedures laid out by Standards by l.S.R.M Committee on Laboratory Tests (ISRMI972). The results of tests carried out are given in Table I.

Table *2.* Laboratory determined thermal conductivity, compressive strength, porosity, density and P-wave velocity values of various stone types

Type of stone	**Thermal Conductivity, (W/mK) at 300 K**	**P-Wave Velocity (m/s)**	**Porosity, (%)**	**Bulk Density (kg/m^3*)**	**Uniaxial Compressive Strength, (Mpa)**
Burdur beige Limestone	2.7	6300	1.82	2690	84.8
Bucak travertine	1.6	5400	2.3	2550	57.0
Lymra limestone	0.8	4300	13.2	2430	44.0
Andésite	0.64	3600	16	2240	50.6
AAC bloke*	0.186	1800	84	500	3.43

AAC " is autoclaved aerated concrete (Ytong) which is a structural, insulating building material made of a combination of cement, lime, gypsum and a siliceous material.



Fıguıe 2 Thermal conductivity veisus P-wave velocity

5 SAVING ENERGY BY USING STONE PLATES IN BUILDINGS

Energy efficiency is a subject that needs to be considered by all engineering disciplines. To an increasing extent, energy usage, and more particularly, energy wastage is receiving close examination. By using stones of a low thermal conductivity improves insulation of buildings giving energy efficient solution.

The increase in limestone usage depends on supply and demand in natural stone market. The early use of stones at the beginning was just placing one stone on top of another as a massive construction without paying much attention to costs as today. Later to achieve larger spaces people begin to choose the shape, position and installation of stone. So builders sought stable ways to make the pieces stay together, this led to masonry stone workshops. However it wasn't long before, that people recognised that raw materials was getting expensive due to scarcity of finding stones and increased costs. So builders had to optimise the stone and make it thinner, smaller and more even. Therefore natural stones loose its role as a foundation element and other materials like concrete were used for this purpose and stones begin to be used lor cladding interiors and exteriors. Today cement mortar together with chemical additives is still used to attach the stone to the support wall. Now even thinner stone panels and faster building techniques are being used. Also it was vital to save energy after the oil crises. Global insulation of buildings by their outer skins was a boom and today is still the rage. Today stone plates are the most widely used material for this job and its anchored to the walls. Research is still centred on how to reduce weight, save labour and of course costs. So new technology involves either reducing stone to the thinnest possible sizes or use lightweight limestones like lymra limestone, since it has a lower thermal conductivity coefficient secondly its lighter due to low bulk density.

6 CONCLUSION

The graphs of thermal conductivity against P-wave velocity, porosity, density and compressive strength are drawn. It's determined from the graphs that, P-wave velocity, bulk density and compressive strength of the rock specimens are directly proportional to thermal conductivity and porosity is inversely proportional to thermal conductivity.

Among the relationships, thermal conductivity against P-wave velocity has the best correlation R=0.9944 (is nearest to unity). This means thermal conductivity of any rock can readily be calculated from laboratory determined P-wave velocity, from the relationship:

$$Y = 0.0681e^{0.0006x} \quad , \quad R^2 = 0.9944 \qquad (3)$$

Thermal conductivity values of 0.75, 1.37and 2.49 W/(mK) are obtained inserting 4000, 5000 and 6000 m/s values in Equation 3. Prediction from P- wave velocity is easier than measuring thermal conductivity on larger plates of 50 x 50 x 3 cm plates, which takes longer time and requires larger plates to prepare. In conductivity tests to reach steady state conditions takes longer time.

Also, thermal conductivity versus porosity curve (Figure 3) has a correlation coefficient very close to unity (R^2=0.97), indicating a meaningful relationship.

$$Y = 3.4934x^{-0.6369} \quad , \quad R^2 = 0.97 \qquad (4)$$

Thermal conductivity versus density relationship is not as good as porosity and P-wavc relations, since the bulk densities of natural rocks doesn't differ much, (2240-2690) as shown in Figure 4. The minerais constituting solid part of these rocks have very close much, (2240-2690) as shown in Figure 4. The minerals constituting solid part of these rocks have very close specific gravity values. The data fitted to an exponential curve as given below.

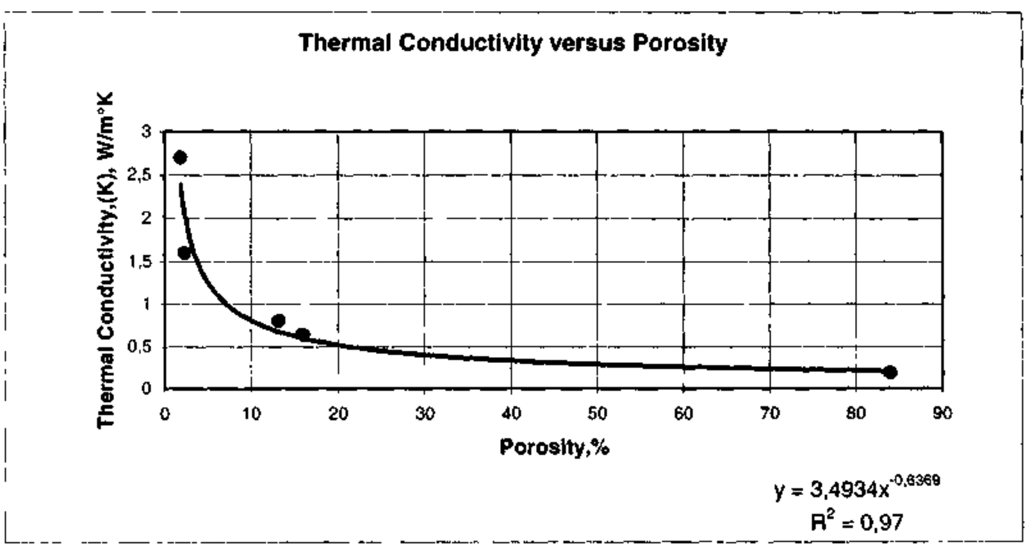
$$Y = 0.0003e^{0.0033x} \quad , \quad R^2 = 0.9236 \qquad (5)$$

Thermal conductivity versus compressive strength curve was also an exponential curve given by;

$$Y = 0.1677e^{0.0135x} \quad , \quad R^2 = 0.9375 \qquad (6)$$

In Equation R^2 is close to unity, this is due to the strength of the rocks shows distinct variation.Energy conservation is an important part of any national energy strategy. Energy conservation in underdeveloped countries with inadequate resources is even more important. Energy conservation in buildings, by using natural rocks that have low thermal conductivity will reduce energy requirement and reduce fossil fuel combustion and its polluting products.

The limestone usage will increase due to its high demand in natural stone market.



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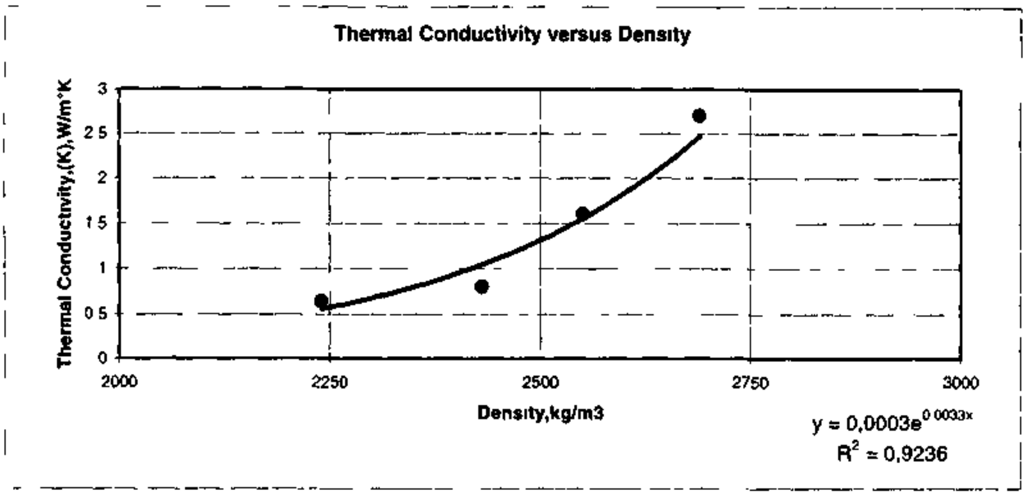
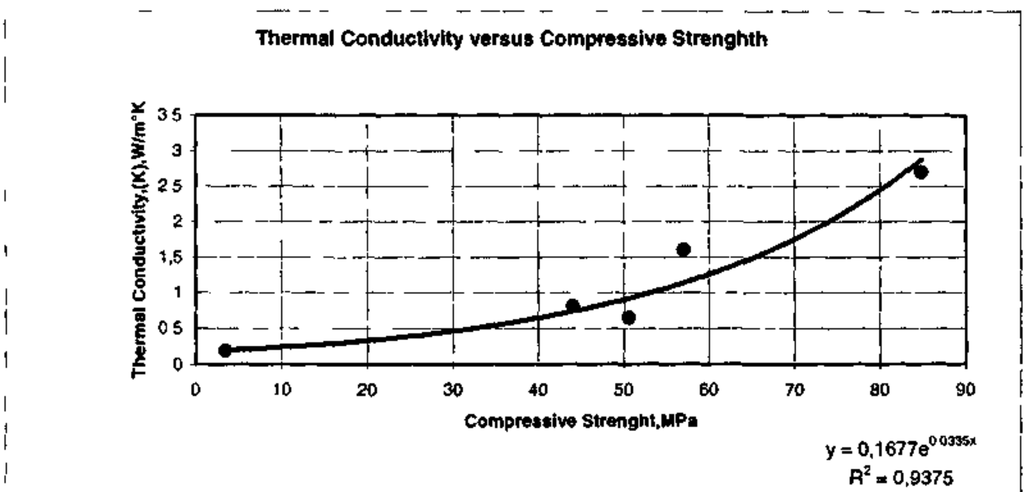


Figure 4 Thermal conductivity versus density



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18"' International Mining Congress and Exhibition of Turkey-IMCET 2003, 0 2003, ISBN 975-395-605-3

A Critical Approach to Usage of Diamond Segmented Frame Saws

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ABSTRACT: Marble is an industrial material with a very high commercial potential in Turkey. At present, one of the machines used for production of slab from marble blocks in marble processing plants is a diamond segmented frame saw. Frame saws are important machines in processing plant due to high production efficiency, production of large slabs and also high installation cost. There are many parameters affects the sawing efficiency during sawing operation with diamond segmented frame saws. These parameters are unchangeable parameters related with stone characteristics, semi-changeable or changeable parameters related with machine and environmental conditions. In addition to these parameters, the industrial usages of frame saws have an important effect on efficiency. In this study, mistakes on industrial usage of diamond segmented trame saws were determined and some suggestions to eliminate these mistakes and consequently suggestions to increase the general machine efficiency were revealed.

INTRODUCTION

Since old periods marble has been used for making of important construction and decoration materials. Marble is preferred as a construction and decoration material due to its sufficient strength, having attractive colors, figures and usefulness. Marble blocks extracted from marble quarry should be subjected to series of processes for usage of human.

Marble processing plant can be defined as a plant in which marble blocks are processed for finish product. The purpose in these plants is the production of required goods according to market demand at possible lowest cost. It is necessary for this purpose that the processes should be carried out efficiently. Marble processing plants consist of various machines having high investment cost. Efficient and conscious utilization of these machines satisfy and increment in efficiency while decrease the production cost of marble.

In scope of this study, revelation of mistakes in industrial usage of diamond segmented frame saws that are important machines having a highest investment cost was aimed. Besides, requirements were considered for eliminating these mistakes and increasing machine efficiency. The mistakes in usage of diamond segmented frame saws and suggestions for elimination of these mistakes were depended on scientific data and observations.

2 MATERIALS AND METHODS

2. / *Diamond segmented flame saws*

Different methods and machines suitable to these methods are used in processing plants for slab production from marble blocks. In marble processing, physical conditions of raw marble blocks such as shapes, dimensions, fracture mechanisms of blocks are considered in determination and selection of processing method.

Diamond segmented frame saws are used to produce the slabs from carbonate originated blocks in marble processing plants. Diamond segments welded on a blade perform sawing process. Sawing process can be carried out in two ways depending on machine structure. In the first way, block is fixed and blades are moved downwards besides forward-backward strokes. In the other way, block on table moves upwards with hydraulic system and blades perform only forward-backward strokes at horizontal plane. The general appearance of diamond segmented frame saw is given in Figure I (Bayram 2002. Kulaksız et. al. 2002).

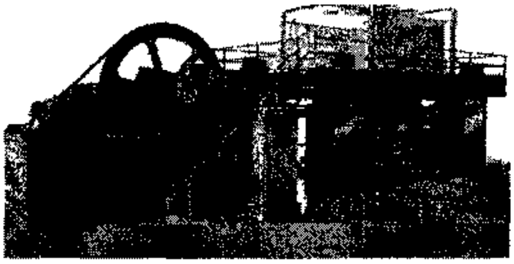


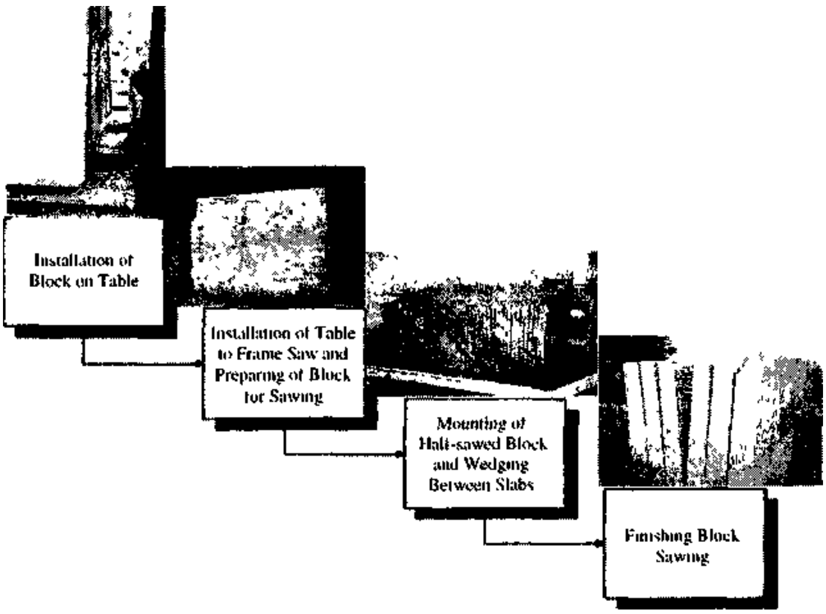
Figure I Genci al appearance of diamond segmented frame saw

Sawing processes in diamond segmented frame saws consist of different steps. These steps affect the number of slab and consequently sawing efficiency. The steps in Figure 2 are generally followed in sawing process. In the first step, block is installed on timber beams on table. The sides of block must be parallel to the side of table. After this step, table is settled to the frame saw. When the block is under the blades completely, block side and blade must be parallel each other. Then, water is supplied to the sawing area. Main motor is run and the forward-backward stroke of blades is realized. Sawing process is performed by downward movement of blade or upward hydraulic movement of block according to the frame saw type. Entrance sawing speed of blade is low. After penetration of blades into block, normal sawing speed is applied. When the blades close to the underside of the block approximately 20-25 cm, the main motor is slopped and water supply is closed. Timber wedges are installed between half-sawed slabs. Using support elements of table presses slabs. Then slabs are mounted by chain tightly. Water is given to the sawing area again and main motor is run. Sawing process is continued at low speed and block is sawed completely. Then, chain and timber wedges are taken out. Slabs on table are installed to stock area by using portal crane.

Diamond segmented frame saws are commonly used in marble processing plant because of their high production capacity and low production cost. The important point on efficient usage of diamond segmented frame saws is to produce slabs at minimum cost by adjusting the effective sawing parameters adequately. The parameters affecting on sawing efficiency can be classified in 3 groups as given in Table 1 (Bayram 2002. Kulaksız et. al. 2002):

- Unchangeable parameters
- Semi-changeable or changeable parameters
- Environmental conditions

Unchangeable parameters affecting on sawing efficiency are related with stone characteristics. Semi-changeable or changeable parameters arc related with diamond segmented frame saws. Environmental conditions arc the conditions at sawing area. It is necessary that these parameters should be considered carefully for efficient usage of frame saws before the sawing operation. The effects of these parameters on sawing might be evaluated by users in detail. Effective parameters should be adjusted adequately for increasing the product efficiency on diamond segmented frame saws.



Figuie 2 Steps of sawing piocess in name sawing

Table I. Parameters affect sawing efficiency un frame saw (Bayram 2002. Kulaksız el al 2002)

1. Unchangeable parameters related with stone characteristics
   - Physical and mechanical properties
   - Chemical properties
   - Mineralogical properties
   - Petrographical properties
   - Discontinuities
   - Textural properties
   - Structural properties
2. Semi-changeable or changeable parameters related with diamond segmented frame saw
   - Sawing speed
   - Interval between segments
   - Structure of segments
   - Water amount and pressure
   - Water purity and pH
   - Dimensions of block
   - Machine structure and motor power
   - Dimensions of blade, blade structure and number
3. Environmental conditions
   - Technical personal
   - Vibration
   - Pressure distribution on blades
   - Forces between diamond grains and stone

Different investigators have performed different studies related with effective parameters on frame sawing up to now. Bayram (2002) and Kulaksız et. al. (2002).summarized these studies as given follow. Löns (1970) measured sawing forces and diamond wear of single segment under some sawing conditions. Gerlach (1981) found that properties of stone and feed rate affected the sawing forces. Meding (1993) found that on a model frame sawing machine, the cutting forces and the segment wear were affected by the feed rate and the sawing times. Wiemann (1968) measured the tensile stress of the frame sawing blades. Jansen (1977) found that the friction among the tension elements reduced the tension acting on the saw blade. Clausen (1992) investigated the method of tool assessment work for frame sawing in the laboratory. In this study, the contact conditions, the sawing forces and the segment patterns were analyzed. Wang and Clausen (2002) performed sawing processes at different parameters and observed the stone surface. In this study, the contact condition between stone and diamond grit was analyzed All these studies are related with specific parameter affected on sawing efficiency, operating conditions and machine structure. But, studies related with efficient usage of frame saw have not been realized. Effects of applications and all parameters in sawing processes have not been investigated. In this study, not only elimination of this lack of frame sawing is aimed but also lime and money consuming due to the wrong usage of machines will be prevented.

2.2 Methodology

Methodology of this study is given in Figure 3. Investigations for this study were performed in a marble processing plant at Afyon-İscehisar Marble Industry Zone. In this plant, 20 marble blocks were sawed with different two types of domestic and imported segments on diamond segmented frame saw which is very well designed according to present technological conditions. The sawed marble blocks are Afyon Violet (AI. A4. A6 and A7), Afyon Sugar (A2, A3. A8, A9, A10 and A11). Afyon While (A5). Kütahya Violet (K2, K4, K6 and K7) Kütahya Green (K1, K3 and K5), Akhisar Onyx (O) and Diyarbakır Beige (D) type marbles. The important mechanical properties of these rocks are given in Table 2. Wearing on diamond segments and average sawing speeds were investigated and interpreted on machine efficiency. After all sawing processes with domestic segments, some segment samples were taken and microscopic investigations was performed for the investigation of suitability of seğmeni usage according to the slone. Furthermore, applications of sawing processes on diamond segmented frame saws in marble processing plant were observed and mistakes in applications were determined. Suggestions for eliminating of these mistakes were revealed.

Table 2 Laboratory test results of investigated rocks (Ba\ram 200; Kulaksız«, al. 2002)

Rock Type	Average Uniaxial Compression Strength (MPa)	Average Tensile Strength (MPa)	Average Stroke Strength (MPa)	Average Shore Sclcroscope Hardness	Average Schmidt Hammer Hardness
Afyon Violet	63	6.8	• 3.3	46	54
Afyon Sugar	58	7.2	3.6	47	55
Afyon White	47	5.7	2	40	51
Kütahya Violet	63.5	6.8	3.6	50	56
Kütahya Green	64	7.5	3.6	46	53
Akhisar Onyx	49	4.2	3	45	55
Diyarbakır Beige	55	4.2	2	46	54

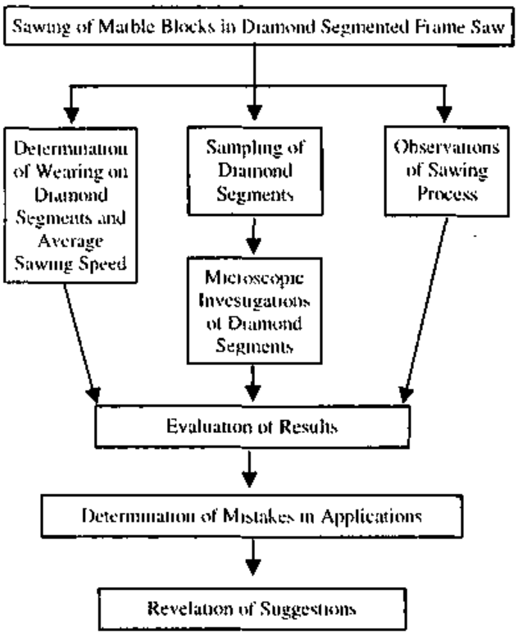


Figure ^ Methodology of study

3 SOME IMPORTANT MISTAKES IN INDUSTRIAL USAGE AND SUGGESTIONS

Diamond segmented frame saws that are the important parts of marble processing should be used very efficiently. Mistakes in usage of diamond segmented frame saws prevent the effective and efficient usage of these machines. The observations in this study revealed thai, these mistakes in a sawing process have no major effect on the production cost and machine efficiency one by one but their repetition increases the production costs and decreases maintenance and usage period of machine in a long time. In this study, some mistakes were determined in the utilization of' frame saws. The mistakes and possible solutions are discussed in below:

- There have been many mistakes in the selection of diamond segments as in the selection of all diamond cutting tools (disc segments, diamond bead etc.) in marble industry. Selection of optimum diamond segments that are using in diamond segmented frame saws is an important factor in efficient usage of frame saws. The production and selection of diamond segments in Turkey arc not depended on any scientific data by marble companies. Selection of diamond segments has been carried out without asking the question of "how a diamond segments should be?" based on rock parameters. This selection has been mostly performed with depend on suggestions of some user, persuasion ability of seller and seller-customer satisfaction. Suitability of selected diamond segments can be determined different sawing efficiency and customer (user) satisfaction according to every marble company. However, it is a fact that physical, mechanical and mineralogical properties of marble arc related with technical parameters of diamond segments.

Microscopic investigations with the fact of wearing types have showed that, the diamond segments used in this study were not suitable to sawing rock. Diamond segment is exposed to wear in sawing operation. As a consequence of matrix wear, the hunchback structure occurred at the front and back of the diamond grits. This hunchback formation is called as comet structure. This structure supports the diamond grit and increases the diamond strength and give information about the sawing quality. The formation of comet structure reveals a better sawing, otherwise it emphasizes that the diamond grits arc not properly active in sawing. Various types of grooves can be formed between these hunchbacks based on the location of diamond grits. The formation of comet and groove are seen in Figure 4. The formation of groove is very important in sawing because by the aid of these grooves, worn diamond, matrix particles and water can be removed out. The main reason of the absence of any groove is that the matrix hardness is higher than the rock. When swarf and water are not removed from environment, the material wears the diamond and especially matrix and as a result of this situation the segment life decreases (Bayram 2002. Kulaksız et. al. 2002). The comet and groove formation were not seen mostly on diamond segments (Fig. 5). This situation affects the sawing efficiency of diamond segments directly.

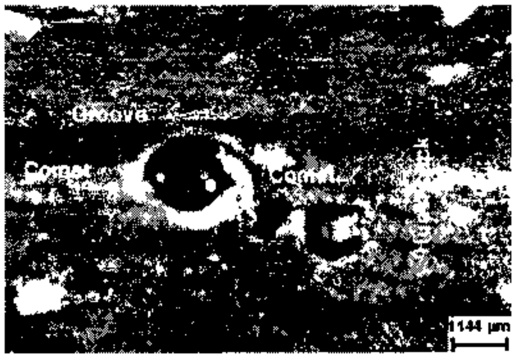


Figure 4. Appearance of cornel and groove on diamond segment (Bayram 2002 Kulaksız et al. 2002)

Fıguıe 5 Appearance ol .segment slructuıc Willi no comet anil groove formations (Bavram 21)02. Kulaksız et al 2002)

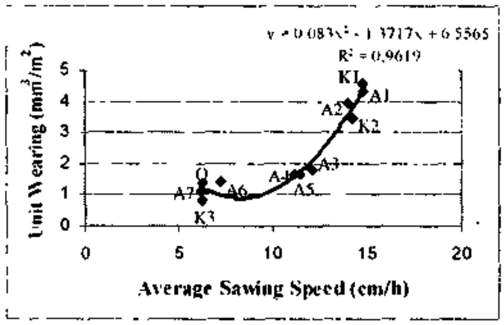
Figure 6 Grooves occui on nıatıı.v ou! o: s.s.vüig (Bayram 2002. Kulaksız et al 2002)

Selection of diamond segments on diamond segmented frame saws must be suitable to physical, mechanical and mineralogical properties of rock. After the evaluation of rock properties such as grain size, hardness, texture and mineralogical composition together, result of this evaluation diamond segment should be selecled. The classification system related with sawability should be formed for rocks and then technical structure, diamond contents and diamond grain size of diamond segments should be determined by this classification system.

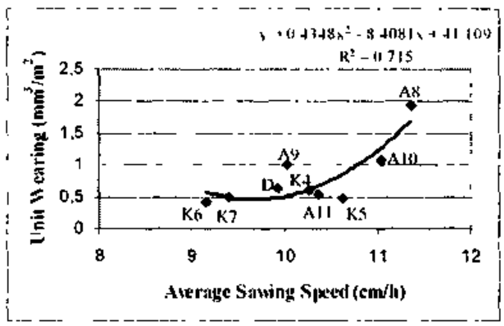
- Some wearing was encountered at the out of sawing process in microscopic investigations (Fig. 6). Especially, when blades ^f&Ttistodged between sawed slabs, grooves ~~on diamond segment perpendicular to forward-backward movement of blade occur. The reason of these grooves is that some diamond grits on segment surface pull out and wear the matrix surface with effect of abrasion between diamond segments and sawed slabs at dislodging of slabs. This wearing should be prevented by pulling of timber wedge that are installed between slabs for easy movement of blades as possible as late. So that, the performance of diamond segment can be increased. Furthermore, these grooves can be occurred from swarf of rock. Swarf can cause to grooves as similar the pulled out diamond grits. The important reason of this problem is the lack of sufficient cooling water .supply to the sawing zone and swarf cannot be removed from environment. Therefore, amount and purity of cooling water must be adjusted carefully (Bayram 2002. kulaksız el. al. 2002).

- One of the most important parameters that can affect the sawing efficiency on diamond segmented frame saws is the sawing speed. In these machines, same type of diamond segments saw different type marble blocks. Due to this characteristic, sawing speed affects the wearing on diamond segments mostly. The wearing on diamond segments is high because of high sawing speed. In the opposite situation, when the sawing process is performed slowly, machine runs more than necessary besides, energy consumption for sawing increases. All these situations can negatively affect the sawing and production cost to a great extent. As a result of sawing processes performed in this study, the high relationships between average sawing speed and wearing on diamond segments were determined lor both domestic and imported segments (Bayram 2002. Kulaksız et. al. 2002). These relationships are seen in Figure 7a and Figure 7b. Determination of optimum sawing speed with respect to the rock type is essential for efficient usage of frame saws.

As a result of detailed investigations it was determined that, suitability of optimum sawing speed according to rock type have not been investigated and sawing speed has been selected randomly. Wearing on diamond segments increases extremely with increasing the sawing speed as seen in Figure 7a and Figure 7b. Sawing speed should be determined by considering the physical, mechanical and mineralogical properties ol rock. Owners ol marble processing plants should be realized the rock properties and their dependence on scientific data. As far as they concern these studies as unnecessary, they should evaluate them as utmost importance.



Figuie 7a Relationship between unit wearing-average sawing speed in tiame sawing processes with domestic diamond segments (Bavmm 2002. Kulaksız et al 2002)



Fisuie 7b Relationship hetween unıl wearing-average sawing speed in ftame sawing processes with imported diamond segments (Bayram 2002 Kulaksız et al 2002)

• One of the most important lack of the marble processing plants is scarcity of qualified personal. Performance of a machine is strongly related with the quality of the technician who is responsible for. Wrong applications of machine operator decrease the production capacity and consequently increase the production cost. In diamond segmented frame saws, operators that are trained and have sufficient skill should be worked. Professional seminars and courses should be organized for personal training.

4 CONCLUSIONS

This study is the small part of a comprehensive study performed on diamond segmented frame saws. Some mistakes in industrial usage of diamond segmented frame saws were determined and suggestions were put forward for eliminating ol mistakes affect on sawing efficiency. The main conclusions of this study should be given below:

- Selection of diamond segment and usage of machines are not depended on scientific data in marble processing plant.
- Marble producers evaluate the scientific investigations and conclusions as unnecessary.
- As a result of these conclusions, the followtngs should be mostly recommended:
- Insufficient communication between scientific investigators and marble producers should be eliminated. The most important mission for this should be carried out by owners of marble processing plants.
- The studies should be supported for increasing the machine efficiency, consequently total plant efficiency.
- When the selection of machines and consumption materials (diamond segments, disc-cutter, abrasive head etc.) is carried out according to scientific data, both machines will use more efficiently and production cost will decrease.

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Thorium as A Nuclear Fuel

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ABSTRACT: Interest in nuclear power is rising while the world looks for non-deplcteable sources of energy that won't contribute to global warming. Thorium (Th) and its compounds are potential fuel sources for nuclear energy. Atomic fission in the ~'-Th/~ '"U fuel cycle or subatomic fuel using a particle accelerator to produce proton particles that interact with ""Th and " U to produce fast neutrons in an energy amplifier are gaining importance in the nuclear energy world. Both processes, will enhance the use of Th fuels in nuclear reactors more than uranium (U). Because it generates less radioactive wastes and cheaper energy. Presence and abundance of Th at the Moon crust and the new use of ThO; fuel seed in standard nuclear reactors enable Th to be very strategic for the next decade. This paper reviews the use of Th mainly in nuclear energy application and evaluates the importance of Turkish Th deposit. The Th fuel cycle, with its potential for breeding fuel without the need for fast-neutron reactors, holds considerable potential long-term. It is key factor in the sustainability of nuclear energy.

I INTRODUCTION

Nuclear power is the most probable solution for the world's energy needs in the short run. Since all other commercial power resources are depletable, nuclear energy will supply world's energy demand until a non-depletable resource is invented. There is a proven U reserve of 2.26 million tons (U.IOK) (Kaya, 2002) in the world. From this total, Turkey only has 9130 tons of U reserve. (DPT, 1996). It is clear that Turkey is dependent on the international U sources. On the other hand. Turkey has a proven reserve of 380.000 tons of ThO; at a grade of 0.21%. amounting about to 1/3 of the total Th reserves in the world (1.4 million tons) (Kaya, 2002), Th, being a fertile element, can be "breeded" to a fissile element [11]U. A similar reaction can also occurs at every reactor fueled with U. Both of these elements, plutonium [:w]Pu and [2~VI]U can be used as fuel in reactors. A mixture of Th-U may provide cheaper, cleaner and safer nuclear power.

2 GENERAL INFORMATION ABOUT Th

Over 40 stable Th bearing minerals have been identified in the environment. Th (Thor. Scandavian god of war) occurs in thorite (TI1SİO4), thorianite (ThO;+ $U0_2$) and monazite ((Ce, Lai Th, Nd. Y) PO4) which is the most common and commercially important Th bearing mineral containing 3 to 9% ThO;. with important deposits in India, Brazil, Sri Lanka, S. Africa, Russia, Scandinavia and Australia. Th, crustal abundance order is 39'\ is now thought to be about three times as abundant as U and as abundant as Pb or Mo. Th is an alternative source of nuclear power. There is probably more energy available from Th than from both U and fossil fuels. It can provide thousands of years of energy. Most of the internal heat of the earth has been attributed to radioactive Th and U.

2. / *Radioisotope Data of Thorium*

Twenty seven isotopes of Th are known with atomic masses ranging from 212 to 237. All are unstable. [21]-Th occurs naturally and has a half life of 1.4*10'" years. It is an a emitter. ""Th goes through six a and four ß decay steps before becoming the stable isotope [2(l<]Pb. [2'] U decays with a reasonably long half life, therefore its quantity, once produced, does not reduce in a human's life span, making this fissile material possible to be used as a fissile fuel.

2.2 Thorium Compounds

Major Th compounds are Th (IV) oxide/dioxide (thoria) ThO,; Th (II) hydride. ThH_2; Th (III/IV) fluoride, ThF/ThF.,; Th (II/IV/II1) sulphide, ThS. ThS,, Th,S,; Th (III) nitride, TliN; Th diodide/ (III/

IV) iodide. Thh, ThI,, ThI_4.Th (IV) bromide. $ThBr_4$; Th (IV) chloride. $ThCl_4$: Th (IV) sclcnide. $ThSe_3$.

23 Thorium Metal

When pure, Th is a silvery-white metal which is air-siable and retains its luster for several months. When contaminated with oxide. Th slowly tarnishes in air becoming gray and finally black. The physical properties of Th are greatly influenced by degree of contamination with the oxide. Pure Th is soft, very ductile and can be cold-rolled, swaged, and drawn. Th is slowly attacked by water, but does not often pyrophoric and should be carefully handled. When heated in air, Th ignites and burns brilliantly with white ligth. Several methods are available for producing Th metal; it can be obtained by reducing ThCh with Ca, by electrolysis of anhydrous $ThCl_4$ in the fused mixture of Na/KCls by Ca reduction of $ThCl_4$ mixed with anhydrous ZnCI;, and by reduction of Cl_4 with an alkali metal.

2.3 Thorium Oxide ($Th()_2$)

Formula weight is 264.037 g/mole. color is white, appereance is crystalline solid, boiling point is 4400 °C, and density is 10000 kg/nr. $ThO_:$ has a melting point of 3300"C, which is the highest of all oxides. Only tungsten and tantalum carbide have higher melting points. Powdered, peletized and wafer ThOi fuels can be used to produce " ' U in reactors.

2.4 Analysis of Thorium

Th and U analysis can be performed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) which require complete sample digest. Radiochemical techniques such as a and y spectroscopy can also be used. The technique of a spectrometry is used to detect a particles and to determine their energy. In this way, quantitative (i.e. activity) and qualitative information (the identity) for a emitting Th can be accurately assessed (Holmes, 2001). Routine detection limit is 1 ppm.

2.5 Use oj Thorium

Th is generally used in non-fuel and fuel applications. In non-fuel applications, the principle use of Th has been in the preparation of the Welsbach mantle, used for portable gas lights. These mantles, consisting of ThO: with about \% Ce-oxide and other ingrediants. glow with dazzling light when healed in a gas flame. Th is an important alloying element in Mg, imparting high strenth and creep resistance at elevated temperatures. Because Th has a low work-function and high electron emmission, it is used to coat tungsten wire used in electronic equipment (i.e. magnetron tubes). The oxide is also used to control the grain size of tungsten used for electric lamps; it is also used for high-temperature laboratory crucibles. Glasses containing ThO: have high reductive index and low dispersion. Consequently, they find application in high quality lenses for cameras and scintille instruments. TI1O2 has also used as catalyst in the conversion of ammonia to HNOj, in petroleum cracking, and in producing H:SO_i. Table I shows Th consumption patterns..

Tabic I. Tliorium consumption patterns in the USA according totheUSGSin 19X4 and 1987

Application Area	1984 (%)	1987 C/r)
Energy	11.8	
Refractory Applications	52.9	57
Lamp Mamies	15.0	18
Aero Space Alloys	7.1	15
Welding R<xls	2.6	5
Ceramics and lighting	10.6	
Others		5

3 THORIUM IN TURKEY AND METHODS OF CONCENTRATION TECHNOLOGIES

Unlike the common knowledge, Th and U are not rare elements. U exists at an average of 2.7 and Th 9.6 ppm in the earth crust. The research of MTA Institute revealed that there is a Th reserve of 380.000 tons of TI1O2 around Eskisehir-Sivrihisar-Kizilcabrcn which is one of the largest Th reserves (Kaya, 2002). Like U mining and refining, Th can be refined with various methods. When mined, both U and Th exist in very small concentrations. Th can be recovered as a by-product from minerals mined for the extraction of Ti, Sn, Zr, and rear earth elements/ oxides (REE/REO).

REO is concentrated from bastnacsite ores at Mountain Pass by a hot flotation. This produces a 60% REO concentrate that may be upgraded to a 70% concentrate by leaching or to a 90% concentrate by calcining (Harben&Kuzvart, 1996). The Ce-rich concentrate yields Ce-oxides and salts, and a Ce-poor lanthanides-rich concentrate used as a feedstock for further processing, either at the mine or in specialised plants around the world. Monozite is separeted from other heavy minerals, usually by wet gravity concentration and then electrostatic and magnetic separation to produce a concentrate with 55-66% REO. Both monazile and xenotime are usually cracked by heating the concentrate in an autoclave at I50"C with a 70% NaOH solution (Gschncidner. 1989). After cooling, the addition of H2O removes the soluable $Na?P0_4$, leaving the REE as REO and Th as $Th(OH)_4$. The REO are dissolved in HCl to form an anhydrous mixed rare-earth chloride, which is reduced electrolytically to make miscbmetal or processed further to yield individual

REE. There are a number ol methods for extracting and separating the individual REE, including liquid-liquid solvent extraction that is based on differences in affinity of the individual rare earths for a chelating agent in an organic. When the REE in water are mixed with chelating agent solution, the REE with the highest affinity becomes enriched in the solvent; if repeated sufficiently the concentration builds up to produce a 99.999% pure product.

In the milling operation, the Th is extracted from the ore by a process called leaching. The dissolved ThO; are then recovered by solvent extraction (SX) or by ion exchange (IE). The product is then calcined to remove excess water. The result is a concentrate of TI1O2. First, Th ore is solved by HNO, or H2SO4 . In order to have a complete solution of Th ore, an acidity of pH 1.2 is needed. The solution is filtered and large particles are separated from the solution. After this process, some chemicals are added to the solution to precipitate some further impurities. Later, the solution is separated from the remaining impurities by the SX. As a product, Th-nitroxyde. Th(NO,)4.nH:0 is obtained. Later, the ThiNChh is heated and excess water is vaporised for 20 hours in 105"C. The product is heated upto 575"C and the Th (NO,(4 is oxidized to TI1O2.

The ThOi is a dust material. This material can be manufactured into small pellets using simple powder metalurgy methods. These pellets would be loaded into luel claddings and lowered into the reactor core. There is a commercially available Torex process (Thorium Oxide Recovery by Extraction). This is a procedure to produce fuel from the burned fuel elements of a reactor. The ~'U/Th fuel is dissolved in very highly concentrated 13M HNO,, 0.05 M HF and 0.1 M Al-ni träte held at boiling temperature. The residual solids are removed from the solution by centrifuging. The solution with Th(NO,h and UO2 (NO,): then enters the first extraction column and is moved in a counlercurrent flow against TBP dissolved in a hydrocarbon solvent. TBP selectively dissolves ThN and U-nitratc while moving upward in the column. The fission products, protactinium and Ai-nitrate leave the column at the bottom together with the scrub solution, which is added at the top of the column. Careful adjustment of these chemical proccses is necessary to separate fission products, especially Zr-95 Irom Th. In the letravalent slate, Th is chemically very similar to Zr. ~ Pa with a half life of 27.0 d is the precursor of " U and must be chemically recovered from the high level waste. Alternatively, the fertile fuel can be cooled until ^{21}Pa has decayed into ^{2}U. In the second column, Th(NO.<)$_4$ is recovered from the TBP by being moved in a counlercurrent flow against diluted HNO,. Th(NO,)$_4$ and HNO, leave the second column at the bottom. The organic solution together with UOi(NOi)i flows into the third column, where U is recxtracled. U is then purified in additional SX separation steps. Small traces of Pu and Np may be separated by additional extraction chromatography. In case more Pu is built up, e.g., in medium enriched "'^{5}U/^{11s}U/Th fuel, the separation from Pu and Np by extraction chromalrography is not sufficient. In these cases the Pu must be co-extracted with U and Th. This may also be achieved by SX in contact with TBP. However, this process is more complicated than the thorex process (Sıkık et.al. 2001).

Ipekoğlu (1983) conducted gravity, magnetic, flotation and acid leaching tests for Eskişehir Th ore. He found that acid leach was necessary for this ore. 99% Th extraction recovery was obtained with a 200 kg/t HCl within 3 hours.

4 PERSPECTIVES OF THORIUM FUEL CYCLES

Th is a source of nuclear power. Three development periods in the past nuclear energy history in the USA can be considered (Lung, 1996). 1945-1958: The follow-ups of the Manattan Project, at leading US Laboratories (Brookhaven. Oak Ridge and Los Alamos)."' U bred from Th is considered as a potential weapon of gun-type model, easier to manufacture than Pu weapons. About 55 kg $^{:i}$U were available in 1958. 1958-1975: Energy applications increased after INFCE's prediction in 1980. About 1.5 tons " U were seperated in the USA during the period from 900 tonnes Th. Many reactor prototypes were built and operated. Th extraction plants were built in US, Germany and France. 6000 tonnes of Th were separeted. 1985-Today: President Ford and Carter did not support the water reactors and nuclear energy well. Disinterest for Th crops up and this line is progresively abandoned. Today. India is still very interested in nuclear energy as principle source for 1 billion inhabitants for energy self indépendance. India has the largest Th reserves (360.000 t monozile) in the world.

4.1 Thorium as a Nuclear Fuel

There is a strikiim parallel between natural U containing 99.3% ^{2S}U and Th almost exclusively composed of ^{2,2}Th. It can he seen that the fertile isotopes are ^{2,1}U and ^{2,2}Th. and that the fissile isotopes are 0.7% ^{2i}*U* and the artificial fissile isotopes comparable to ^{2U}U for Th (Lung, 1996). A new fuel increase the time nuclear reactors can run between shutdowns. Longer runs mean cheaper electricity, which should help nuclear power plants compete with coal and natural gas powered plants. The new fuel should also generate less waste than all-U fuel (www.eurekalcrt.org).

Advantages of the Th Cycle: ''U bred (rom Tlı is, seen from a neutronic standpoint at least, the best of the 3 nuclear fuels 2"U. 2,'JPu and 2,"U. As a matter of fact, the eta ratio of neutron yield per fission, to neutrons absorbed is higher to that of 2,<U/2,WPu. This means that " U will be a good fuel in any reactor type. Th comes out of the ground as a I 00% pure, usable isotope, which does not require enrichment, whereas natural U contains only 0.7% fissionable " U. So some 40 times the amount of energy per unit mass might be available for Th (www.world-nuclear.org). Moreover, from the perspective position of U and Th in the periodic table, the long-lived minor actinides resulting from fission are in much lower quantity with the Th cycle, especially compared with the Pu cycle. This ecological advantage is an important argument brought forward these days. Th produces 10 to UKXX) times less long-lived radioactive waste than U or Pu. The radioactive waste from Th reactor contains vastly less long-lived material than that from conventional reactors. In particular, Pu is completely absent from the Th reactor's waste. Finally, quadrivalent Th and its compounds are very stable and among the highest known refractories. ThO melts around 3300"C (UO: 2700-2800"C). This stability authorizes high burnups and high temperaiures. It does complicate somewhat, however, the chemical treatments for the preparation of Th compounds or their dissolution for reprocessing. Moreover, 2.. U also keeps its good neutronic properties with high temperatures, better than either 2 ' U or 2WPu. These properties have led naturally to recommend the Th cycle for high temperature reactors. Because Th docs not sustain chain reaction, fission stops by default if we stop priming it. and a runaway chain reaction accident is improbable (www.cavendish science.org).

Disadvantages- of the Th Cycle: The first remark is that a reactor fulled with Th only will not diverge. Th needs a "match" which, today could only he ~ ' U or Pu. Here is indeed an excellent way to use up the excess Pu stocks on the market these days. It appears from what proceeds that sooner or later " U formed should be separated to be incorparated in efficient nuclear fuel elements. This means that reprocessing is an integral part of a sustainable Th fuel cycle. In a reactor, "•"Th by neutron absorption produces first :1,Th and 2"Pa which has a 27-day half-life to produce:"Pa (Fig. 1):

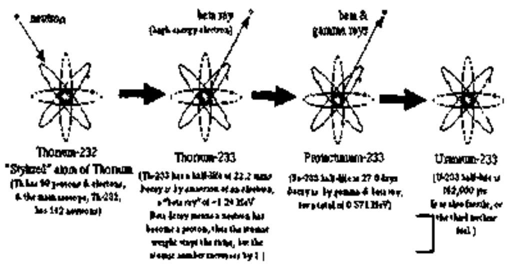

Figure1 Production of ^{233}U from ^{232}Th.

This rather long half-lite of:.:Pa results in a reactivity surge after reactor shutdown due to "13U production, and this must be taken into account. ThO: dissolution is not as easy that of UCK But this problem can be overcome with a buffered floride addition in the dissolver solution. Finally, one of the principal drawbacks of the Th cycle today is the presence of hard Y emitters (2 to 2.6 MeV) among the descendents of the ~ "Th isotope, and especially of2 2U, an a emitter of 72 years half-life which is always present along " U at concentrations ranging from some tenths to some hundreds ppm. This obliges to manufacture :1' U based fuels completely remotely in y-shield environment, a very expensive technique which only starts to be mastered with MOx UOi-PuOi fuel elements fabrication.

5 THORIUM-FUELED REACTORS

A typical reactor which consume fissionable fuel and produces only energy is called a burner. A reactor which creates energy and fuel which produces fuel less than it consumed in the process is called a converter. A reactor, which creates more fuel than it consumes, is called a breeder. Global warming caused by fossil fuels and a boost from International Atomic Energy Agency regarding the use of Th in nuclear reactors will increase the importance of nuclear energy. Almost all of the world's active 440 power reactors (357.000 MWc) are conventional and rely on U-fuel rather than Th. Natural U is 99.3% 2,SU which can not sustain a chain reaction. But it also contains 0.7% " U, a fissile isotope that can sustain a chain reaction. Most power reactors operate with slightly enriched U, typically about 4% "5U. In contrast to natural U, Th lacks a fissile isotope. But it is "fertile". When bombarded with neutrons, a portion of the Th is converted to ""U, a fissile isotope. The source or "seed" fuel would breed 2..U. The 2,1U then could unloaded from the reactor, separated from the Th fuel, and fed back into the reactor in a closed-fuel-cycle. Alternatively, the 23,U could remain in the reactor, eventually becoming a key component in the chain reaction.

Over the decades, several nations (Germany, India, Japan, Russia, the UK and the USA) experimented with Th-U fuel, but the economics of it never seemed to work, in part because the physiscs of Th and U differed greatly. Most Th-cycle schemes relied on reprocessing/recycling of nuclear fuel. Today. India remains a strong proponent of the Th fuel cycle. Test reactor irradiation of Th fuel to high burnups has also been conducted and several test reactors have either been partially or completely loaded with Th-based fuel.

5.1 Radkowsky Light Water Reactor (LWR)

A joint US-Russian project still in the research and development phase, would produce little weapons-useable material. Because of its Th-fuel design, the amount of Pu produced by a Radkowsky reactor would be about 20% of the Pu produced by a more conventional U-fuel reactor (Friedman, 1997). Radkowsky did some experiments with Th-U fuel in 1977 at Shippingport, Pensilvania for about five years. Radkowsky Thorium Power Corp. was established in 1992. Its reactor core are less expensive by up to 20%' and additional savings occur because its design would use less fuel than would a comparable U-fuel reactor. The Th-U blanket would be left in place for about 10 years to maximize "'1) burnup. In contrast, the seed elements would be placed every 18 mounths or so. The net result; over its operation life time, the Radkowsky design would use less fuel than would a comperable U-fuel reactor. The ligth water breeder reactor uses U-Th fuel. It is possible to produce fissile isotope of :'1,U from " "Th. " U produces more neutrons if fissioned by a low energy (thermal) neutron than does 215U. This characteristic means that more excess neutrons are available to convert fertile material. In a carefully designed and constructed reactor, U-Th reactors have enough excess fission neutrons to overcome the parasitic neutron absorptions inherent in a water cooled and moderated reactor. In fast breeder reactor, the designers chose a seed and blanket core configuration. The fissile material is concentrated in the central core region while the fertile material surrounds the central core region including the top and bottom. Most of the neutrons produced in the central core are used to sustain the chain reaction, while most of the those than leak out at boundary are either reflected back into the fissile material or absorbed by fertile material.

The LWR. WERT-1000. designed by Radkowsky for Russia can achieve powers up to 1000 MWe OOOOMWth) and has a power density of 106 W/cnr' (Radkowsky&Galperin. 1998). The seed and blanket lattice parameters is optimised such that ~'U produced is burned at the same time. Radkowsky Th fuel provides a practical and attractive solution to the utilisation of Th since there is no reprocessing plant is necessary. Th-fueled nuclear reactors are important for Russia and Asia. Russian Pu can be used as core fissile material neutron source at the Radkowski's advanced LWR. Japon. Indonesia, Vietnam, Malasia and China are also posibblc users of the Radkowsky design.

Further development of nuclear power depends on improving its performance with regard to economics, safety, waste production, and proliferation resistance. The use of Th in a once-through fuel cycle has the potential to improve all four areas. It is likely to reduce the need for control materials in a fresh core while enhancing the production of fissile materials during fuel residence, both of which will reduce the fuel cost. While the above potential benefits will need to be evaluated in specific-designs, one benefit is almost design independent, and that is the benefit of added proliferation resistance (Kazimi et.nl.. 1999).

5.2High Temperature Gas-Cooled Reactors (HTGR)

The high enriched (HE) Th and U (93% 2J5U) and the low-enriched (LE) U (8-12% 23,U) fuel cycles concept are considered for utilization in HTGRs. For both fuel compositions suitable reprocessing procedures are required which are capable to separate the actinides Th, U and Pu from fission products and from each other. In any case, the processes under consideration utilize tri-n-butylphosphate (TBP) together with a straight-chain paraffinic diluent (Cs-Cu, to day usually dodecane) as extradant in an aqueous nitrate system. Most commonly, the related processes are known by the acronyms Purex and Thorex, which will be explained later. Kloosterman et al. (1997) has performed burnup calculations on a PWR fueled with three fuel types: ordinary UO: fuel (LEU), 20W% enriched UOi in ThO: (medium enriched U: MEU) and 93W% enriched UO: (HEU) mixed in ThO?. From the radiotoxicity point of view, the use of HEU fuel has preference. Up to 20.000 years of storage, the radiotoxicity per unit electricity generated is lower by a factor of 5-10 compared to ordinary LEU fuel. For MEU fuel, this factor is 2.

5.3 Fast Breeder Reactors (FBR)

In the USA, FBRs were cancelled quite early in their history. In 1980, congress rejected the Carter administration's request to back the project and since no advancement had been achieved in USA in the FBR field. This cancellation resulted in a delay which would move the operation date of the first commercial FBR to after 2000. Furthermore, in 1984 U.S. Congress terminated all funding for the development of a breeder reactor. (Archie, 1991). Although the tendency to reduce research in this project was in effect in early 1980s, after the Chernobyll accident, in many of the countries the accident resulted in a avalanche of support loss. For example, in Japan, the commercial breeder plans were scrapped because of the fallen nuclear energy support. Although in this country, more than 300 billion yens were invested, the possibility to build a FBR in the Japan before 2030 is diminished.

On the other hand, some countries need the breeded energy to continue with their nuclear weapon and power programs. India and Pakistan recently demonstrated their nuclear capability with test explosions of nuclear bombs. Neither Pakistan nor India has U reserves, like Turkey. But still, they have a number of commercial power plants. India has its own designs and recently Indian FBR went critical and also in 1998 their Th reactor was commissioned. In India, Kakrapar-1 was the first reactor in the world to use Th rather than depleted U, to achieve power flattering across the reactor core. Both Kakrapar-1 and 2 units were loaded with 500 kg Th fuel and operated about 300 and J 00 days full power operation, respectively. Rasjasthan-3 and 4 reactors are under construction (www.world-nuclear.org/info).

5.4 *Heavy Weiter Reactors*

Heavy water moderated reactors have better neutron economy and a harder neutron spectrum with respect to other kinds of reactors. This ability makes them one of the most economically suitable converter reactor when utilization of Th is considered. The most popular type Candu (Canadian Deuterium-Uranium) heavy water reactors use Th fuels. No apparent change must be made but some considerations must be taken for the shutdown conditions and initial fuel loading (Sikik. 2001). Candu is fueled by natural U generate Pu. FBRs use this Pu-based fuel to breed :"''u from Th and then advanced nuclear power systems will use the " "U. The spent fuel will then be reprocessed to recover fissile materials for recycling.

5.5 *Pressurized Water Reactors (PWR)*

Th-based fuel for PWRs was investigated at the Shippingport reactor in the USA using both ~"U and Pu as the initial fissile material. It was concluded that Th would not significantly affect operating strategies or core margincs. The ligth water breeder reactor (LWBR) concept was also sucessfully tested here from 1977 to 1982 with Th and :1 U fuel clad with zircaloy using seed/blanket concept (www.world-nuclear.org/info). The 60 MWe Lingen PWR in Germany utilised Th/Pu-based fuel test elements. Temkin (1985) clearly reveals that a pressurised heavy water reactor (PHWR) is more advantegous with respect to LWRs. First of all, PHWR gives more energy output with respect to PLWR therefore more effective in power generation, secondly a PHWR has a much higher design life compared to the PLWR, and lastly, the criticality control necessity is smaller in comparison with that for PLWRs. India is working on Advanced Heavy Water Reactors and like the Canadian Candu-NG.

5.6 *Accelerator Driven Systems (ADS)*

Powerful accelerators can produce neutrons by spallation. This process may be linked to conventional nuclear reactor technology in ADS to transmute heavy isotopes in spent nuclear fuel into shorter-lived fission products. There is also increasing interest in the application of ADS to Th fueled reactors. The ADS is a coupled system of a subcritical reactor and an external accelerator. Extra neutrons are generated by a spallation process in the target and the external source neutrons initiate a significant multiplication in the reactor core allowing for an efficient transmutation and incineration potential. The proton beam enters the center of the reactor core through an evacuated tube and hits the Pb target where neutrons are emitted. The pool type reactor is cooled by liquid Pb/Pb-Bi. In the design given a bubble lift pump supports natural convection and transports thermal energy to the heat exchangers. Besides transmutation the system additionally serves as a power generator (www.iket.fzk.de). There are some problems in Th-based fuel cycle (i.e. high cost of fuel fabrication due to " "U contamination and "KTh contamination in recycling) (IAEA, 2000).

5.7 *Pebble Bed Modular Reactors (PBMR)*

Arising from German work, the PBMR was conceived in S. Africa is now being developed by a multinational consortium. It can potentially use Th in its fuel pebbles. Between 1967 and 1988, the experimental pebble bed reactor at Jülich, Germany operated for over 750 weeks at 15 MWe, about 95% of the time with Th-based fuel. The fuel used consisted of about 100.000 billard ball-sized fuel elements. Overall a total of 1360 kg of Th was used. Maximum burnups of 150.000 MWd/t were achieved. Th fuel elements with a 10:1 Th/U (HEU) ratio were irradiated in the 20 MWth Dragon reactor (OECD/Euratom project worked between 1964 and 1973 at Winfrith, UK. Th and Pu utilization in PBMR was investigated with aim to predict the economical value of vast Th reserves of Turkey by Sikik et al.(2001). Neutronics and thermal-hydraulics analysis of the reactor core were performed for various mixtures of U, Pu and ThO: fuel pebbles. Various U enrichments. Pu concentrations and Th with certain impurities were considered. Burnup calculations for equilibrium cores were performed and the amount of U and Th consumption was calculated.

5.X Energy Amplifiers (EA)

1984 Nobel Physic prize winner Prof. Carlo Rubbia devised EA at the CERN for Th-fucl. The cross-section of EA is given in Fig. 2. In the EA, a proton beam impinges on Pb, the high energy protons splitting Pb nuclei, leading to release of neutrons. In Rubbia's design, the molten Pb doubles also as primary coolant. Most of the EA is below ground level. High energy protons emerge through a window in the tip of the proton beam tube inside the core. Proton split Pb nuclei, with neutrons emitted into the core. The molten Pb carries nuclear heat upward by convection. The Pb vessel is nearly 30 in long and 6 m in diameter and contains 10.000 tons of Pb. Fission rate is determined by the proton accelerator. If the accelerator stops sending protons, fission stops almost instantly. Thus shutdown is easy and also accidents can be prevented. The radioactive waste from the Th reactor contains vastly less long-lived radioactive material than that from conventional reactors, (www.cavendishscience.org).

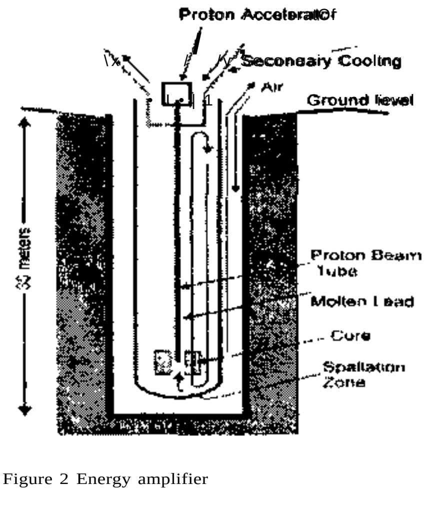

Figure 2 Energy amplifier

6 CLOSED FUEL CYCLE- THE Th/^{2}"U FUEL RECYCLING

Converter reactors operating on " U as a fissile fuel and ^{2,12}Th as a fertile material generate fissile ^{2,5}U which, after removal of the fuel from the reactor core, can be separated by chemical reprocessing. The fissile $^{2;,5}$U obtained in this way can be recycled either in the same reactors or in reactor cores with pure ^{2,s}U/^{2,,2}Th fuel. However the generation of -^{M}U must be started with ^{1,5}U/^{2TM}U/ ^{232}Th fuel. Since this fuel also contains fertile ~^{K}U, Pu will be produced besides ^{2W}U. The production of Pu can be restricted by limiting the amount of ~~U contained in the fuel. This applies to highly HEU fuel with 93% ^{2,5}U enrichment.

7 BREEDER FUEL CYCLE-THE Th/"- U FUEL BREEDING

In principle, it is possible to design FBR's with ""U/Th fuel, which still attain breeding ratios above 1. Firstly, thermal and fast breeder reactors can be started with Pu/$^{2,:;}$U available from chemical reprocessing of spent fuel from the thermal converter reactors. Later, when a FBR economy will have developed, sufficient :"U would be generated also by the FBR's themselves to start additional FBR plants. However this is not the only way to start breeder reactors. If Pu/^U were not available in sufficient quantities from thermal reactor fuel reprocessing, breeders could also produce their own initial cores of Pu/^{2}"U fuel by starting with ^{2,5}U/$^{2,I(}$U or

8 CONCLUSIONS

All predictions today coincide to confirm for the next 30 years the world energy demand foreseen at the time of INFCE in 1980. We are also confronted with the problem of greenhouse effect. These challenges will foster nuclear energy again and in the longer term Th will have its place.

Th-fuel use reduces energy cost, due to longer runs and reduced U consumption. Separating ^{2} "U from Th is a relatively easy task compared to the enrichment of the U. As a result, such breeded fuel would be much cheaper than enriched fuel. Th-fuel also gives lower and less radiotoxic wastes than U fuel. Different types of reactors can be used with Th fuels, some with special designs, some with virtually no design change. As a result, especially PWR (Candu), LWR, HTR, PBMR and energy amplifier type of reactors show great promise in utilizing Th/U fuels. FBRs can produce the fissile fuel for these reactors. Especially India's experiments with these kinds of reactors and other similar experiments reveal that although the effectivenes is below of a HTR, the process is possible, feasible and preferrable

Turkey has very large Th resources in basnasite ore second to India's vast reserves. Even though there is no economical value of Th as nuclear fuel presently, the utilization of Th in some reactors can be feasible in the near future. If such a combined cycle is utilized, the best resource conservation is obtained. It must be noted that the earth is not the (wily source and place to utilize such reactors. For example, Nasa's Lunar Prospector satellite has found large amounts of Th on the surface of the moon. In the future, if a colony is founded on the surface of moon, it would be much cheaper and easier to use Th assisted reactors to obtain power (Lawrence et. al., 1999). It must be pointed that all of the research on Th is only a fragment of the FBR researches. Pu-

U cycle dominates the research and Th reactors/ technology has been researched very little. More research must be done on this technology.

Turkey must evaluate strategic Th reserves and use nuclear energy in order to became independent in energy production and provide sufficient, reliable and cheap energy for its developing industry.

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Improving The Strength Characteristics of The Pumice Aggregate Lightweight Concretes

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ABSTRACT: Lightweight concrete is commonly used in civil engineering field, specially as a filler material or for the manufacture of heat and sound insulating units, as well as load bearing structural elements. In most industrialised countries, lightweight concrete production is performed by using a highly mechanised processes based on different automation techniques. Various artificial and natural porous aggregates are generally used in these types of concretes. The most popular among them are ceramsite, slag pumice, ash gravel, expanded perlite, volcanic slag, pumice, vermiculite etc. All the porous aggregates have their own characteristic properties, which markedly affect the properties of lightweight concretes. Among the lightweight concretes, pumice concrete was generally considered as being unsuitable for load bearing uses. For this reason, it has been mainly used for the production of partitions and panel walls. Strength requirements for building blocks are most commonly set at 2.5 MPa for filler blocks and 5.0 MPa for load bearing blocks. In general cases, the effects of admixtures, such as crushed gravel, tly ash and limestone powder, in lightweight aggregate mixes are not known very well. Therefore, the admixture types, affecting the compressive strength of a mixture should be determined by a series of experimental test works. In this paper, many investigations were carried out in order to obtain maximum compressibility of lightweight concretes by using several additional mixes and admixtures.

I INTRODUCTION

Pumice stone is a very popular raw material as a lightweight rock, due to having a desired properties for making the different products based on its physical, chemical and mechanical properties. For this reason, it has a large using area in civil industry as a construction material and it has been used for centuries in the world. Pumice aggregate can be found in many places around the world where volcanoes have been present.

Pumice aggregates combined with Portland cement and water produces a lightweight thermal and sound insulating, fire-resistant lightweight concrete for roof decks, lightweight floor fills, insulating structural floor decks, curtain wall system, either prefabricated or in-situ, pumice aggregate masonry blocks and a variety of other permanent insulating applications.

It is a common practice to classify lightweight concrete into three categories. These are insulating concrete, intermediate concrete and constructional concrete. This classification is based on unit weights, and integrates between types and uses of aggregates. All the research studies, carried out to analyse the performance of the lightweight pumice concrete for stability and durability conditions, have showed that these concrete types could be achieved with pumice aggregates.

It has been stated that, despite the different properties of porous aggregates, lightweight concretes have some common regularities and properties. Lightweight aggregates generally have an enormous advantage in comparison to natural aggregates due to their structural pores and their consistent properties (Kornev et.al. 1980).

From these aggregates, pumice is a lightweight, porous effusive rock, with an extremely vacuolated structure, and closed pores due to the formation of gaseous bubbles during the rapid cooling and consolidation of the magma (Failla et.al. 1997).

2 PUMICE AGGREGATES IN THE CONCRETE

Pumice is a well known lightweight concrete aggregate, although its use has mainly been restricted to dry mixes such as for block making and masonry use. There are both advantages and drawbacks connected with the material as an aggregate. Its compressive strength is low, between 5 and 7 MPa for usual pumice material of normal gradation. Therefore, high strength constructional concrete is not to be expected. However, the relation between weight and strength may be favourable for pumice concrete, and the ease of handling, insulating qualities and other properties then make it advantageous.

The surface texture of pumice is such that their concrete types require more binding media than if they were made of smooth or glazed surface aggregates. The abrasive nature causes a define stiffness in lean concrete, which may be an advantage in mixes for block making since it causes less breakdown of the products in production. On the other hand, some of the binding media enters into the pumice surface and more of the binding media is required, which increases costs of production. In rich concrete the dense cement paste imparts the drying of the aggregates.

3 LIGHTWEIGHT AGGREGATE CONCRETE

Lightweight concrete is a broad term covering concrete made with a wide variety of aggregates, both natural and artificial. Lightweight concrete already plays an important role in .structural engineering and its use is steadily increasing. The predominant feature of a structural material is, no doubt, its compressive strength. With the modern trend towards taller structures and longer spans, there is a growing demand for stronger concrete. Lightweight concretes are cement-bonded products. Therefore, it is not surprising that many of the common properties as development of strength, drying shrinkage, bond to reinforcement etc. are very much influenced by the properties of the cement or the "binder matrix" used. It has been found that, a new binder composition makes it possible to produce a stronger lightweight concretes. To achieve the strength and quality required for high strength lightweight aggregate concrete needs a higher proportion of cement content in the mixture than dense concrete and mostly replacement of lightweight fines by sand (Bürge, 1983).

Lightweight concrete is generally a concrete with specific gravity 800-1800 kg/nr\ Specific gravity can be lowered either by using porous, therefore light, aggregates instead of ordinary ones, or introducing air into the mortar, or removing the fine fractions of aggregate, and compacting concrete only partially. In all cases, the main aim is to introduce voids into the aggregate into the mortar or between mortar and aggregate. A combination of the three methods can also be made in order to reduce furtherly the weight of concrete. The use of lightweight aggregates is by far the simplest and most commonly used method of making a lightweight concrete and pumice is the most widely used lightweight aggregate especially for lightweight structural concretes. The specific gravity of the concrete is about to 900 - 1600 kg/m^1.

Structural lightweight aggregate concretes are considered as alternatives to concretes made with dense natural aggregates because of the relatively high strength to unit weight ratio that can be achieved (Bomhard, 1980).

Other reasons for choosing lightweight concrete as a construction material are becoming increasingly important as more attention is being paid to energy conservation and to the use of waste materials to replace exhaustible natural sources. For example, the thermal resistance of such materials increases with the decreasing density and this ensures considerable amount of energy savings (Newman andBremner, 1980).

Strength of coarse aggregate for constructive lightweight concretes is always considerably lower than that for mortar component. Therefore, under force actions their destruction takes place in grains and interlayer of mortar rather than due to adhesion rupture between aggregates and mortar as in heavy concrete. Adhesion between aggregates and matrix is considerably higher than that in dense aggregates that is not only the effect of porous rough surface of granules, but also physicochemical influence of hardened cement paste and aggregates due to self vacuum treatment, strengthening of contact zone as well as formation of new hydrated compounds. All these processes, proceeding during lightweight concretes hardening, affect positively the adhesion between aggregates and mortar and also bond between tendons and concretes.

Positive factor in lightweight concretes is also the "compatibility" of elastic properties for porous aggregate and mortar as strength and elastic modulus of aggregates in heavy concretes are several times higher than those of mortar. Therefore, concentration of stresses on the boundary of porous aggregates and cement mortar decreases and as a consequence, there increase the stresses corresponding to the boundary of micro cracks formation and to creep transition from linear to non-linear one.

in connection with the fact that porous aggregates have rather low elastic modulus, most types of lightweight concretes as compared to heavy ones, have non-elastic (plastic) strains both in compression and tension, it is explained by higher brittleness of lightweight concretes. Figure 1 shows typical stress-strain diagrams under compression of lightweight and heavy concretes.

In lightweight concrete, coating with uniform bonds throughout the surface of aggregate granules is created in contact zone between mortar and aggregate due to absence of water film because of suction of chemically uncombined water by aggregate. This develops a higher adhesion between porous aggregate and mortar and promotes decrease of plastic strains.

Lightweight concretes have high shrinkage that is the cause of low elastic modulus of porous aggregates. In connection with this shrinkage of lightweight concretes is, as a rule, 1.3-2 times higher than that ia heavy concrete depending on the sort of coarse and fine aggregate (Kornev et.al., 1980). Maximum compressibility of lightweight concretes is considerably higher than that in heavy concrete. The simplified example of this is given in Figure 2. It is determined by the fact that elastic modulus of lightweight concrete are markedly lower than those of heavy concrete. Although plastic strains of heavy concrete are comparatively high, but they do not compensate higher elastic strains of lightweight concretes. High maximum compressibility of lightweight concretes affects positively on the strength of pre-stressed members (Kornev et al., 1980).

4 STRENGTH OF LIGHTWEIGHT PUMICE CONCRETES

There are several considerations that limit the maximum strength of high strength lightweight aggregate concrete. The decisive factor is the individual particle strength of the largest pieces of lightweight aggregate. Each particular material has a limiting strength "ceiling" beyond which there can be no appreciable strength gain despite large increases in cementitious materials. This strength "ceiling" is a function of the strength of the vitreous material and the quantity, size, shape and distribution of the envelope pores. All coarse aggregates have continuous gradations of low inter particle void content that requires a minimum amount of cementitious mortar to achieve salısfactory workabi 1 ity.

The influence of the top size of coarse lightweight aggregate on ultimate compressive strength was analysed by several investigations in which the effects of other variables were minimized. For this particular material, maximum achievable strength occurs when the aggregate top size is limited to approximately 10-15 mm.

Long term strength gain of the structural lightweight concrete was generally greater than the conventional concretes due to the continuous hydration of the binder with the slowly released moisture, resulting from water absorbed within the pores of the lightweight aggregate. This process of "internal curing" is possible when the moisture content of the lightweight aggregate at the time of mixing is at least equal to that achieved by soaking for one day (Holm, 1980).

According to the principles of rock mechanics, the experimental research findings related with the technical properties of lightweight concrete were evaluated and defined in detail in order of importance. The strength of concrete generally show a variation with the function of the rock components, water/solid ratio and cement dosage used in concrete mixture. For this reason, the strength value of the mixture is generally defined with the value after a period of 28 days curing time. In general applications, the strength of the concrete after 28 days can be acquired by the way of determining the uniaxial compressive strength of the standard concrete samples. In addition, especially in excessive stress conditions, the critical stress value with the unit elongation or strain must be investigated in detail.

4.1 Mechanical Characteristics

Lightweight concrete compression tests show that the breakage occurs in the aggregates not in the cement paste. Consequently, grain resistance to crushing is extremely important in lightweight concrete. The various methods are used to measure this parameter. Some specifications suggest an empirical method whereby 1 litre of aggregate is compressed into an 11,3 cm diameter and 18 cm high cylinder, by a piston which penetrates into the cylinder by 20 mm in 100 seconds. The load bearing on the piston, divided by its surface area represents the resistance to crushing of the sample grains. This test carried out on pumice aggregates resulted in a 24,5 kg/cm^2 crushing resistance.

So as to avoid a low-resistance, high deformation lightweight concrete, an acceptable quality mortar must be employed. This calls for the use of a type of sand which unlike pumice, shows good resistance characteristics. Shore or crushed sand may be used to totally or partially replace the lightweight aggregate (size up to 3 mm). More specifically, shore sand was used instead of the lightweight aggregate in the 0-0,5 mm range and crushed sand was used instead of the lightweight aggregate in the up to 3mm range in the batches (FailIa et al, 1997).

4.2 Aggregate pre-soaking

Lightweight concrete characteristics generally depend on the aggregate water content prior to mixing. Excessive water content causes lack ot adherence between the aggregate and mortar, while low aggregate water content causes the aggregate to soak up part of the mortar water, thus causing a cement sub-hydration and consequent reduction of the concrete shape alteration capacity. Both cases result in lower resistance characteristics than when the aggregates are moderately soaked just prior to concrete preparation. The pre-soaking time chosen for pumice aggregates (30 minutes) has shown to give the best results as to resistance and workability characteristics (Failla et al, 1997).

4J Compression Resistance

Lightweight conglomerates subjected to compression behave differently from ordinary conglomerates. While in the latter case, stresses propagate from aggregate to aggregate, in the former they propagate through the mortar matrix, which is much Stifter than the aggregates that it contains. Thus, in general, if the quantity and the quality of the inortar in a lightweight concrete is increased, the resistance of the inortar structure is enhanced and consequently the conglomerate compression resistance is also increased. On the other hand, mortar content in lightweight concrete should not be increased excessively so as not to result in a net increase of the conglomerate mass volume as well as avoiding the rising to the surface of the larger grains during mixing (Failla et al, 1997).

The cement mortar content to be used in the manufacture of acceptable resistance lightweight concrete should be 50-60 % by volume. These limitations were observed in the preparation of pumice concrete. As previously mentioned above, fine pumice (0-3 mm) in the aggregate was replaced so as to increase mortar quality and therefore concrete resistance and workability. This fact has resulted in a noticeable increase in the 28 day compression resistance. Comparing the results of the tests of the various mixes, one may observe that the resistance characteristics are also greatly influenced by the nature and screen size of the sand. In general, lightweight concrete shows a rapid initial hardening with a parallel noticeable increase in compression resistance. In actual fact, lightweight concrete achieves approximately 80% of the 28 days resistance level only 3 days after casting. The following relationship between the two resistances was established for lightweight concrete.

$$R_{2„}= 13+1,1\ R_7 \qquad (I)$$

When it is compared to the one generally applied to conventional concrete, one may note that lightweight concrete hardening is initially much faster than that of conventional concrete as seen from the Equation 2.

$$R_{2S}=40+1,IR_7 \qquad (2)$$

5 PUMICE LIGHTWEIGHT CONCRETE - EXPERIMENTAL RESEARCH

A comprehensive experimental research work was carried out to determine the engineering properties of the Turkish pumice lightweight concretes. The tests were performed in the Pumice Research Centre Laboratory of Süleyman Demirel University, Turkey. Different cement dosages were used in each batch. The pumice lightweight concrete mixtures were cast with the cement dosages of 250 and 300 kg/m\

Pumice used in this experimental research, belongs to Kayseri Region, Centre Anatolian of Turkey. It is a crumbly pyroclastic rock characterised by its dark grey colouring. It is rich in highly vesicles volcanic glass which gives it high porosity and low density. It is mostly siliceous and rich in dissolved volatile constituents, especially for water vapour. The most important constituents of this pumice are silica (70 %) and alumina (14%). Also found are iron oxide as 2,5%, calcium oxide as 1%, potassium oxide and sodium oxide as 9%, magnesia, titanium dioxide and manganese oxide in lower levels. Loss at ignition varies from 2% to 3% according to the pumice structure. It has a low thermal conductivity coefficient. Therefore, it is a very good heat insulation material in construction industry.

The same tests are included in the standard for masonry units. However, the limits are not the same in both cases as. for example, in the grading requirements. Here, as a brief explanation, the research findings of the strength characteristics and the elastic properties of the pumice lightweight concrete mixtures prepared were given in the following paragraphs.

Pumice concrete samples were prepared as 10x10x10 cm cube samples. The cube samples were used in testing the mixture strengths and the water/solid ratio was determined as 0.10-0.35 for granulomere mixtures of the cubic samples. To determine the strength of cubic samples, 7, 14 and 28 curing day, cube strength experiments were carried out. Granulometric compositions used in lightweight concrete mixtures are as follows: 16 mm- 8 mm *(Coarse aggregate),* 8 mm - 4 mm *(Metlinm aggregate),* 4 mm - 0 mm *(Fine aggregate).*

The standard lightweight samples were tested after 7 and 28 days curing time to determine the effects of heavy coarse and fine gravel quantities on the reference concrete (no additional admixture-only pumice aggregates) strength). The research findings are plotted in Figure 1 to Figure 10.

In order to improve the mechanical resistance characteristics of pumice concrete, gravel was used instead of fine pumice in several test mixes. In lightweight concrete, unlike in ordinary concrete, the cement mortar (cement + sand + water) has a greater compression resistance than the grain resistance. Consequently, stresses in the gravels arc transferred by the mortar matrix.

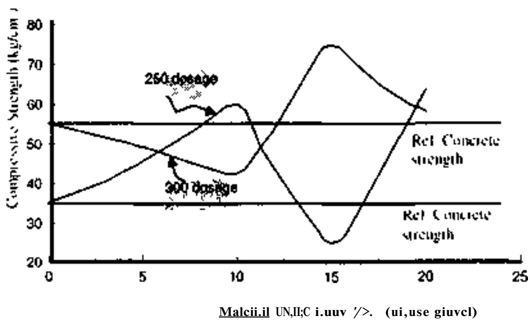

Figure I Effect of coarse gravel quantity on strength

It can be clearly concluded from the Figure 1 that, when the strength of the concrete samples after 28 days curing time is compared with the reference concrete samples, lower cement content will be more efficient for these types of concretes. In this approach, the optimum gravel usage ratio was defined approximately as 13%. Due to the fact that, the mechanical characteristics of the pumice aggregates are considerably lower than that of dense aggregates, the excessive quantities of gravel in the matrix structure may cause shear forces on the pumice aggregates.

It can be seen from the Figure 2 that, lower cement usage with fine gravel will be more efficient for compression resistance of the concrete after 28 days curing time. When the fine gravel is gradually increased in the reference concrete mixture, higher strength values can be acquired thanks to higher adhesive forces and so more compact structure occuring with pumice aggregates. However, the total percentage of the fine gravel must be optimised to prevent decrease in strength and increase in dry unit volume weights. According to the research findings, it was observed that the most suitable fine gravel content in the matrix structure will be approximately 16%.

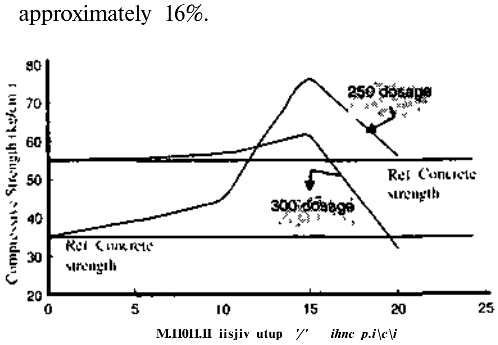

Figure 2. Effect of fine gravel quantity on strength

In addition to coarse and fine aggregates, the pyrophyllilc was used as 5% volume of cement dosage for reducing the water in the mixture and Re-acquiring the adhesive characteristics to the matrix structure. As can be seen from the Figure 3 that, the pyrophyllilc admixture has a positive affect on the strength characteristics of the samples with respect to occuring stronger bonds between the aggregates and matrix structure. When Figure 3 is investigated in detail, this activity is specially obtained for lower cement dosages. For this reason, in order to obtain high strength matrix structure, so increase the strength of pumice aggregate concrete, a certain quantities of coarse gravel, fine gravel and pyrophyllite admixture must be optimised in the mixture.

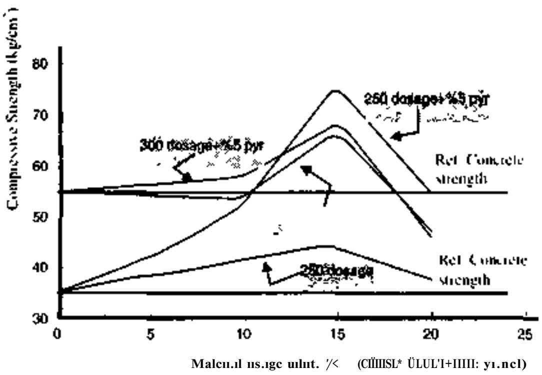

Figure 'S. Effect of pyrophylhte quantity on siiength

The efficiency and variation percentage ot additional admixtures on the strength of concrete was examined for the matrix structure types mentioned above. From this point of view, the strength changes in the new matrix composition was calculated by percentage in comparison to reference concrete and the acquired results were given in the Figure 4 to Figure 6.

These figures show that the increase in strength of matrix structure is higher for lower cement levels. In addition, it was observed that the reference.

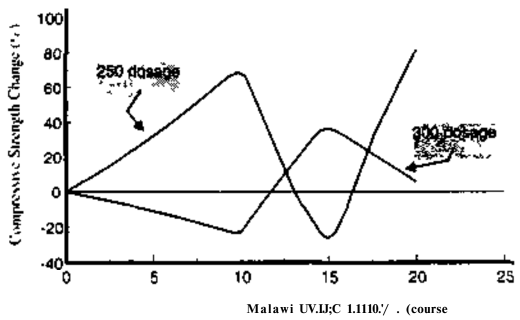

Figure 4. Increasing ratio of strength lor coarse gravel

concrete strength increased approximately with 120 % by the most efficient matrix structure which is composed of *5%* fine gravel, *5%* coarse gravel and *5%* pyrophyllite by volume of cement dosage

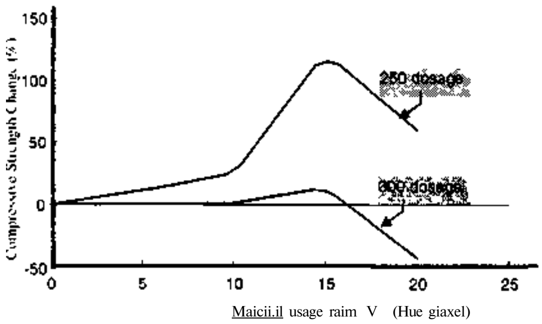

Figure 5. Incıeasıng ratio of strength for tine gravel

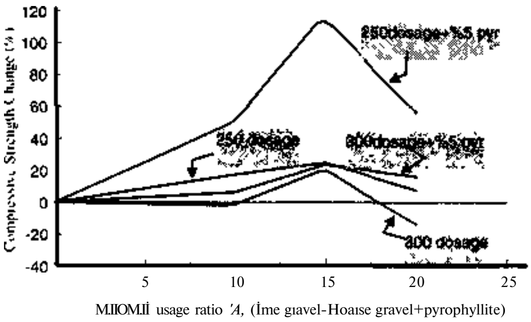

Figure 6 Increasing ratio of strength for pyrophyllite

Another important parameter of the matrix structure which is used for lightweight concrete is the dry unit volume weights of the batches. As known, lower dry unit volume weights and higher strength of matrix structure is generally desired for the obtain high performance lightweight concrete. The analysis findings of the dry unit volume weights were given comparatively in Figure 7 to Figure 10 tor different mixture proportions. From these relationships between the strength and dry unit volume weight, it can be assumed that the increase in cement dosage is more effective on the dry unit volume weights in comparison to different admixtures. However, when the cement dosage is decreased to certain levels, there will be a rational relationship between the dry unit volume weight and the strength of matrix structure. This relation was analysed statistically and the exponential trend was obtained. In other words, the higher dry unit volume weights will cause the higher strength of matrix structure. It can be assumed that from these investigations, the average dry unit volume weights of the matrix structures having different admixtures must be varied between 830-850 kg/m[1] to increase the reference concrete.

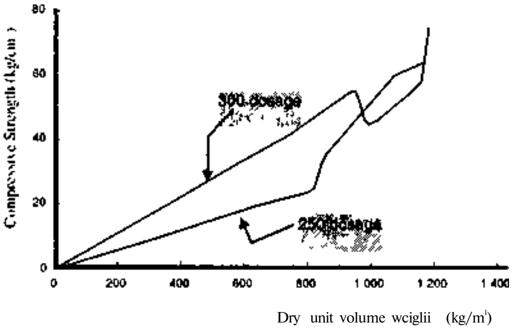

Figure 7 Effect of dry unit volume weight on strength (coarse gravel)

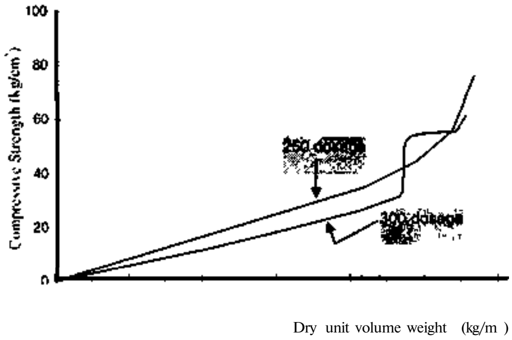

Figure 8. Effect of dry unit volume weight on strength (fine gravel)

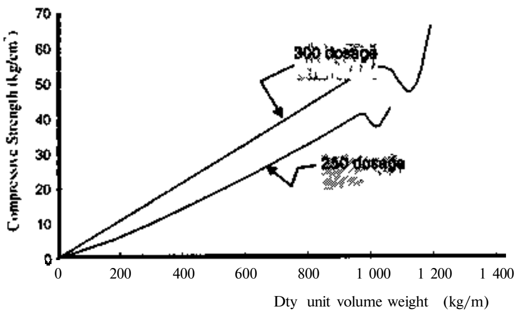

Figure 9 Elfecl of dry unit volume weight on stiength (coarse gravel+fine gravel)

In this research, the general view ot different admixture types used in pumice aggregate concretes was discussed based on the research activity carried out. The eeneral observation is derived as the strength of pumice aggregate concretes could increase with the different additives. However, the care must be taken on which type of additive material should specially be used to increase the concrete strength. This practise could follow by making a series of experimental lest works.

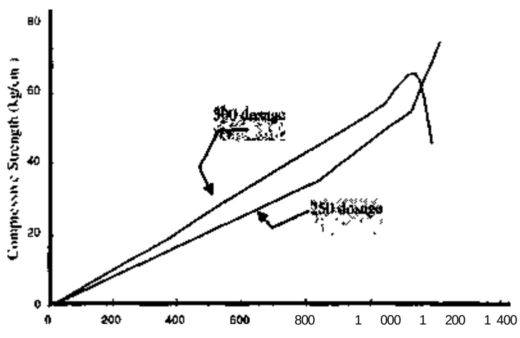

Figure I0. Effect of dry unit volume weight on strength (coarse gravel+fme gravel+pyrophyllite)

5 RESULTS

This paper presents a review on the role of different admixtures in concrete. Various factors such as water /cement ratio, curing conditions and different admixtures have a considerable influence on the concrete strength.

In order to reduce the density for load bearing structural members and to improve the strength properties, a new binder matrix has been investigated. The binder matrix is composed of cement, variable amounts of heavy fine and coarse gravel with pyrophyllite. The use of pumice as lightweight aggregate in combination with crushed gravel and pyrophyllite was found to be advantageous.

In recent years, there has been considerable interest in improving the properties of concrete products by incorporating potentially beneficial materials such as fly ash and pyrophyllite. These materials generally affect the physical and mechanical properties of fresh and hardened concrete.

In addition, it can be clearly concluded that the pumice granulometry used in the mixture combination has a considerable effect on the strength from this approach. Here, the maximum stress value for each block sample of separate mixtures is different from each other and it was also observed that the increasing of line aggregates in the mixture generally affects the maximum strength and strain values. Although the increase in tine aggregates obtains high strength, high quantities of line aggregates are not desired because of causing the high density.

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