SAND, SAND ADDITIVES, SAND PROPERTIES, and *SAND RECLAMATION*

Prof. Dr. Altan Turkeli

MSE-432

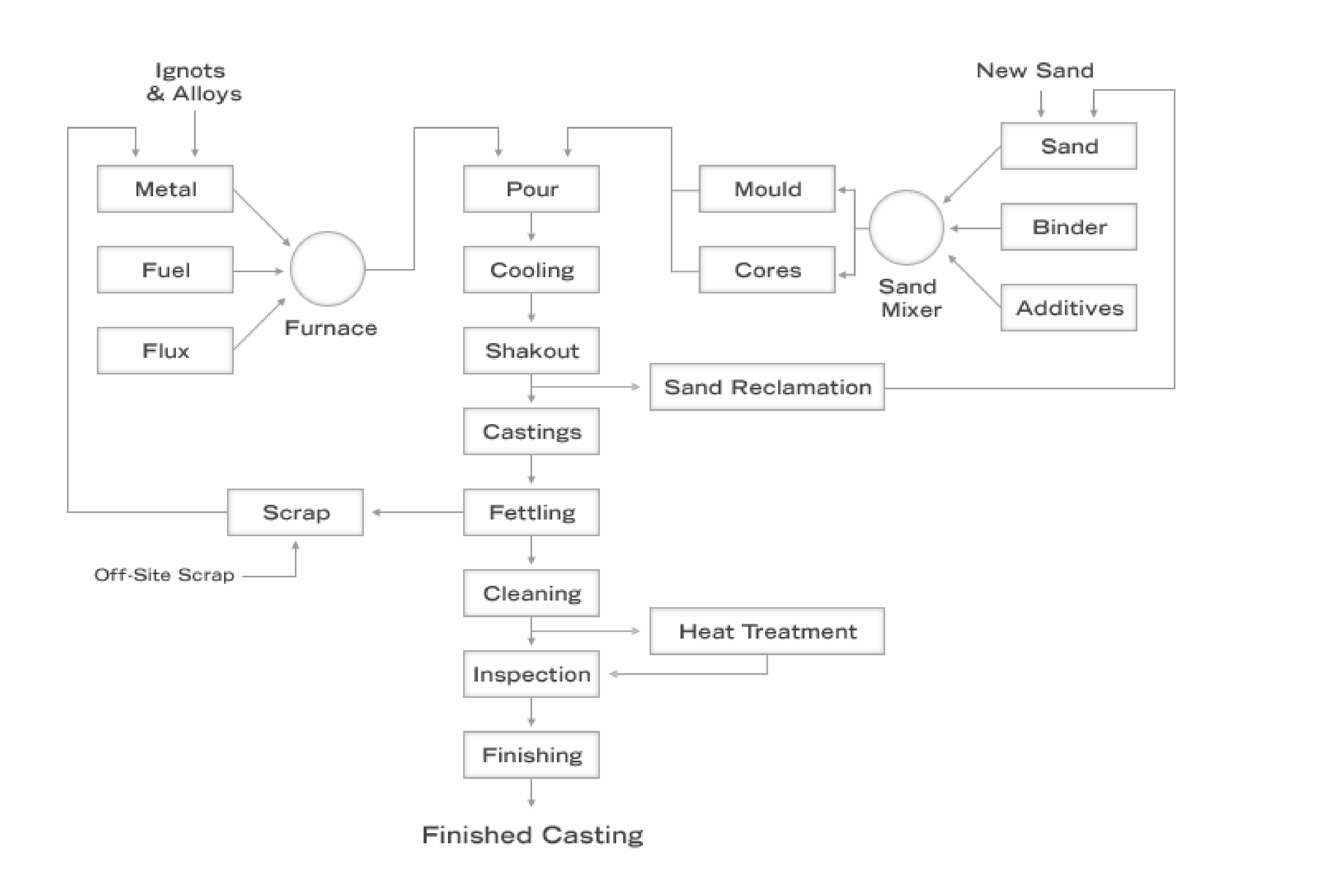
Foundry Technology

SAND ADDITIVES
Casting Sand

- SAND (SiO_2......)
- CLAYS (Bentonite.....)
- WATER

- CELLULOSE (Wood flour, Cob flour.....)
- OIL-CHEMICALS (Soda ash, Polymers....)
- REFRACTORIES (Alumina, Silica flour...)
- SOLUBLES (Corn flour, Corn sugar...)

Flow Chart of a Metal Casting System



SAND

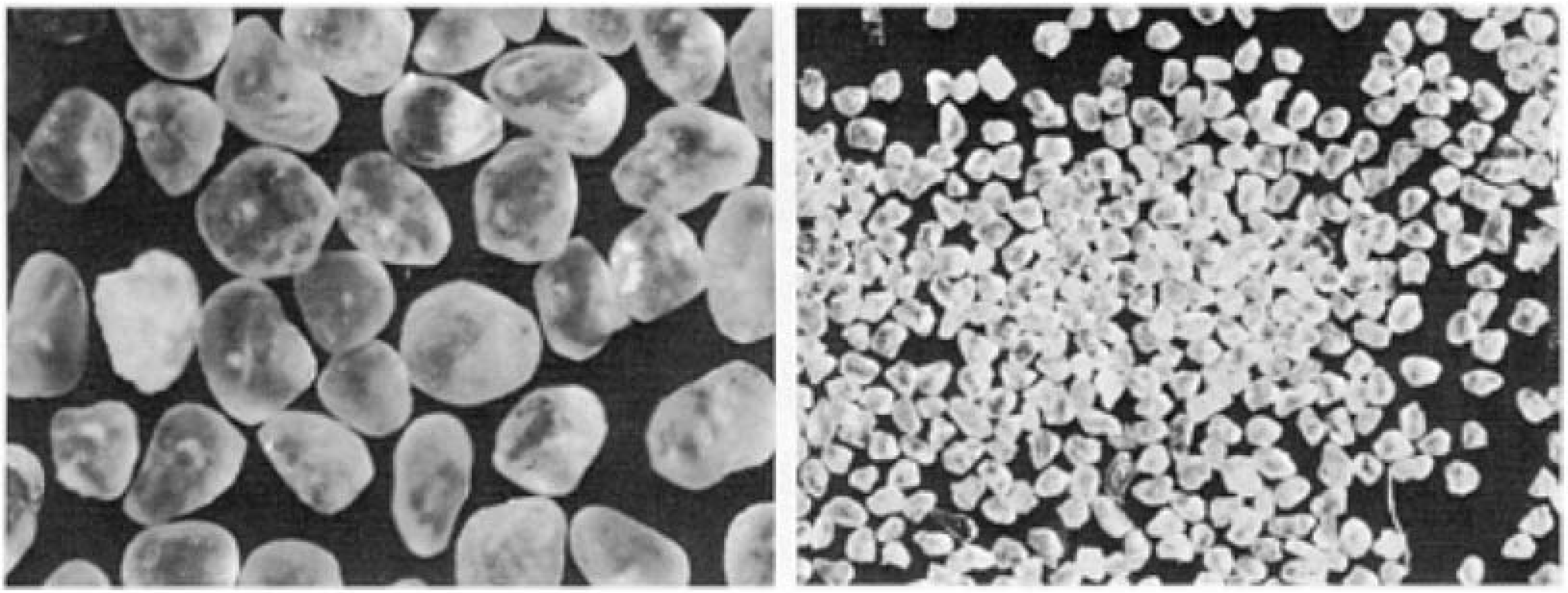


Fig. 1 Two sizes of rounded sand grains. 35×.

SAND

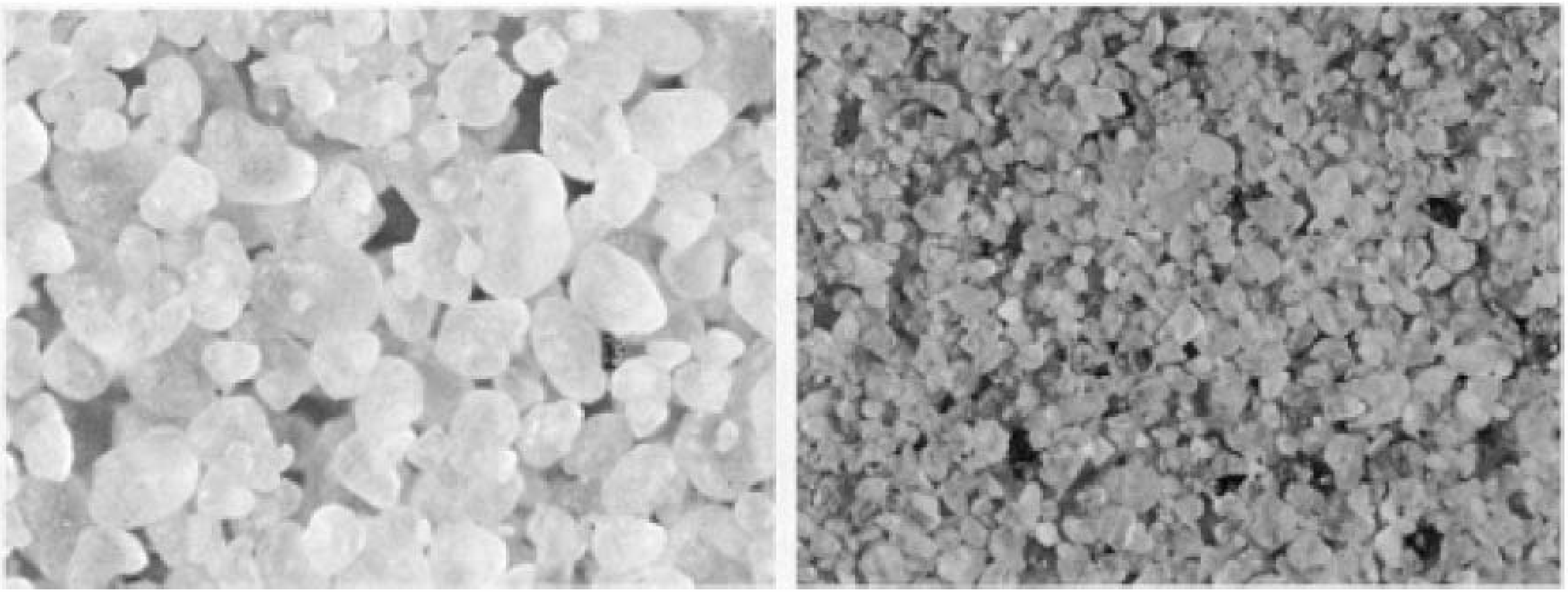


Fig. 2 Sizes of pores in faces of molds made from coarse sand and from fine sand. 35×.

Grain shape

Grain shape is defined in terms of angularity and sphericity. Sand grains vary from well rounded to rounded, sub-rounded, sub-angular, angular and very angular. Within each angularity band, grains may have high, medium or low sphericity. The angularity of sand is estimated by visual examination with a low power microscope and comparing with published charts, Fig. 12.1.

The best foundry sands have grains which are rounded with medium to high sphericity giving good flowability and permeability with high strength at low binder additions. More angular and lower sphericity sands require higher binder additions, have lower packing density and poorer flowability.

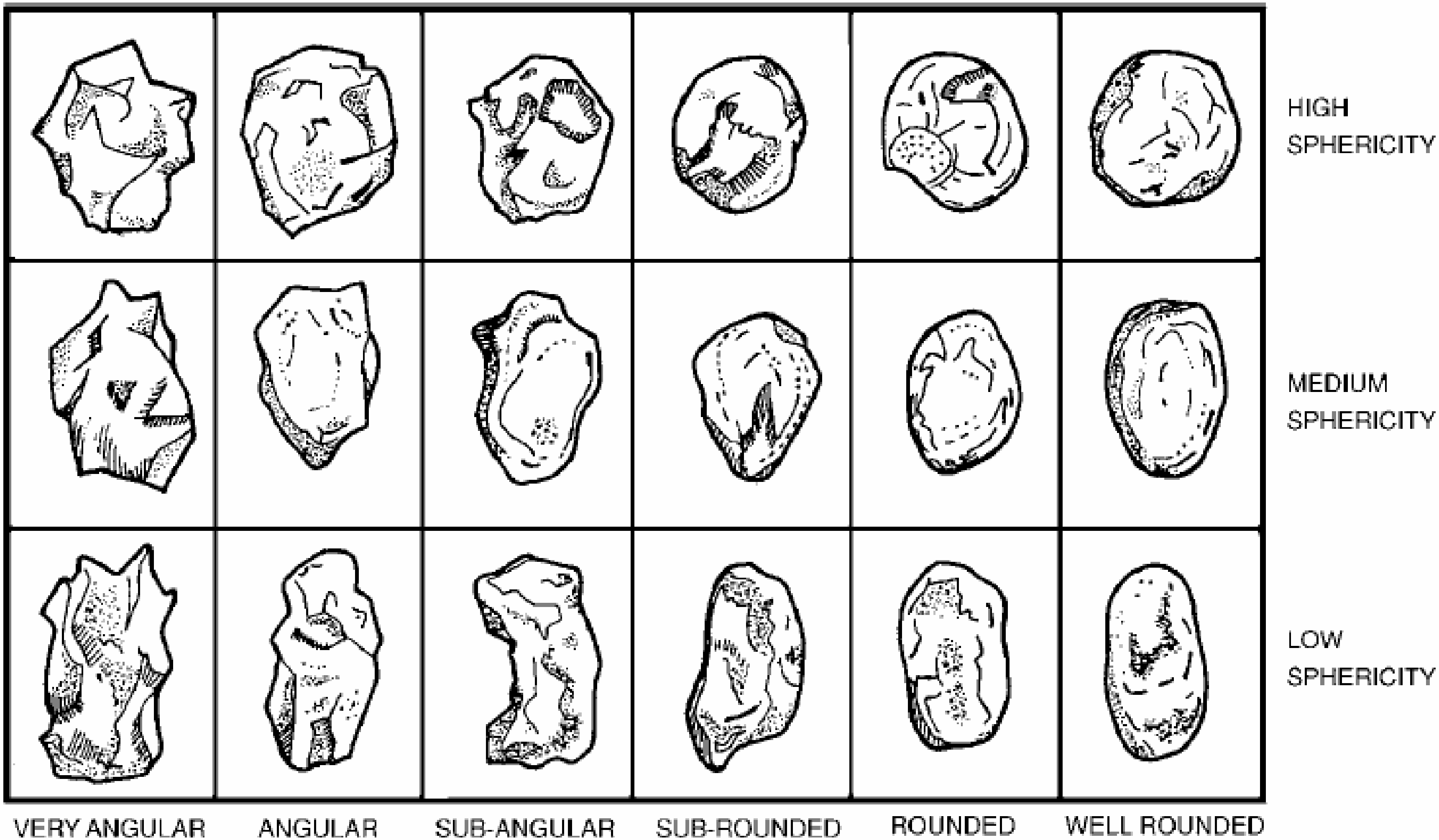


Figure 12.1 *Classification of grain shapes.*

Casting Sands

- ***Silica Sands***
- ***Zircon***
- ***Olivine***
- ***Chromite***
- ***Aluminum Silicates***

Silica Sands

- Most green sand molds consist of silica sands bonded with a bentonite-water mixture. (The term green means that the mold, which is tempered with water, is not dried or baked.) The composition, size, size distribution, purity, and shape of the sand are important to the success of the mold making operation.

- Sands are sometimes referred to as natural or synthetic.
- **Natural or Synthetic**
- Natural sands contain enough naturally occurring clays that they can be mixed with water and used for sand molding.
- Synthetic sands have been washed to remove clay and other impurities, carefully screened and classified to give a desired size distribution, and then reblended with clays and other materials to produce an optimized sand for the casting being produced.
- Because of the demands of modern high-pressure molding machines and the necessity to exercise close control over every aspect of casting production, most foundries use only synthetic sands.

Composition

- Foundry sands are composed almost entirely of silica (SiO_2) in the form of quartz. Some impurities may be present, such as ilmenite (FeO-TiO_2), magnetite (Fe_3O_4), or olivine, which is composed of magnesium and ferrous orthosilicate [$(Mg,Fe)\ SiO_4$]. Silica sand is used primarily because it is readily available and inexpensive.

- Quartz undergoes a series of crystallographic transitions as it is heated. The first, at 573 °C, is accompanied by expansion, which can cause mold spalling. Above 870 °C, quartz transforms to tridymite, and the sand may actually contract upon heating. At still higher temperatures (> 1470 °C), tridymite transforms to cristobalite.

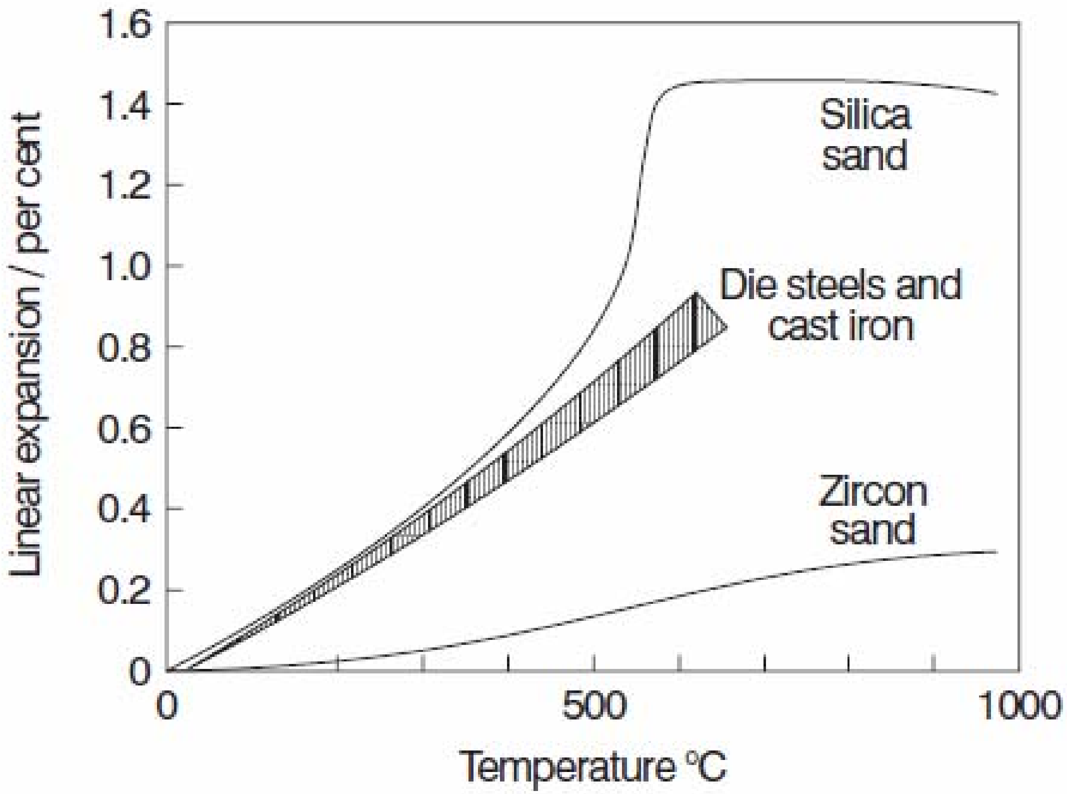


Figure 11.4 *The expansion/temperature relations for iron-based die materials, and silica and zircon sand moulding materials. (J. Campbell,* Foundry International, *March 1992)*

Shape and Distribution of Sand Grains

- The size, size distribution, and shape of the sand grains are important in controlling the quality of the mold. Most mold aggregates are mixtures of new sand and reclaimed sand, which contain not only reclaimed molding sand but also core sands. In determining the size, shape, and distribution of the sand grains, it is important to realize that the grain shape contributes to the amount of sand surface area and that the grain size distribution controls the permeability of the mold.

- As the sand surface area increases, the amount of bonding material (normally clay and water) must increase if the sand is to be properly bonded. Thus, a change in surface area, perhaps due to a change in sand shape or the percentage of core sand being reclaimed, will result in a corresponding change in the amount of bond required.

- Rounded grains have a low surface-area-to-volume ratio and are therefore preferred for making cores because they require the least amount of binder. However, when they are recycled into the molding sand system, their shape can be a disadvantage if the molding system normally uses a high percentage of clay and water to facilitate rapid, automatic molding. This is because rounded grains require less binder than the rest of the system sand.

- Angular sands have the greatest surface area (except for sands that fracture easily and produce a large percentage of small grains and fines) and therefore require more mulling, bond, and moisture. The angularity of a sand increases with use because the sand is broken down by thermal and mechanical shock.

- The porosity of the mold controls its permeability, which is the ability of the mold to allow gases generated during pouring to escape through the mold. The highest porosity will result from grains that are all approximately the same size.

- As the size distribution broadens, there are more grains that are small enough to fill the spaces between large grains. As grains break down through repeated recycling, there are more and more of the smaller grains, and the porosity of the mold decreases.

- However, if the porosity of the mold is too great, metal may penetrate the sand grains and cause a burn-in defect.
- Therefore, it is necessary to balance the base sand distribution and continue to screen the sand and use dust collectors during recycling to remove fines and to determine the proper bond addition.
- Most foundries in the United States use the American Foundrymens' Society (AFS) grain fineness number as a general indication of sand fineness. The AFS grain fineness number of sand is approximately the number of openings per inch of a given sieve that would just pass the sample if its grains were of uniform size, that is, the weighted average of the sizes of grains in the sample. It is approximately proportional to the surface area per unit weight of sand exclusive of clay.

Table 1 Screen scale sieves equivalent

USA series No.	Tyler screen scale sieves, openings per lineal inch	Sieve opening, mm	Sieve opening, μm	Sieve opening, in., ratio $\sqrt{2}$, or 1.414	Permissible variation in average opening, ±mm	Wire diameter, mm
6	6	3.35	3350	. . .	0.11	1.23
8[a]	8[a]	2.36	2360	0.0937	0.08	1.00
12	10	1.70	1700	0.0661	0.06	0.810
16[a]	14[a]	1.18	1180	0.0469	0.045	0.650
20	20	0.850	850	0.0331	0.035	0.510
30	28	0.600	600	0.0234	0.025	0.390
40	35	0.425	425	0.0165	0.019	0.290
50	48	0.300	300	0.0117	0.014	0.215
70	65	0.212	212	0.0083	0.010	0.152
100	100	0.150	150	0.0059	0.008	0.110
140	150	0.106	106	0.0041	0.006	0.076
200	200	0.075	75	0.0029	0.005	0.053
270	270	0.053	53	0.0021	0.004	0.037

Size of sample: 50 g; AFS clay content: 5.9 g, or 11.8%; sand grains: 44.1 g, or 88.2%

USA sieve series No.	Amount of 50 g sample retained on sieve		Multiplier	Product
	g	%		
6	none	0.0	3	0
12	none	0.0	5	0
20	none	0.0	10	0
30	none	0.0	20	0
40	0.20	0.4	30	12
50	0.65	1.3	40	52
70	1.20	2.4	50	120
100	2.25	4.5	70	315
140	8.55	17.1	100	1710
200	11.05	22.1	140	3094
270	10.90	21.8	200	4360
Pan	9.30	18.6	300	5580
Total	44.10	88.2		15,243

	Sand A	Sand B
6	0.0	0.0
12	0.0	0.0
20	0.0	0.0
30	1.0	0.0
40	24.0	1.0
50	22.0	24.0
70	16.0	41.0
100	17.0	24.0
140	14.0	7.0
200	4.0	2.0
270	1.7	0.0
Pan	0.3	1.0
Total	100.0	100.0
AFS grain fineness No	60.0	60.0

Sieves used for sand grading are of 200 mm diameter and are now usually metric sizes, designated by their aperture size in micrometres (μm). The table lists sieve sizes in the British Standard Metric series (BS410:1976) together with other sieve types.

Sieve aperture, micrometres and sieve numbers

ISO/R.565 series (BS410:1976) (μm)	*BSS* *No.*	μm	*ASTM* *No.*	μm
(1000)	16	1003	18	1000
710	22	699	22	710
500	30	500	30	500
355	44	353	45	350
250	60	251	60	250
(212)	72	211	70	210
180				
(150)	100	152	100	149
125			120	125
90	150	104	150	105
63	200	76	200	74
(45)	300	53	325	44

Notes: The 1000 and 45 sieves are optional.
The 212 and 150 sieves are also optional, but may be included to give better separation between the 250 and 125 sieves.

Calculation of average grain size

The adoption of the ISO metric sieves means that the old AFS grain fineness number can no longer be calculated. Instead, the average grain size, expressed as micrometres (μm) is now used. This is determined as follows:

1 Weigh a 100 g sample of dry sand.
2 Place the sample into the top sieve of a nest of ISO sieves on a vibrator. Vibrate for 15 minutes.
3 Remove the sieves and, beginning with the top sieve, weigh the quantity of sand remaining on each sieve.
4 Calculate the percentage of the sample weight retained on each sieve, and arrange in a column as shown in the example.
5 Multiply the percentage retained by the appropriate multiplier and add the products.
6 Divide by the total of the percentages retained to give the average grain size.

Example

ISO aperture (μm)	*Percentage retained*	*Multiplier*	*Product*
≥710	trace	1180	0
500	0.3	600	180
355	1.9	425	808
250	17.2	300	5160
212	25.3	212	5364
180	16.7	212	3540
150	19.2	150	2880
125	10.6	150	1590
90	6.5	106	689
63	1.4	75	105
≤63	0.5	38	19
Total	99.6	–	20 335

Average grain size = 20 335/99.6
= 204 μm

Calculation of AFS grain fineness number

Using either the old BS sieves or AFS sieves, follow, steps 1–4 above.

5 Arrange the results as shown in the example below.

6 Multiply each percentage weight by the preceding sieve mesh number.

7 Divide by the total of the percentages to give the AFS grain fineness number.

Example

BS sieve number	*% sand retained on sieve*	*Multiplied by previous sieve no.*	*Product*
10	nil		
16	nil		
22	0.2	16	3.2
30	0.8	22	17.6
44	6.7	30	201.0
60	22.6	44	1104.4
100	48.3	60	2898.0
150	15.6	100	1560.0
200	1.8	150	270.0
pan	4.0	200	800.0
Total	100.0	–	6854.2

AFS grain fineness number = 6854.2/100
= 68.5 or 68 AFS

Foundry sands usually fall into the range 150–400 µm, with 220–250 µm being the most commonly used. Direct conversion between average grain size and AFS grain fineness number is not possible, but an approximate relation is shown below:

AFS grain fineness no.	35	40	45	50	55	60	65	70	80	90
Average grain size (µm)	390	340	300	280	240	220	210	195	170	150

While average grain size and AFS grain fineness number are useful parameters, choice of sand should be based on particle size distribution.

Table 12.1 gives size gradings of typical foundry sands used in the UK and Germany.

Table 12.1 Typical UK and German foundry sands

Sieve size		*Sand type*				
microns	*BSS no.*	*UK sands*		*German sands*		
		Chelford 50	*Chelford 60*	*H32*	*H33*	*F32*
1000	16	trace	nil			
700	22	0.7	0.4			
500	30	4.5	2.3	1.0	0.5	1.0
355	44	19.8	10.0	15.0	7.5	7.0
250	60	44.6	25.7	44.0	30.0	30.0
210	72	21.6	23.8	39.0	60.0	60.0
150	100	8.2	28.7			
100	150	2.6	7.6			
75	200	nil	1.3	1.0	2.0	2.0
75	–200	nil	0.2	nil	nil	nil
AFS grain fineness no.		46	59	51	57	57
Average grain size mm		0.275	0.23	0.27	0.23	0.23

Note: Haltern 32, 33 and Frechen 32 are commonly used, high quality German sands.
German sieve gradings are based on ISO sieves.
The German sands have rounder grains and are distributed on fewer sieves than UK sands, they require significantly less binder to achieve the required core strength.

Sieve grading of Chelford 60 sand:

Aperture size (μm)	*BSS mesh no.*	*% wt. retained*
1000	16	nil
700	22	0.4
500	30	2.3
355	44	10.0
250	60	25.7
210	72	23.8
150	100	28.7
105	150	7.6
75	200	1.3
–75	–200	0.2

AFS grain fineness no. 59
Base permeability: 106

Size distribution

The size distribution of the sand affects the quality of the castings. Coarse-grained sands allow metal penetration into moulds and cores giving poor surface finish to the castings. Fine-grained sands yield better surface finish but need higher binder content and the low permeability may cause gas defects in castings. Most foundry sands fall within the following size range:

Grain fineness number	50–60 AFS	Yields good surface finish at low binder levels
Average grain size	220–250 microns	
Fines content, below 200 mesh	2% max	Allows low binder level to be used
Clay content, below 20 microns	0.5% max	Allows low binder levels
Size spread	95% on 4 or 5 screens	Gives good packing and resistance to expansion defects
Specific surface area	120–140 cm^2/g	Allows low binder levels
Dry permeability	100–150	Reduces gas defects

Safe handling of silica sand

Fine silica sand (below 5 microns) can give rise to respiratory troubles. Modern foundry sands are washed to remove the dangerous size fractions and do not present a hazard as delivered. It must be recognised, however, that certain foundry operations such as shot blasting, grinding of sand covered castings or sand reclamation can degrade the sand grains, producing a fine quartz dust having particle size in the harmful range below 5 microns. Operators must be protected by the use of adequate ventilation and the wearing of suitable face masks.

Zircon

- Zircon is zirconium silicate ($ZrSiO_4$). It is highly refractory and possesses excellent foundry characteristics. Its primary advantages are a very low thermal expansion, high thermal conductivity and bulk density (which gives it a chilling rate about four times that of quartz), and very low reactivity with molten metal. Zircon requires less binder than other sands because its grains are rounded. The very high dimensional and thermal stabilities exhibited by zircon are the reasons it is widely used in steel foundries and investment foundries making high-temperature alloy components.

Olivine

- Olivine minerals (so called because of their characteristic green color) are a solid solution of forsterite (Mg_2SiO_4) and fayalite (Fe_2SiO_4). Their physical properties vary with their chemical compositions; therefore, the composition of the olivine used must be specified to control the reproducibility of the sand mixture. Care must be taken to calcine the olivine sand before use to decompose the serpentine content, which contains water .
- The specific heat of olivine is similar to that of silica, but its thermal expansion is far less. Therefore, olivine is used for steel casting to control mold dimensions. Olivine is somewhat less durable than silica , and it is an angular sand.

Chromite

- Chromite ($FeCr_2O_4$), a black, angular sand, is highly refractory and chemically unreactive, and it has good thermal stability and excellent chilling properties. However, it has twice the thermal expansion of zircon sand, and it often contains hydrous impurities that cause pinholing and gas defects in castings. It is necessary to specify the calcium oxide (CaO) and silicon dioxide (SiO_2) limits in chromite sand to avoid sintering reactions and reactions with molten metal that cause burn-in.

Aluminum Silicates

- Aluminum silicate (Al2SiO5) occurs in three common forms: kyanite, sillimanite, and andalusite. All break down at high temperatures to form mullite and silica . Therefore, aluminum silicates for foundry use are produced by calcining these minerals. Depending on the sintering cycle, the silica may be present as cristobalite or as amorphous silica. The grains are highly angular. These materials have high refractoriness, low thermal expansion, and high resistance to thermal shock. They are widely used in precision investment foundries, often in combination with zircon.

Bulk density =The mass of powdered or granulated solid material per unit of volume

Table 12.3 Properties of non-silica sands (compared with silica)

Property	Silica	Zircon	Chromite	Olivine
AFS grain size no.	60	102	74	65
Grain shape	rounded	rounded	angular	angular
Specific gravity	2.65	4.66	4.52	3.3
Bulk density (kg/m^3)	1490	2770	2670	1700
(lb/ft^3)	93	173	167	106
Thermal expansion 20–1200°C	1.9% non linear	0.45%	0.6%	1.1%
Application	general	refractoriness chill	resistance to penetration chill	Mn steel

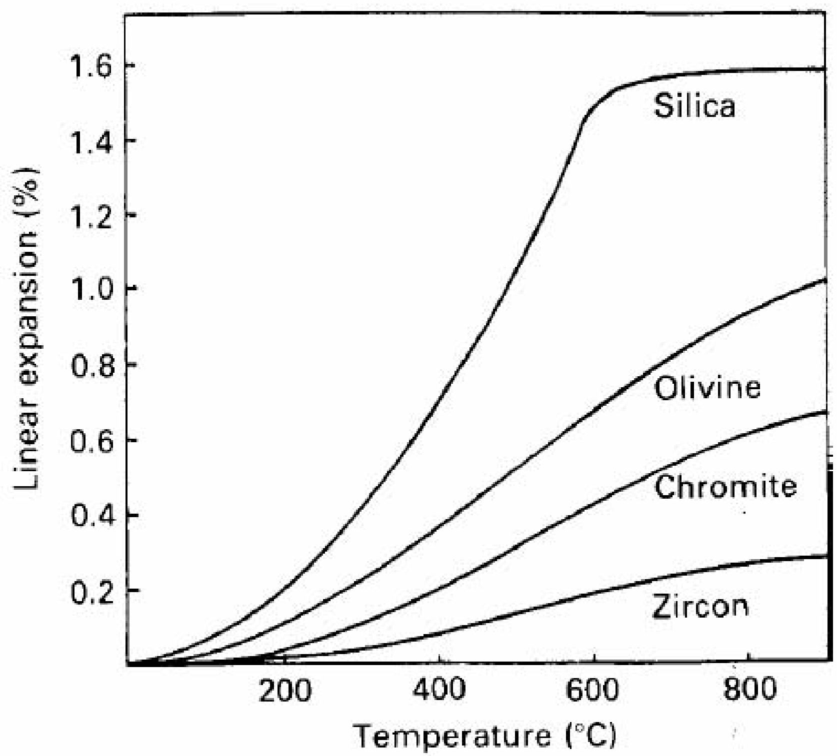


Figure 12.2 *Thermal expansion characteristics of zircon, chromite and olivine sands compared with silica sand.*

SAND ADDITIVES
Water

- Water
- H_20

SAND ADDITIVES
Clays

- Clays
- Bentonite, Southern (Ca-Bentonite)
- Bentonite, Western (Na-Bentonite)
- Fireclay
- Kaolin Clay

- The most common clays used in bonding green sand molds are bentonites, which are forms of montmorillonite or hydrated aluminum silicate. Montmorillonite is built up of alternating tetrahedra of silicon atoms surrounded by oxygen atoms, and aluminum atoms surrounded by oxygen atoms, as shown in Fig. 1. This is a layered structure, and it produces clay particles that are flat plates. Water is adsorbed on the surfaces of these plates, and this causes bentonite to expand in the presence of water and to contract when dried.

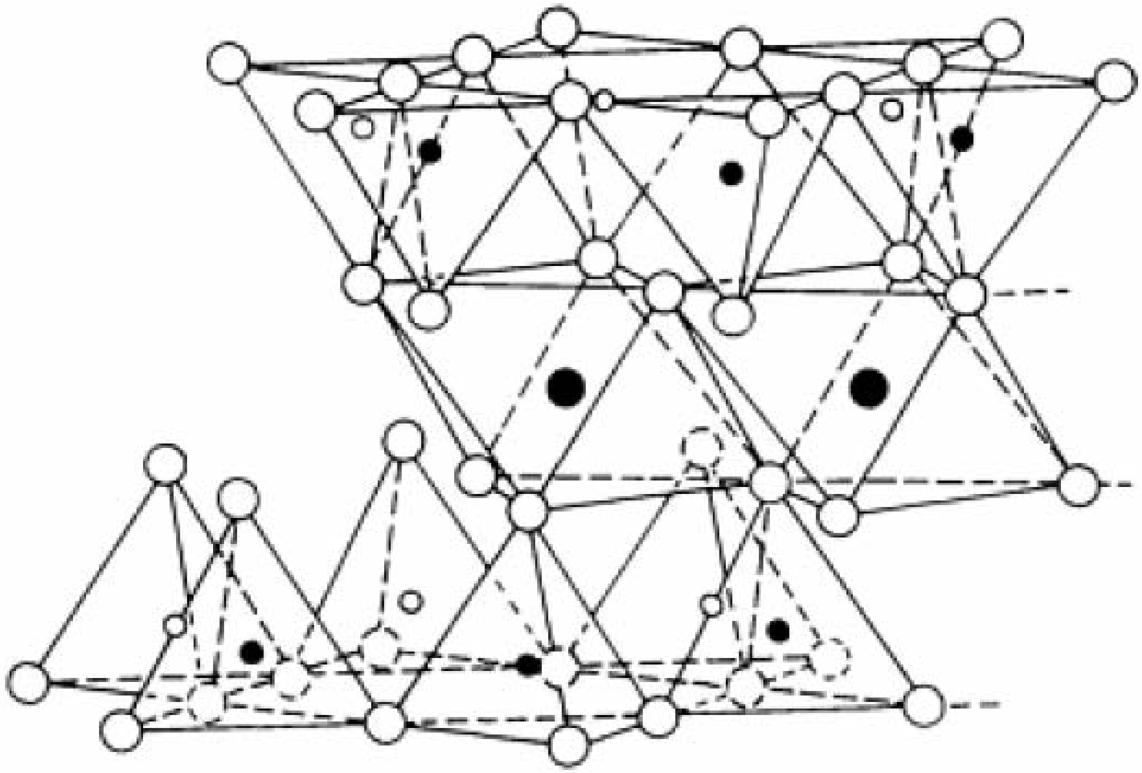
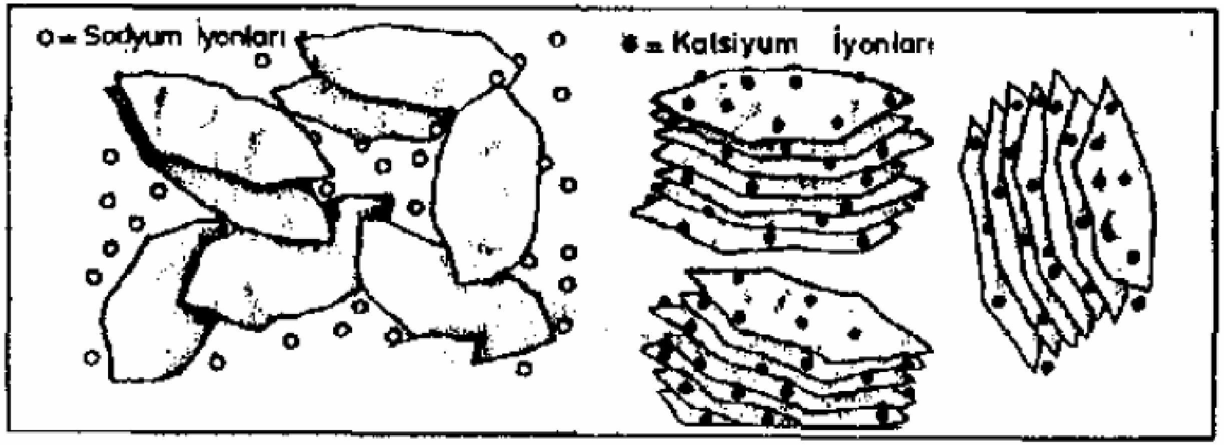


Fig. 1 Structure of montmorillonite. Large closed circles are aluminum, magnesium, sodium, or calcium. Small closed circles are silicon. Large open circles are hydroxyls. Small open circles are oxygen.

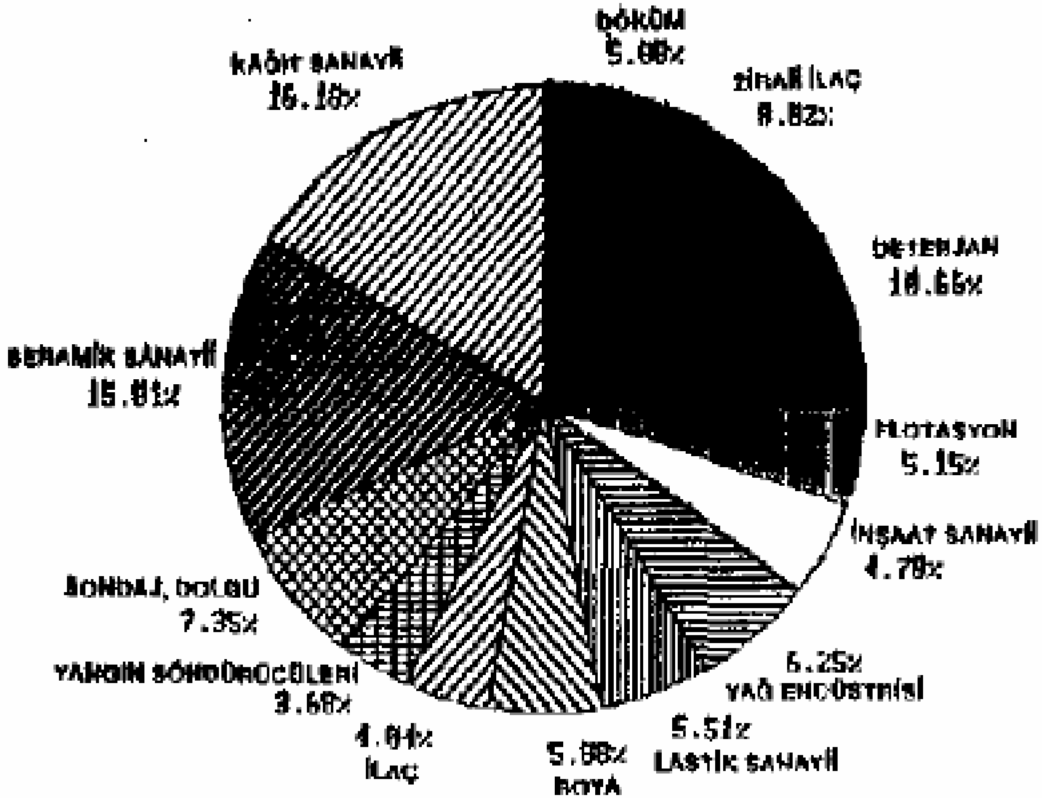


ŞEKIL 2 : Na ve Ca bentonitlerine ait şişmiş montmorolit kristalleri

BİLEŞİM	TSE		REŞADİYE		ÜNYE	
	EN FAZLA	EN AZ	EN FAZLA	EN AZ	EN FAZLA	EN AZ
SiO_2	68	58	65	54	70	40
Al_2O_3	25	18	23	17	18	7
Fe_2O_3	5.5		5	3	4	1
FeO	0.5		3	1		
MgO	4.5		4	1	4	1
CaO	0.5		3	0.3	20	1
Na_2O+K_2O		0.5	3	0.3	1	0.3

TABLO 2 : Türkiyenin farklı yörelerinden hazırlanan bentonitlerin kimyasal analizi ve TSE tarafından taslak olarak önerilen kimyasal bileşim aralığı

ŞEKIL 1 : BENTONITLERIN KULLANILDIĞI YERLER



D)Bentonitin Şişmesi (Hacim büyümesi):

Bentonitin en önemli özelliklerinden bir tanesi de su içinde kabarıp şişmesi ve jelimsi bir kitle meydana getirmesidir. Bir kilin gerçekten ve kelimenin ticari anlamı ile bentonit olabilmesi için en azından kendi hacminin beş katı şişmesi gerekmektedir.Normal olarak iyi vasıflı bentonitler 10 - 20, çok ender bentonitlerde 25 hatta 30 kat şişebilmektedirler.

BENTONITE, SOUTHERN

(INORGANIC)

Description.............(Ca^{++} calcium bentonite) also known as nonswelling bentonite.
Typical Color.............cream, tan, bluish gray
Purpose.... basic bond in green sand system. To promote good green strength, moderate dry and hot compression strengths. Gives higher green, lower dry and hot strengths and promotes better flowability than western bentonite.
Bulk Density .... 52 lb/ft^3
Typical Sizing .... 60-90% thru USA Sieve 200
pH 4.0-8.5
Fusion Point 1900-2440F (1038-1338C)
% Volatile @ 900F (482C) 0*
% Volatile @ 1800F (982C) 0.5
% Total Combustibles...................... 0.5*
Effective Temperature of Destruction 1292F (700C)
Effect on:
Green Compression Strength ....increases
Dry Compression Strength ....increases
Hot Compression Strength ....increases

Miscellaneous Data or Observations
Typical base exchange (in me/100 g) .... Na(<5), K(2.8), Ca(74.7), Mg(1.0)

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*Does not include chemically or mechanically held water.

Typical Chemical Analysis (Percent)

SiO_2	56-59	CaO	1.2-35
Al_2O_3	18-21	Na_2O	0.34-46
Fe_2O_3	5.4-9.1	H_2O, as shipped	5.0-8.0
MgO	3.0-3.3		

BENTONITE, WESTERN

(INORGANIC)

Description .... powdered (Na^+ sodium bentonite). Also known as Wyoming bentonite, high-swelling bentonite.
Typical Color .... bluish, cream, gray, light yellow
Purpose ...... basic bond in a green sand system. To promote green, dry and hot compression strengths. To prevent erosion, cuts, washes, and allow for silica sand expansion.
Bulk Density .... 54 lb/ft³
Typical Sizing .... 60-92% thru USA Sieve 200
pH 9.0-10.0
Fusion Point 1900-2440F (1038-1338C)
% Volatile @ 900F (842C) 0*
% Volatile @ 1800F (982C) 5
(H_2O of hydration driven off @ 1292F (700C). Lattice destroyed @ 1832F (1000C).
% Total Combustibles 0.5*
Effective Temperature of Destruction 1832F (1000C)
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... increases

Miscellaneous Data or Observations

1) Base exchange (in me/100 g)
   Total Na, K, Ca & Mg 85-100
   Combined Na & K ions .... 60.0% min.
   Combined Ca & Mg ions .... 40.0% max.
2) Consists primarily of the mineral montmorillonite.
3) Various other grinds available.

*Does not include chemically or mechanically held water.

Typical Chemical Analysis (Percent)

SiO_2	60-62
Al_2O_3	21-23
Fe_2O_3	3-4
Na_2O	2.5-2.7
MgO	0.2-3
CaO	0.5-1.5
K_2O	0.4-0.45
H_2O, as shipped	5.0-9.0

Fireclay

- Fireclay consists essentially of kaolinite, a hydrous aluminum silicate that is usually combined with bentonites in molding sand. It is highly refractory, but has low plasticity. It improves the hot strength of the mold and allows the water content to be varied over greater ranges. Because of its high hot strength potential, it is used for large castings. It is also used to improve sieve analysis by creating fines whenever the system does not have an optimum wide sieve distribution of the base sand. However, because of its low durability, its use is generally limited. In addition, the need for fireclay can usually be eliminated through close control of sand mixes and materials.

FIRECLAY

(INORGANIC)

Description .... 50 mesh
Typical Color .... gray
Purpose ...... basic bond in a green sand system. Increases green, dry and hot strengths. Used particularly to increase dry and hot properties.
Bulk Density .... 60 lb/ft^3
pH 4-5
Fusion Point 3000F (1649C)
% Volatile @ 900F (482C) .... varies
% Volatile @ 1800F (982C) 9.0
% Total Combustibles 9.39*
Effective Temperature of Destruction 3055F (1679C)
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... increases

Miscellaneous Data or Observations
PCE Cone 31 .... 3055F (1679C)
AFS GFN 180
Finer and coarser grinds also available.

*Includes approximately 4-5% H_2O as shipped.

Typical U.S.A. Sieve Analysis (Percent Retained)

30	0.3	140	11.4
40	1.7	200	11.5
50	5.3	270	12.7
70	9.5	Pan	335
100	13.5		

Typical Chemical Analysis (Percent)

SiO_2	57.32
Al_2O_3	28.50
Fe_2O_3	1.23
TiO_2	1.98
$CaCO_3$	0.08
MgO	0.22

KAOLIN CLAY

(INORGANIC)

Description . . . . also called "China Clay" although China Clay is primarily used in the ceramic industry, and is slightly different.

Typical Color . . . . gray

Purpose . . . . primarily increases dry and hot compression strengths

Bulk Density . . . . 30 lb/ft³

pH 4.5

Fusion Point 2921F (1605C)

% Volatile @ 1800F (982C) 14.2

% Total Combustibles 14.2

Effective Temperature of Destruction 3000F (1649C)

Effect on:

Green Compression Strength . . . . increases

Dry Compression Strength . . . . increases

Hot Compression Strength . . . . increases

Miscellaneous Data or Observations

Modulus of rupture . . . . 75 psi

H_2O of plasticity 32.7%

*Includes H_2O as shipped.

Typical Chemical Analysis (Percent)

SiO_2	44.90
Al_2O_3	38.90
Fe_2O_3	0.40
TiO_2	0.06
CaO	0.06
MgO	0.10
Na_2O	0.22
K_2O	0.20

Typical Particle Size Analysis

% Finer	Microns
98	26.6
95.7	8.5
90.5	6.9
81.5	3.9
69.7	2.3
55.4	1.8
39.7	0.44
30.3	0.32

Typical Particle Size Analysis

Microns	Percent
Below 10	90
Below 5	80
Below 2	60
Below 1	44
Below0.5	24
Below 0.25	10
Below 0.10	2

Sand Properties

- Green Compression Strength
- Dry Compression Strength
- Hot Compression Strength
- Moisture (water)
- Permeability
- Flowability
- Refractoriness
- Thermal Stability
- Collapsibility
- Produces good casting finish
- Mold Hardness
- Deformation
- Is reusable
- Remove heat from the cooling casting

GENERAL PROPERTIES OF MOLDING SANDS

- From a general viewpoint, the molding sand must be readily moldable and produce defect-free castings if it is to qualify as a good one. Certain specific properties have been identified, and testing procedures adapted for their quantitative description.
- The AFS "Foundry Sand Hand-book"[1] sets forth the standard conditions of testing the sand properties. Those properties of most obvious importance include:

GENERAL PROPERTIES OF MOLDING SANDS

1. Green strength. The green sand, after water has been mixed into it, must have adequate strength and plasticity for making and handling of the mold.
2. Dry strength. As a casting is poured, sand adjacent to the hot metal quickly loses its water as steam. The dry sand must have strength to resist erosion, and also the metallostatic pressure of the molten metal, or else the mold may enlarge.

GENERAL PROPERTIES OF MOLDING SANDS

3. Hot strength. After the moisture has evaporated, the sand may be required to possess strength at some elevated temperature, above 100 ^{o}C. Metallostatic pressure of the liquid-metal bearing against the mold walls may cause mold enlargement, or if the metal is still flowing, erosion, cracks, or breakage may occur unless the sand possesses adequate hot strength.
4. Permeability. Heat from the casting causes a green-sand mold to evolve a great deal of steam and other gases. The mold must be permeable, i.e. porous, to permit the gases to pass off, or the casting will contain gas holes.

GENERAL PROPERTIES OF MOLDING SANDS

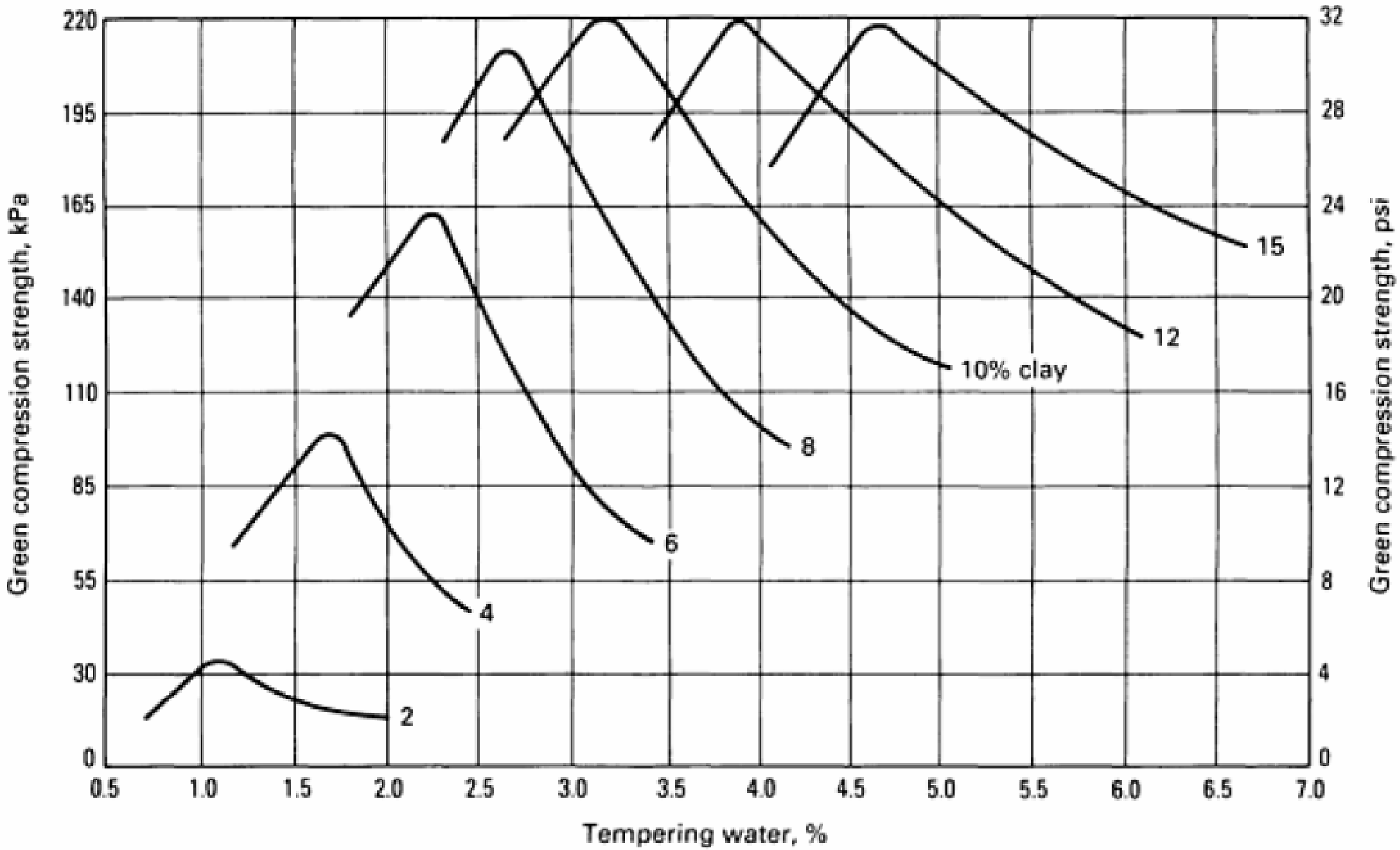
5. Thermal stability. Heat from the casting causes rapid expansion of the sand surface at the mold-metal interface. The mold surface may then crack, buckle, or flake off (scab) unless the molding sand is relatively stable dimensionally under rapid heating.
6. Refractoriness. Higher pouring temperatures, such as those for ferrous alloys at 2400 to 3200 F, require greater refractoriness of the sand. Low-pouring-temperature metals, for example, aluminum, poured at 1300 F, do not require a high degree of refractoriness from the sand.

GENERAL PROPERTIES OF MOLDING SANDS

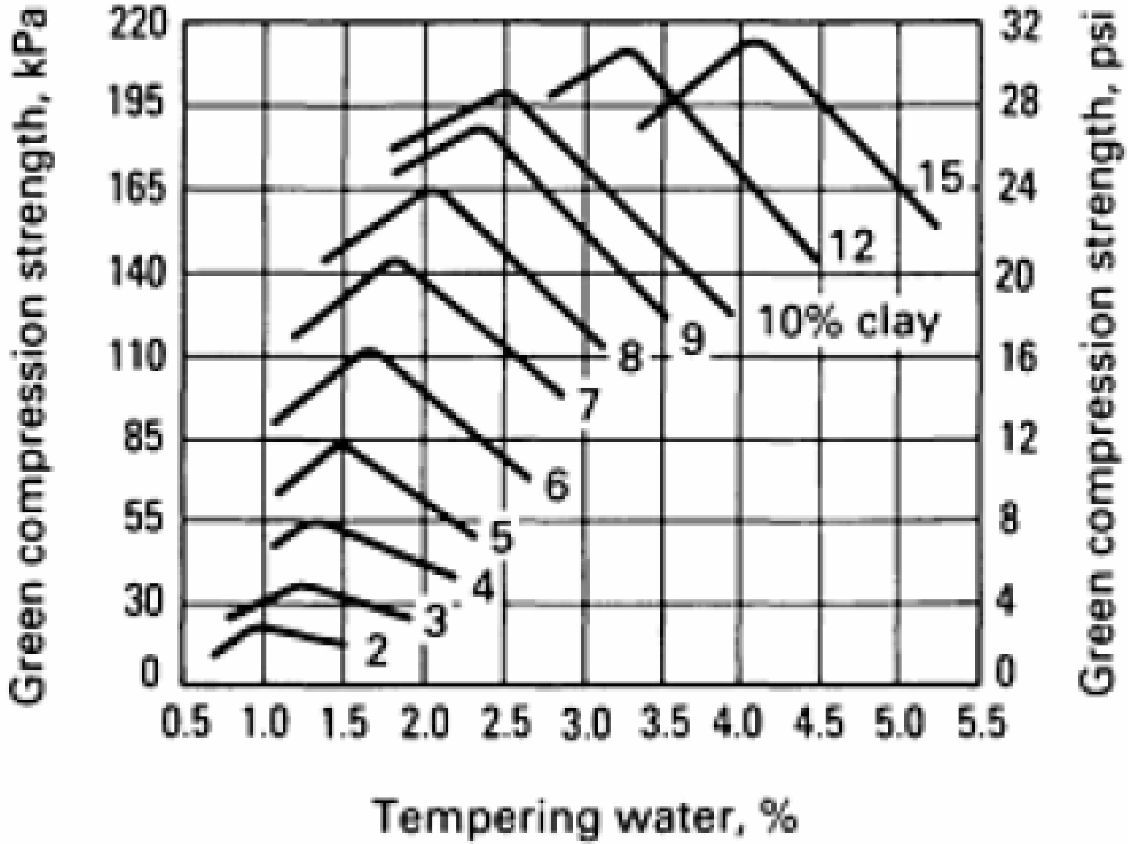
7. Flowability. The sand should respond to molding processes.
8. Produces good casting finish.
9. Collapsibility. Heated sand which becomes hard and rocklike is difficult to remove from the casting and may cause the contracting metal to tear or crack.
10. Is reusable.
11. Offers ease of sand preparation and control.
12. Removes heat from the cooling casting.

This list by no means includes all the properties which might be desirable. Obviously, the most important characteristic of a molding sand is that it facilitate the economic production of good castings.

(a) Southern bentonite.

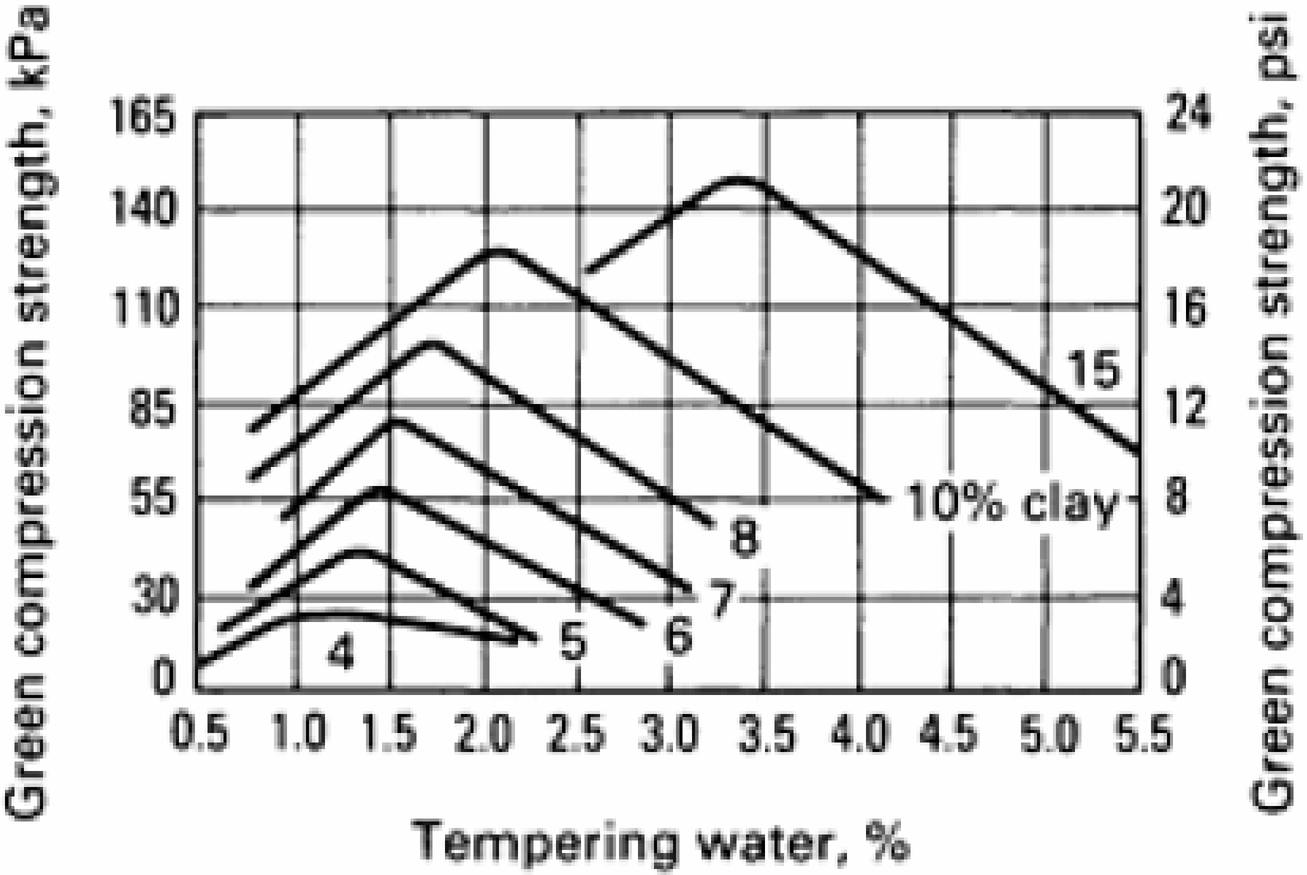


(b) Western bentonite.



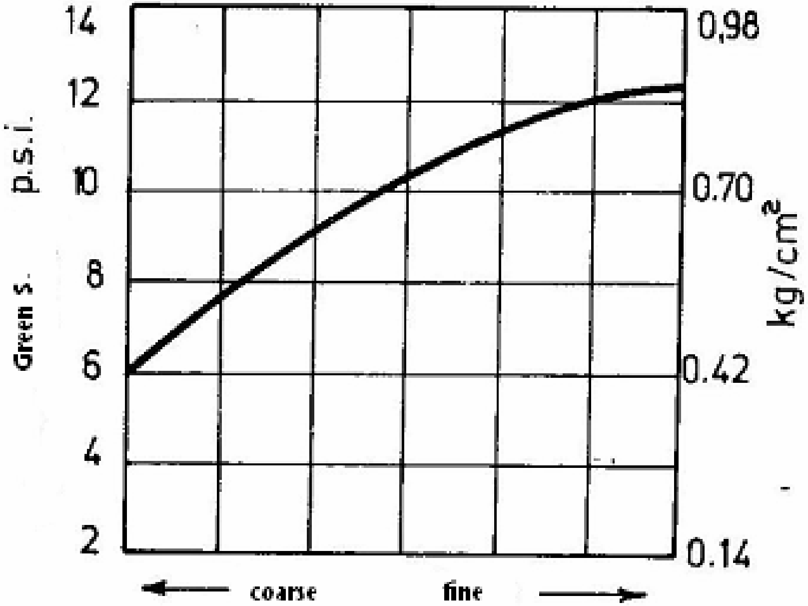
(b)

Kaolinite.

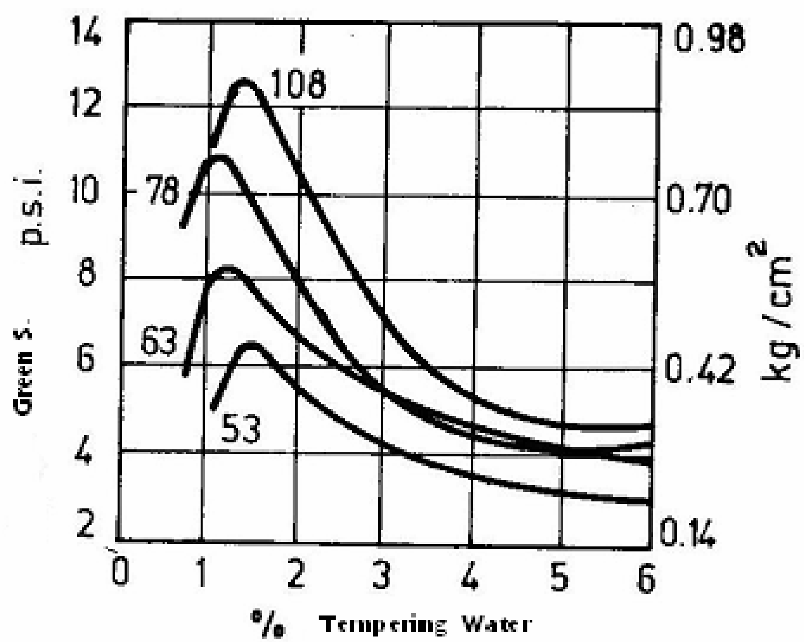


Green compression strength, kPa
165
140
110
85
55
30
0
Green compression strength, psi
24
20
16
12
8
4
0
15
10% clay
8
7
6
5
4
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
Tempering water, %

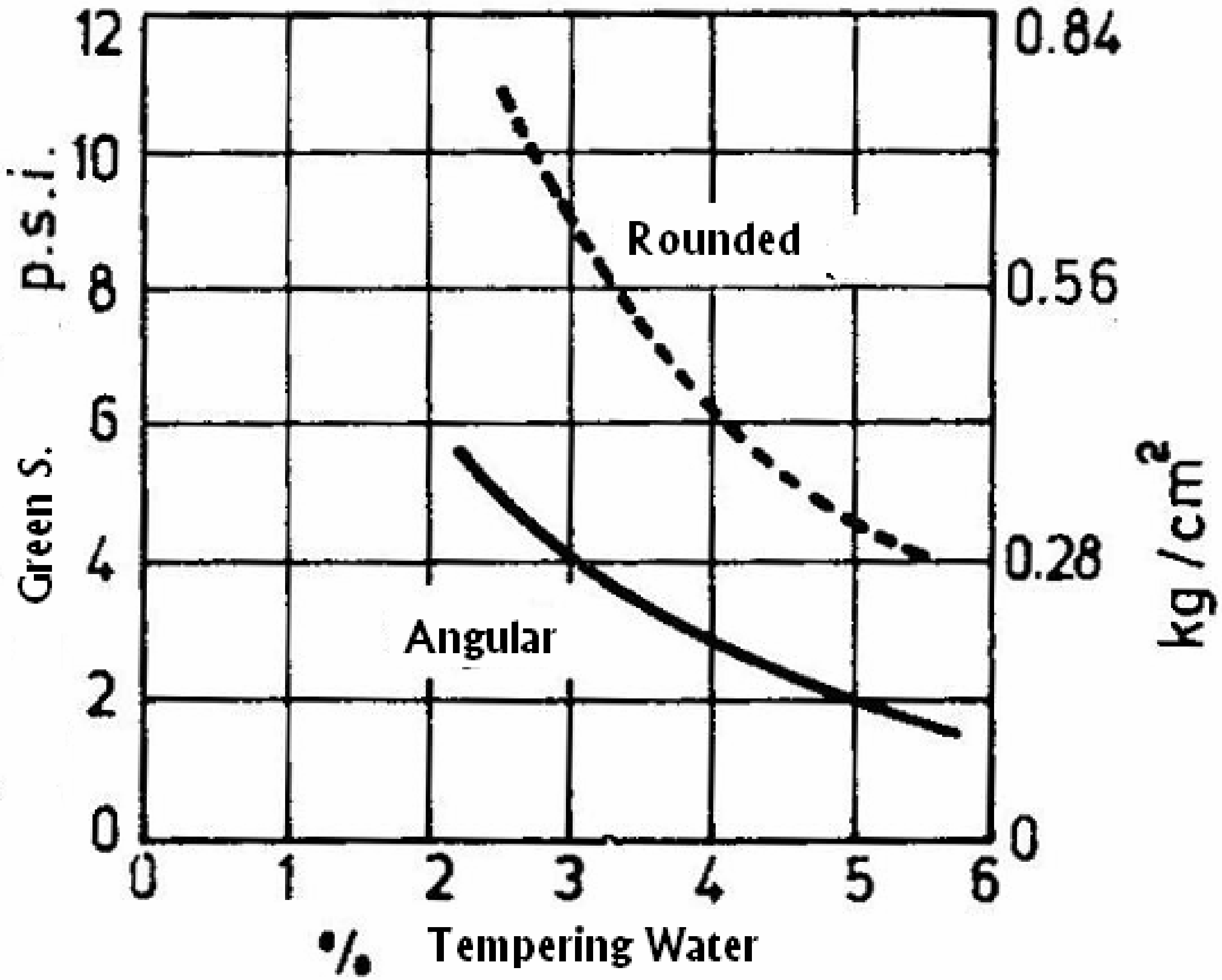
(c)



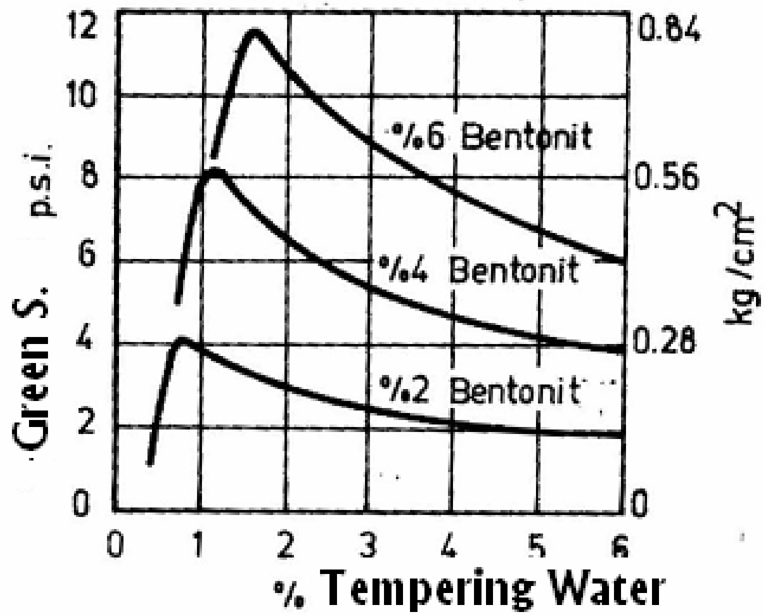
Şekil 3.1 Tane inceliğinin yaş mukavemete etkisi[1].



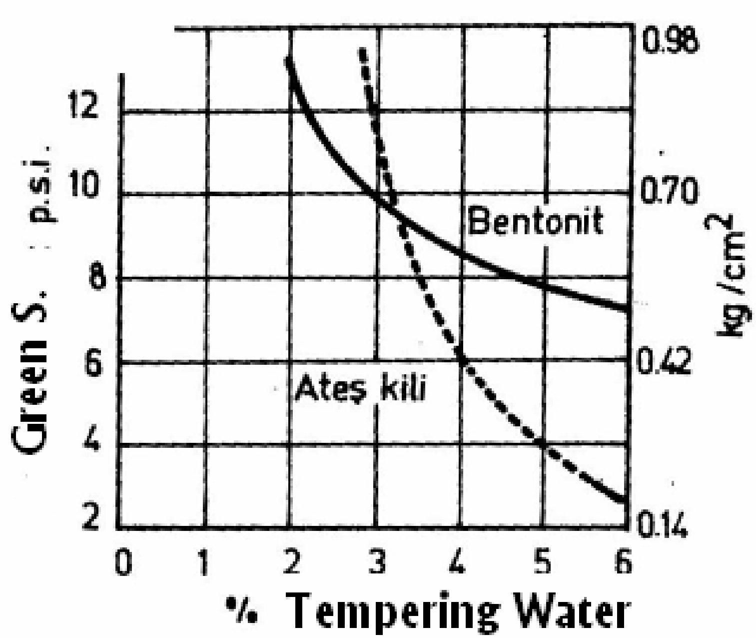
Şekil 3.2 Değişik tane inceliğine göre yaş mukavemetteki değişim[1].



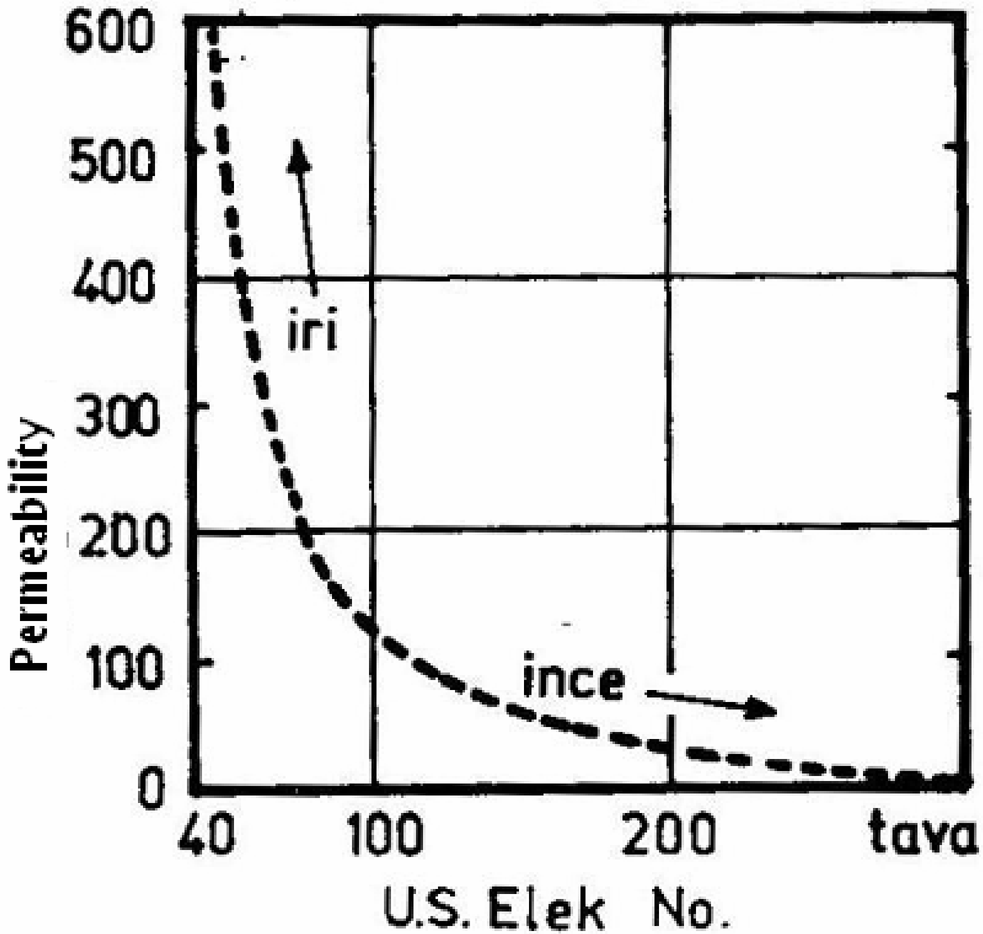
Şekil 3.3 Kum tane şekline göre yaş mukavemetteki değişim[1].



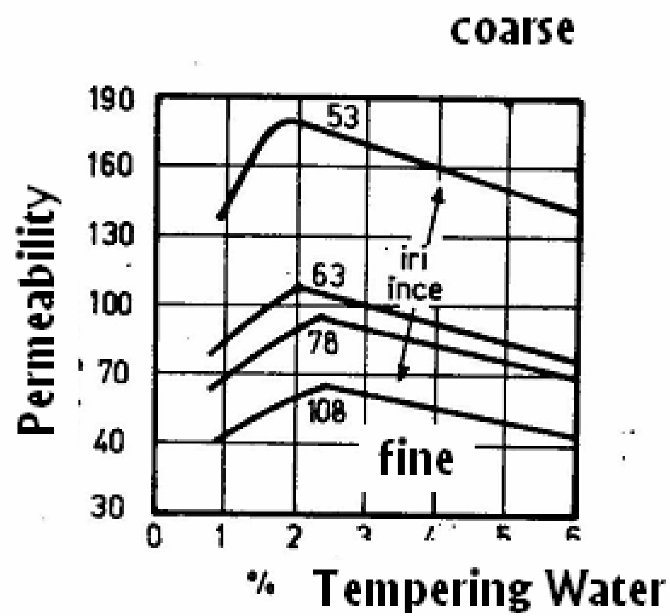
Şekil 3.4 Değişik bentonit yüzdeleri için nem miktarına göre yaş mukavemetteki değişim[1].



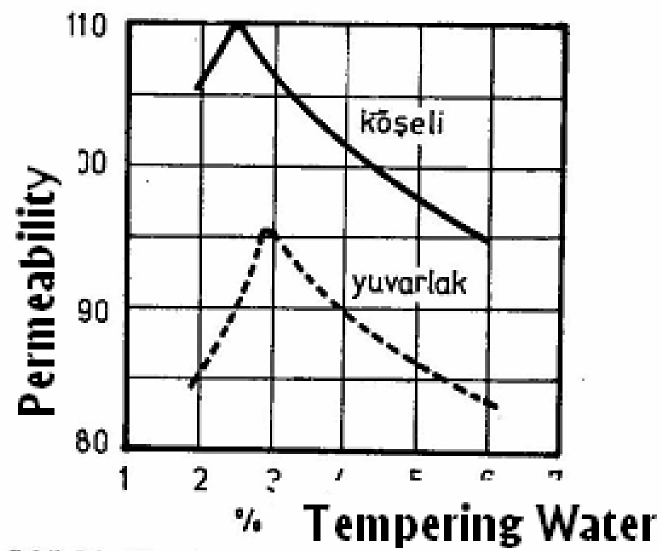
Şekil 3.5 Bentonit ve ateş kilinin yaş mukavemete etkisi[1].



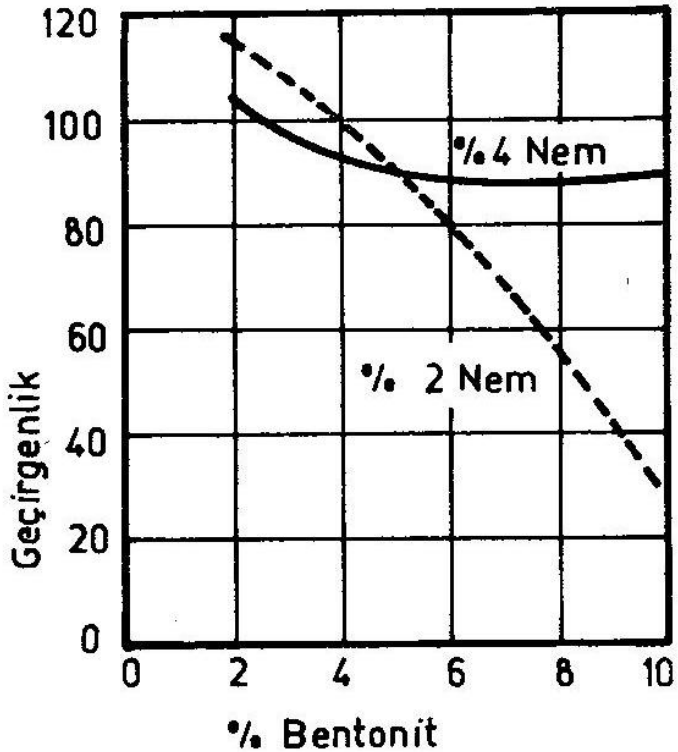
Şekil 3.6 Kum tane boyutuna göre gaz geçirgenliği değişimi[1].



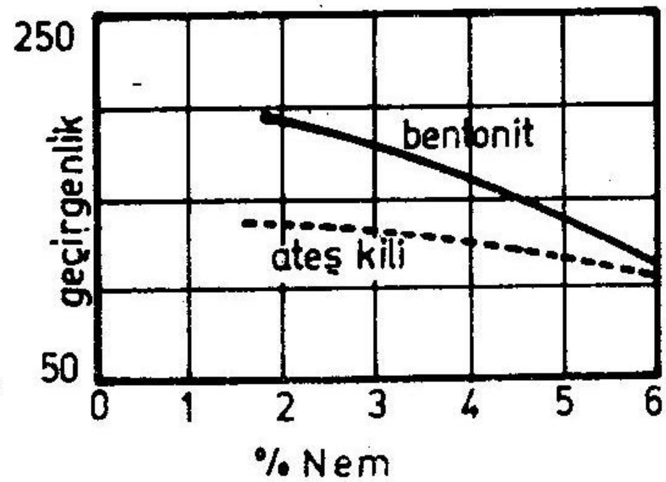
Şekil 3.7 Kum tane inceliği ve nem miktarına göre gaz geçirgenliği değişimi[1].



Şekil 3.8 Kum tane şeklinin gaz geçirgenliğine etkisi.



Şekil 3.9 Bentonitin ve nem oranının gaz geçirgenliği üzerine etkisi.



Şekil 3.10 Bentonit ve ateş kilinin gaz geçirgenliği üzerine etkisi.

Tablo 3.1 — Gri Dökümler için Kum Karışımları[1]

Kum			Malzeme, % Ağırlık				Özellikler			Döküm Ağırlığı kg
Tip	Tane Sınıfı	İncelik No.	Kum	Bentonit	Hububat	Diğer	Su	Yaş Mukavemet kg/cm²	Geçirgenlik	
Yaş	4	70-100	89.4	5.3		5.3 Ateş kili	2.8	0.58	110	1-14
	4	70-100	94.0	4.1	0.2	1.7 Taş kömür tozu	4.4-5.5	0.70	76	68-362
Kurutulmuş kabuk	4 3	70-100 100-140	45.5 45.5	3.9	0.6	4.5	3.5-4.0	0.56	70-80	27 ve üstü

Tablo 3.2 — Çelik Dökümleri İçin Kum Karışımları[1]

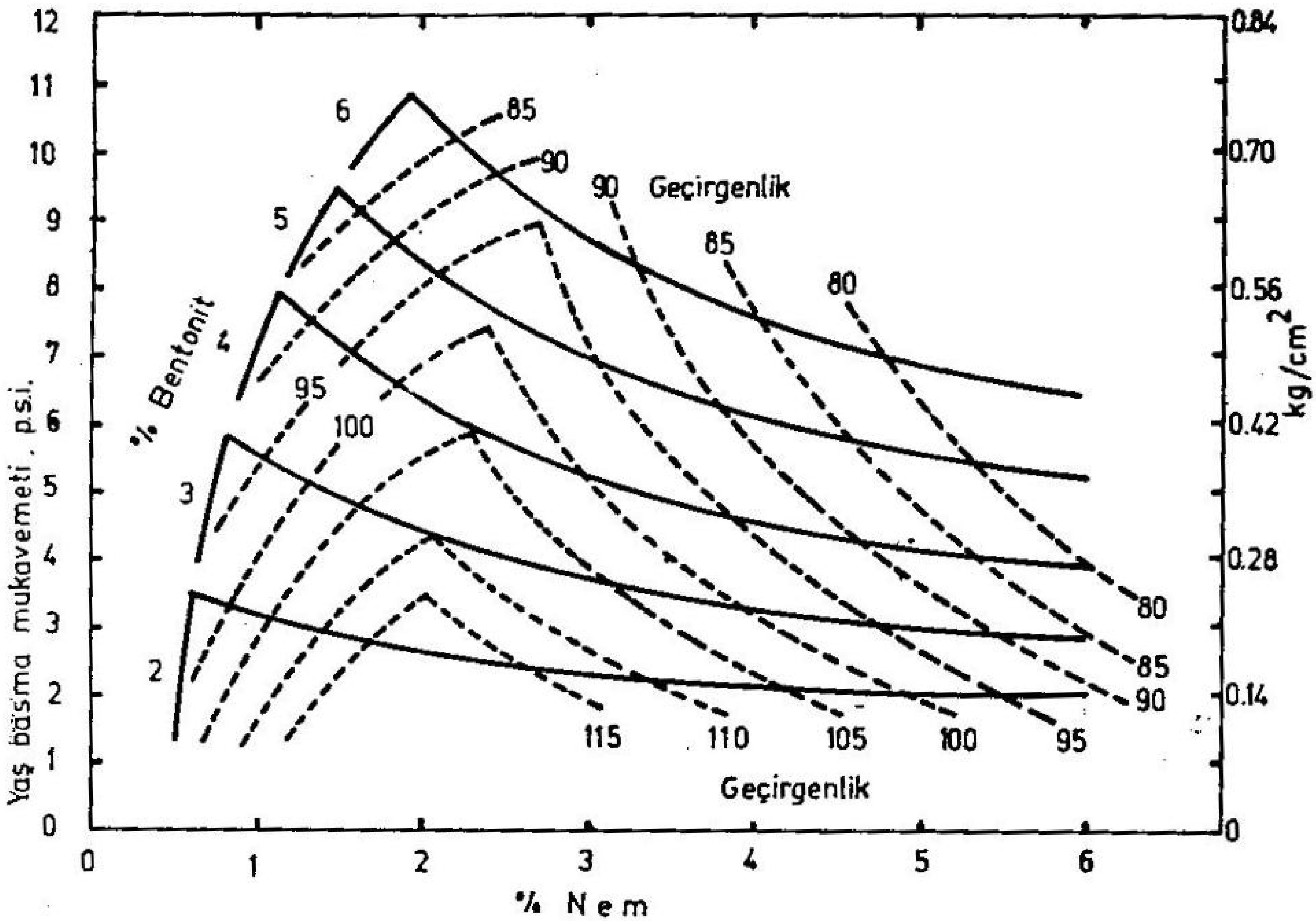
Kum			Malzeme, % Ağırlık				Özellikler			Döküm Ağırlığı kg
Tip	Tane Sınıfı	İncelik No.	Kum	Bentonit	Hububat	Diğer	Su	Yaş Mukavemet kg/cm²	Geçirgenlik	
Yaş yüzey kumu	5	50-70	94.0	5.0	1.0		3.0-4.0	0.53-0.60	120	225
Yaş dolgu kumu		Kullanılmış kum	97.5	1.8	0.7		2.5-3.5	0.35-0.50	120	225
Kurutulmuş kabuk	5	50-70	95.5	3.0	1.5		4.0-4.5	0.39-0.46	90-120	45 ve üstü

Tablo 3.3. — Alüminyum Dökümler İçin Kum Karışımları[1]

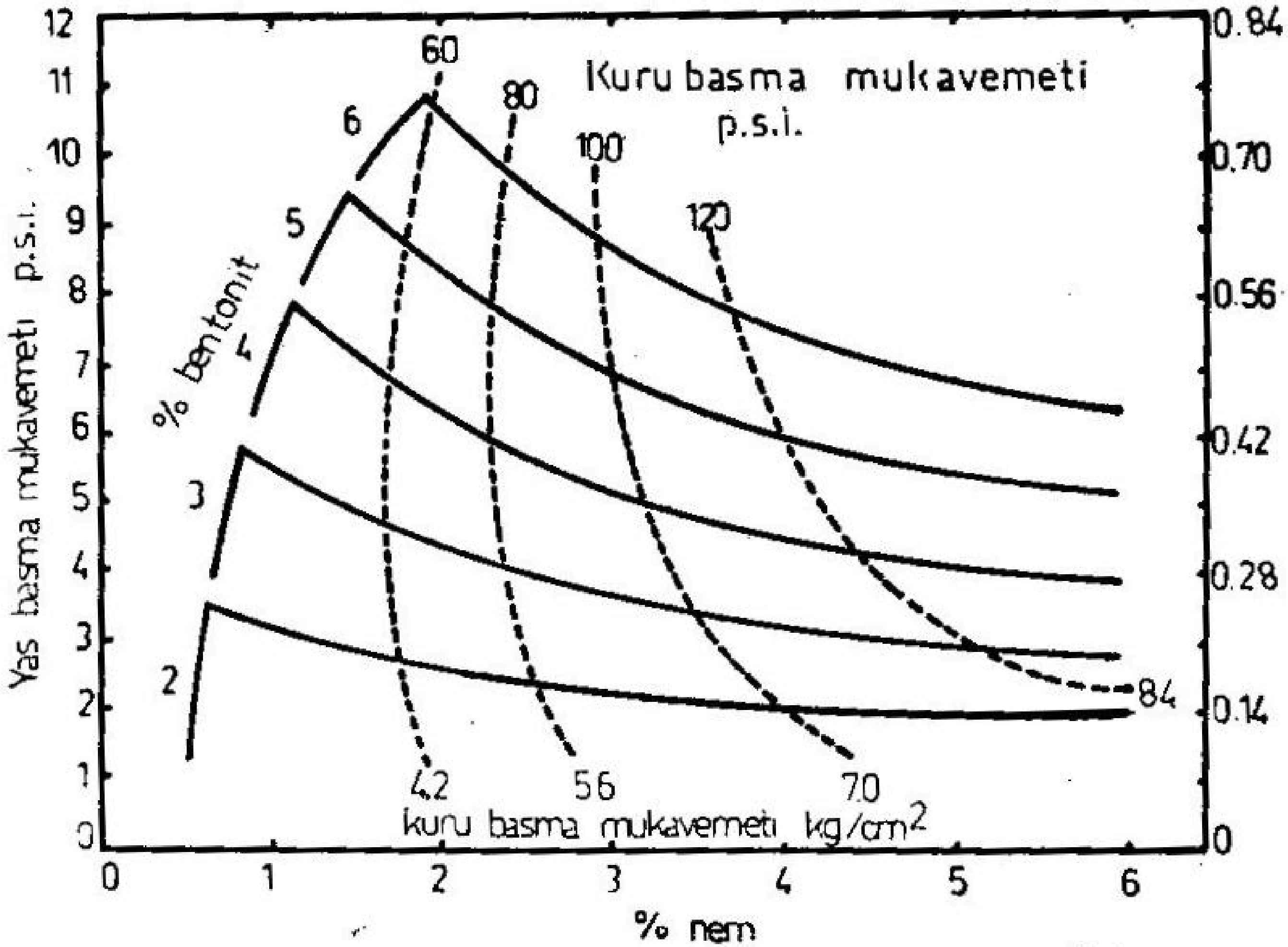
Kum		Malzeme, % Ağırlık					Özellikler			Döküm Ağırlığı kg
Tip	Tane Sınıfı	İncelik	Kum	Bentonit	Hububat	Diğer	Su	Yaş Mukavemet kg/cm^2	Geçirgenlik	
Yaş	4	70-100	95.0 97.0	5.0 3.0			5.0-5.5	0.35-0.70	50-100	90

Tablo 3.4 — Bakır Esaslı Alaşımlar İçin Kum Karışımları[1]

Kum		Malzeme, % Ağırlık					Özellikler			Döküm Ağırlığı kg
Tip	Tane Sınıfı	İncelik	Kum	Bentonit	Hububat	Diğer	Su	Yaş Mukavemet kg/cm^2	Geçirgenlik	
Yaş	4	70-100	95.0	4.0	1.0		4.0	0.42-0.50	60-70	900
	3	100-140 Kullanılmış kum	20.0 75.0	5 0			4.0	0.50-0.84	30-50	900
	4	70-100	80.0	4.0	1.0	15.0 silis tozu	5.5	0.50-0.84	40-80	özel



Şekil 3.18 Nem miktarı, bentonit miktarı, yaş basma mukavemeti ve gaz geçirgenliği arasındaki ilişki.
(63 AFS tane inceliğindeki kum için).



Şekil 3.19 Nem miktarı, bentonit miktarı, yaş basma mukavemeti ve kuru basma mukavemeti arasındaki ilişki[1]. (63 AFS tane inceliğindeki kum için).

SAND ADDITIVES

- Clays
- Water
- Carbons
- Cellulose
- Oil-Chemicals
- Refrakteries
- Starches-Solubles (Nişaşta)

SAND ADDITIVES
Clays

- Clays
- Bentonite, Southern (Ca-Bentonite)
- Bentonite, Western (Na-Bentonite)
- Fireclay
- Kaolin Clay

BENTONITE, SOUTHERN

(INORGANIC)

Description .... (Ca^{++} calcium bentonite) also known as nonswelling bentonite.
Typical Color .... cream, tan, bluish gray
Purpose .... basic bond in green sand system. To promote good green strength, moderate dry and hot compression strengths. Gives higher green, lower dry and hot strengths and promotes better flowability than western bentonite.
Bulk Density .... 52 lb/ft^3
Typical Sizing .... 60-90% thru USA Sieve 200
pH 4.0-8.5
Fusion Point 1900-2440F (1038-1338C)
% Volatile @ 900F (482C) 0*
% Volatile @ 1800F (982C) 0.5
% Total Combustibles 0.5*
Effective Temperature of Destruction 1292F (700C)
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... increases

Miscellaneous Data or Observations

Typical base exchange (in me/100 g) .... Na(<5), K(2.8), Ca(74.7), Mg(1.0)

---

*Does not include chemically or mechanically held water.

Typical Chemical Analysis (Percent)

SiO_2	56-59	CaO	1.2-35
Al_2O_3	18-21	Na_2O	0.34-46
Fe_2O_3	5.4-9.1	H_2O, as shipped	5.0-8.0
MgO	3.0-3.3		

BENTONITE, WESTERN

(INORGANIC)

Description ....powdered (Na^+ sodium bentonite). Also known as Wyoming bentonite, high-swelling bentonite.
Typical Color .... bluish, cream, gray, light yellow
Purpose ...... basic bond in a green sand system. To promote green, dry and hot compression strengths. To prevent erosion, cuts, washes, and allow for silica sand expansion.
Bulk Density .... 54 lb/ft³
Typical Sizing .... 60-92% thru USA Sieve 200
pH 9.0-10.0
Fusion Point 1900-2440F (1038-1338C)
% Volatile @ 900F (842C) 0*
% Volatile @ 1800F (982C) 5
(H_2O of hydration driven off @ 1292F (700C). Lattice destroyed @ 1832F (1000C).
% Total Combustibles 0.5*
Effective Temperature of Destruction 1832F (1000C)
Effect on:
Green Compression Strength ....increases
Dry Compression Strength ....increases
Hot Compression Strength ....increases

Miscellaneous Data or Observations

1) Base exchange (in me/100 g)
   Total Na, K, Ca & Mg 85-100
   Combined Na & K ions .... 60.0% min.
   Combined Ca & Mg ions ....40.0% max.
2) Consists primarily of the mineral montmorillonite.
3) Various other grinds available.

*Does not include chemically or mechanically held water.

Typical Chemical Analysis (Percent)

SiO_2	60-62
Al_2O_3	21-23
Fe_2O_3	3-4
Na_2O	2.5-2.7
MgO	0.2-3
CaO	0.5-1.5
K_2O	0.4-0.45
H_2O, as shipped	5.0-9.0

FIRECLAY

(INORGANIC)

Description .... 50 mesh
Typical Color .... gray
Purpose ...... basic bond in a green sand system. Increases green, dry and hot strengths. Used particularly to increase dry and hot properties.
Bulk Density .... 60 lb/ft³
pH 4-5
Fusion Point 3000F (1649C)
% Volatile @ 900F (482C) .... varies
% Volatile @ 1800F (982C) 9.0
% Total Combustibles 9.39*
Effective Temperature of Destruction 3055F (1679C)
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... increases

Miscellaneous Data or Observations
PCE Cone 31 .... 3055F (1679C)
AFS GFN 180
Finer and coarser grinds also available.

*Includes approximately 4-5% H_2O as shipped.

Typical U.S.A. Sieve Analysis (Percent Retained)

30	0.3	140	11.4
40	1.7	200	11.5
50	5.3	270	12.7
70	9.5	Pan	335
100	13.5		

Typical Chemical Analysis (Percent)

SiO_2	57.32
Al_2O_3	28.50
Fe_2O_3	1.23
TiO_2	1.98
$CaCO_3$	0.08
MgO	0.22

KAOLIN CLAY

(INORGANIC)

Description . . . . also called "China Clay" although China Clay is primarily used in the ceramic industry, and is slightly different.

Typical Color . . . . gray

Purpose . . . . primarily increases dry and hot compression strengths

Bulk Density . . . . 30 lb/ft^3

pH 4.5

Fusion Point 2921F (1605C)

% Volatile @ 1800F (982C) 14.2

% Total Combustibles 14.2

Effective Temperature of Destruction 3000F (1649C)

Effect on:

Green Compression Strength . . . . increases

Dry Compression Strength . . . . increases

Hot Compression Strength . . . . increases

Miscellaneous Data or Observations

Modulus of rupture . . . . 75 psi

H_2O of plasticity 32.7%

*Includes H_2O as shipped.

Typical Chemical Analysis (Percent)

SiO_2	44.90
Al_2O_3	38.90
Fe_2O_3	0.40
TiO_2	0.06
CaO	0.06
MgO	0.10
Na_2O	0.22
K_2O	0.20

Typical Particle Size Analysis

% Finer	Microns
98	26.6
95.7	8.5
90.5	6.9
81.5	3.9
69.7	2.3
55.4	1.8
39.7	0.44
30.3	0.32

Typical Particle Size Analysis

Microns	Percent
Below 10	90
Below 5	80
Below 2	60
Below 1	44
Below0.5	24
Below 0.25	10
Below 0.10	2

SAND ADDITIVES
Water

- Water
- $H_{2}0$

SAND ADDITIVES
Carbons

- Carbons
- Asphalt
- Gilsonite (a kind of asphalt)
- Graphite
- Lamp Black (lamba isi)
- Lignite (brown coal)
- Pitch, Coal Tar (zift, kömür katranı)
- Seacoal (pulverized coal)

- Carbon is added to the mold to provide a reducing atmosphere and a gas film during pouring that protects against oxidation of the metal and reduces burn-in.
- Carbon can be added in the form of seacoal (finely ground bituminous coal), asphalt, gilsonite (a naturally occurring asphaltite), or proprietary petroleum products.
- Seacoal changes to coke at high temperatures expanding three times as it does so; this action fills voids at the mold/metal interface. Too much carbon in the mold gives smoke, fumes, and gas defects, and the use of asphalt products must be controlled closely because their overuse waterproofs the sand.
- The addition of carbonaceous materials will give improved surface finish to castings. Best results are achieved with such materials as seacoal and pitch, which volatilize and deposit a pyrolytic (lustrous) carbon layer on sand at the casting surface.

ASPHALT

(ORGANIC)

Description .... ground*
Typical Color ....brown to black
Purpose ....improves casting finish and controls mold atmosphere. Replacement or supplement ffor seacoal or pitch.
% Volatile @ 900F (482C) 75-80
% Volatile @ 1800F (982C) 83-92
% Total Combustibles ....99+
Effect on:
Green Compression Strength ....little or none
Dry Compression Strength ....increases
Hot Compression Strength .... decreases
Sulphur Range .... trace to 2% max

Miscellaneous Data or Observations

1) Product source is usually from refining process of oil. It is the still residue. Type depends on cracking process.
2) Softening point of solid type can be obtained from 140-380F (60-193C). Softening point of foundry powder types is 300-340F (148-171C).
3) Volatile will vary according to specific cracking process used by the individual refinery in manufacturing asphalt from crude petroleum.

*4) Liquid types are available. See chapter 4 on oils and chemicals — asphaltic oils and asphalt emulsions.

GILSONITE
(ORGANIC)

Description .... naturally occurring hydrocarbon similar to asphalt
Typical Color .... brownish-black
Individual Characteristics .... powder
Purpose .... improves casting finish and controls mold atmosphere. Replacement for pitch in smaller dry sand work.
Bulk Density .... 38.5 lb/ft^3
% Volatile @ 1800F (982C) 75-85
% Total Combustibles 99
Effect on:
Green Compression Strength .... little or none
Dry Compression Strength .... increases
Hot Compression Strength .... decreases

Miscellaneous Data or Observations
Gilsonite is heat softening. Softening point is 300-380F (150-190C) (ball and ring ASTM #28-51T).
Specific gravity .... 1.04 to 1.06

Typical Chemical Analysis (Percent)

C	85.0	S	0.3
H_2	10.5	Si-Ni	0.2
N_2	2.5	Trace elements	balance
O_2	1.5	Ash content	0.2

GRAPHITE

(ORGANIC)

Description .... pure carbon distinguished by its hexagonal crystallinity
Typical Color .... gray to black
Purpose .... improves casting peel and finish
Bulk Density .... 28-50 lb/ft^3
% Total Combustibles 75-80
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... increases

Miscellaneous Data or Observations

Specific gravity .... 2.1 to 2.25
Mohs hardness .... 1/2 to 1-1/2
Sublimation point ..... greater than 6000F (3315C)
Above data and analysis based on Mexican graphite. Many other types from throughout the world are available, all of which have different properties. Mexican graphite is the most widely used in the United States.

Typical Chemical Analysis (Percent)

Moisture	0.75
Volatile	4.00
Carbon	83.25
Ash	12.00

Typical Ash Analysis (Percent)

SiO_2	6.65	SO_2	0.012
Al_2O_3	2.64	SO_3	0.001
FeO_3	1.48	P_2O_5	0.53
CaO	0.04	Na_2O	0.11
MgO	0.20		

LAMP BLACK

(ORGANIC)

Description .... extremely fine, pure carbon
Typical Color .... black
Individual Characteristics .... powder
Purpose .... improves casting peel and finish
% Volatile @ 1800F (982C) 2-15
Effect on:
Green Compression Strength .... decreases
Dry Compression Strength .... decreases
Hot Compression Strength .... decreases

Miscellaneous Data or Observations

Produced by burning gas or oil with a very smoky, reducing flame. Lamp black (soot) collects in special housing and then is packaged for sale.

LIGNITE

(ORGANIC)

Description .... causticized
Typical Color ....brown to black
Purpose .... improves casting peel and finish
pH .... 8.0+
% Volatile @ 900F (482C) 22-25
% Volatile @ 1800F (982C) 40-60
% Total Combustibles 60-85

Effect on:

Green Compression Strength .... increases
Dry Compression Strength .... decreases
Hot Compression Strength .... decreases

Miscellaneous Data or Observations

Varies widely according to mining source. Can be used to reduce the viscosity of a slurry system. Will increase temper water requirements.

PITCH, COAL TAR

(ORGANIC)

Description .... byproduct of coke manufacturing

Color .... black

Purpose .... primary use is as a binder for dry sand work. Heat hardening forms a coke bond between sand grains which also provides peel.

Bulk Density .... 37-42 lb/ft^3

% Volatile @ 1800F (982C) 48

% Total Combustibles 98-99

Effect on:

Green Compression Strength .... little or none

Dry Compression Strength .... increases

Hot Compression Strength .... decreases

Miscellaneous Data or Observations

A petroleum derived pitch. Used for the same purpose, having similar characteristics.

Typical Screen Analysis

MESH	%	MESH	%
6	0.0	70	0.28
12	0.0	100	1.60
20	0.02	140	5.18
30	0.02	200	9.80
40	0.04	270	7.72
50	0.06	Pan	75.36

Typical Chemical Analysis (Percent)

C	92.0
H_2	4.8
N_2	1.4
O_2	1.0
S	0.6 max.
Ash	0.2 max.

SEACOAL

(ORGANIC)

Description .... ground, bituminous coal
Typical Color ....brown to black
Purpose .... improves casting peel or finish
Bulk Density .... 44-53 lb/ft³
pH 7.0
% Volatile @ 900F (482C) 20.00
% Volatile @ 1800F (982C) 38.00
% Total Combustibles .... 93 min

Effect on:

Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... decreases

Miscellaneous Data or Observations

Properties and analysis will vary according to mining source. Different grinds are available. Treated coals are also available. Treatments can be simple oils, oleic acid or paraffin to make coals dustless.

Typical Gas Analysis (Percent)

Volatile Portion	
tar fraction	58
bed water	17
light oils	4.5
uncondensable gases	20.5

Typical Chemical Analysis (Percent)

C	82
H_2	5.4
N_2	1.6
O_2	6.6
S	0.7
Ash	3.7

Analysis of Ash (Percent)

SiO_2	49.22
Al_2O_3	25.32
Fe_2O_3	17.64
CaO	2.96
MgO	1.28
Misc.	3.58

SAND ADDITIVES
Cellulose

- Cellulose
- Cob Flour (mısır unu)
- Furfural Residue (liquid aldehyde)
- Oat Hulls (yulaf kabuğu)
- Walnut Shell Flour (çeviz kabuğu unu)
- Wood Flour

- **Cellulose** is added to control sand expansion and to broaden the allowable water content range. It is usually added in the form of wood flour, or nut shells.
- Cellulose reduces hot compressive strength and provides good collapsibility, thus improving shakeout.
- At high temperatures, it forms soot (an amorphous form of carbon), which deposits at the mold/metal interface and resists wetting by metal or slags.

- It also improves the flowability of the sand during molding. Excessive amounts generate smoke and fumes and can cause gas defects. In addition, if present when the clay content drops too low, defects such as cuts, washes, and mold inclusions will occur in the castings.

COB FLOUR

(ORGANIC)

Description . . . . ground corn cobs
Typical Color . . . . yellow to reddish brown
Purpose . . . . . reduces sand expansion defects and improves shakeout. Acts as a cushioning material and improves sand flowability.
Bulk Density . . . . 16-21 lb/ft^3
pH 6.0-7.5
% Volatile @ 900F (482C) 96*
% Volatile @ 1800F (982C) 98-99*
% Total Combustibles 98-99
Approximate Temperature of Destruction 700F (371C)

Effect on:
Green Compression Strength . . . . . . .little or none
Dry Compression Strength . . . . decreases
Hot Compression Strength . . . . decreases
Typical Chemical Analysis . . . . a complete hydrocarbon

Miscellaneous Data or Observations

Increases temper water requirements.

---

*Volatiles are of an oxidizing nature.

FURFURAL RESIDUE

(ORGANIC)

Typical Color . . . . dark brown
Purpose . . . . reduces sand expansion defects and improves shakeout. Acts as a cushioning material.
pH 4-5
% Volatile @ 900F (482C) 90
% Volatile @ 1800F (982C) 90
% Total Combustibles 95

Effect on:

Green Compression Strength . . . . decreases
Dry Compression Strength . . . . decreases
Hot Compression Strength . . . . decreases

Miscellaneous Data or Observations

Material partially charred.

OAT HULLS

(ORGANIC)

Description . . . . ground
Typical Color . . . . yellow-brown
Purpose . . . . . reduces sand expansion defects and improves shakeout. Acts as a cushioning material and improves sand flowability.
Bulk Density . . . . 18-22 lb/ft^3
pH 6.0-8.0
% Volatile @ 900F (482C) 96*
% Volatile @ 1800F (982C) 98-99*
% Total Combustibles 98-99
Approximate Temperature of Destruction 700F (370C)

Effect on:
Green Compression Strength . . . . increases
Dry Compression Strength . . . . decreases
Hot Compression Strength . . . . decreases
Typical Chemical Analysis . . . . a complete hydrocarbon

Miscellaneous Data or Observations

Increases temper water requirements.

---

*Volatiles are of an oxidizing nature.

WALNUT SHELL FLOUR

(ORGANIC)

Typical Color .... tan
Purpose .... reduces sand expansion defects and improves shakeout. Acts as a cushioning material.
Bulk Density .... 33 lb/ft³
pH 4-6
% Volatile @ 900F (482C) 21.7*
% Volatile @ 1800F (982C) 25
% Total Combustibles 99

Effect on:
Green Compression Strength .... little or none
Dry Compression Strength .... decreases
Hot Compression Strength .... decreases

Miscellaneous Data or Observations

Increases temper water requirements.

*Volatiles are of an oxidizing nature.

Typical Chemical Analysis (Percent)

Nitrogen (N)	0.10
Furfural (Calculated as Pentosan)	10.00
Sugar (Calculated as Glucose)	0.30
Cellulose	60.00
Lignin	24.00
Cutin	5.00
Methoxyl	6.50
Chlorine (Cl)	0.10
Ash	0.50

Typical Particle Size

Sieve	%
12	0
20	0.2
30	0.3
40	1.1
50	2.4
70	7.9
100	17.9
140	28.5
200	19.6
270	5.9
Pan	16.2

WOOD FLOUR

(ORGANIC)

Purpose ..... reduces sand expansion defects and improves shakeout. Acts as a cushioning material and improves sand flowability.

Bulk Density .... soft wood, 17-20 lb/ft³
hard wood, 25-30 lb/ft³

pH 4.0-7.0*

% Volatile @ 900F (482C) 96**

% Volatile @ 1800F (982C) 98-99**

% Total Combustibles 99

Approximate Temperature of Destruction 700F (371C)

Effect on:

Green Compression Strength .... little or none

Dry Compression Strength .... decreases

Hot Compression Strength .... decreases

Typical Chemical Analysis .... a complete hydrocarbon

Miscellaneous Data or Observations

Increases temper water requirements.

---

*Varies with source.

**Volatiles are of an oxidizing nature.

SAND ADDITIVES
Oils-Chemicals

- Oils-Chemicals
- Asphalt Emulsion
- Asphaltic Oils
- Kerosene (gaz yağı)
- Soda Ash
- Wetting Agent

ASPHALT EMULSION

(INORGANIC)

Description .... asphalt bitumen, water and a suitable emulsifying agent

Purpose .... improves casting peel and finish. A replacement or supplement for seacoal.

Bulk Density .... 8.4 lb/gal

pH 9.0

% Volatile @ 900F (482C) 92.0

% Volatile @ 1800F (982C) 99.3

Other 0.7

% Total Combustibles 99.8

Effect on:

Green Compression Strength .... increases

Dry Compression Strength .... increases

Hot Compression Strength .... decreases

Miscellaneous Data or Observations

Asphalt emulsions are sometimes preferred due to ease of application and reduced fire hazard.

Typical Cationic Emulsion (parts)

Asphalt	65
Water	35
Tallow diamine	0.30
Calcium chloride	0.10
Glacial acetic acid	0.12

Typical Anionic Emulsion (parts)

Asphalt bitumen	55
Water	44
Sodium linoleate alkali	0.01

ASPHALTIC OILS

(ORGANIC)

Description .... composed principally of hydrocarbons

Purpose ....improves casting peel and finish

% Volatile @ 900F (482C) 95

% Volatile @ 1800F (982C) 98

% Total Combustibles 99

Effect on:

Green Compression Strength ....increases

Dry Compression Strength ....little or none

Hot Compression Strength .... decreases

Miscellaneous Data or Observations

Liquid polymers of natural origin, thermoplastic.

Typical Chemical Analysis (Percent)

C	84.42
H_2	8.53
O_2	1.86
N_2	1.12
S	2.0

KEROSENE

(ORGANIC)

Description ....hydrocarbon oil byproduct of petroleum distillation
Purpose ...... increases amount of volatiles, adds lubricity, keeps sand moist longer
% Volatile @ 900F (482C) 99.95
Distillation End Point 550F (288C)
% Total Combustibles......................99.95
Effective Temperature of Destruction 500F (260C)
Effect on:
Green Compression Strength .... decreases
Dry Compression Strength .... decreases
Hot Compression Strength .... decreases
Typical Chemical Analysis............... a complex hydrocarbon

Miscellaneous Data or Observations

Specific gravity @ 68F (20C) 0.785
Flammable boiling point between 302-572F (150-300C).

POLYMERS

(ORGANIC)

Description .... giant molecule formed when thousands of the original molecules have been linked together end-to-end

Typical Color .... various

Purpose .... supplement for cereal and to prevent expansion defects

Effect on:

Green Compression Strength .... increases

Dry Compression Strength .... increases

Hot Compression Strength .... increases

Miscellaneous Data or Observations

These are generally organic. Used in conjunction with soda ash or tetrasodium pyrophosphate.

SODA ASH

(INORGANIC)

Description . . . . sodium carbonate
Typical Color . . . . white
Individual Characteristics . . . powder, hygroscopic
Purpose . . . . pH control
pH (in aqueous solution) 11.6
Melting point 1563F (851C)
Begins to lose CO_2 @ 752F (400C)

Effect on:
Green Compression Strength . . . . increases
Dry Compression Strength . . . . increases
Hot Compression Strength . . . . increases
Typical Chemical Analysis . . . . Na_2CO_3

Miscellaneous Data or Observations

Specific gravity 2.533
Molecular weight 106
Soluble in water. Slightly soluble in absolute alcohol.

WETTING AGENT

(INORGANIC)

Description .... promotes spreading of a liquid over a solid. It must therefore have the property of reducing the contact angle to a value of zero.

Typical Color or Characteristics .... may vary depending on type and source of supply

Purpose .... reduces the surface tension of water to such a point that temper water will spread and penetrate the material to be wetted to a far greater extent and in a faster time than is possible with regular water.

Effect on:

Green Compression Strength .... increases

Dry Compression Strength .... increases

Hot Compression Strength . no significant change

Miscellaneous Data or Observations

Wetting agents and emulsifiers are much the same kind of materials but seen from rather different viewpoints. Material may be organic or inorganic.

Typical Chemical Analysis (Percent)

Moisture	7.9
Polyoxyethylene Alkphenol surfactant	92.1

SAND ADDITIVES
Refractories (other than clays)

- **Refractories (other than clays)**
- Alumina
- Chromite Flour
- Fly Ash
- Iron Oxide
- Olivine Flour
- Silica Flour
- Staurolite Flour
- Zircon Flour

ALUMINA

(INORGANIC)

Description . . . . Al_2O_3
Typical Color . . . . white
Individual Characteristics . . . . calcined alumina
Purpose . . . . increases sand mixture refractoriness
Bulk Density . . . . $47\ lb/ft^3$, loose
$60\ lb/ft^3$, packed
pH 9.0-10.50
Fusion Point 3670F (2021C)
% Volatile @ 900F (482C) .10
% Volatile @ 1800F (982C) .10
% Total Combustibles 20
Effect on:
Green Compression Strength . . . . increases
Dry Compression Strength . . . . increases
Hot Compression Strength . . . . increases

Miscellaneous Data or Observations

Produced by fusing bauxite in a special controlled atmosphere electric furnace.

Typical Chemical Analysis (Percent)

Sp. Gr.	3.75	Fe_2O_3	0.020
Al_2O_3	99.100	TiO_2	0.002
Na_2O	0.400	H_2O (combined)	0.100
SiO_2	0.024	H_2O (absorbed)	0.100

CHROMITE FLOUR

(INORGANIC)

Typical Color ....dark brown to black
Purpose ....reduces metal penetration and improves surface finish
Bulk Density .... 105 lb/ft³
Typical Sizing ....300 mesh
pH .... 7.0-9.5 (20% in H_2O)
Fusion Point 3800F (2090C)
% Volatile @ 1800F (982C) 0.12
Loss on Ignition 0.02%
% Total Combustibles .... .14
Effective Temperature of Destruction 4500F (2482C)
Effect on:
Green Compression Strength ....increases
Dry Compression Strength ....increases
Hot Compression Strength ....increases

Miscellaneous Data or Observations

Specific gravity 4.45
Thermal exp (in./in.) 0.005
Hardness (Moh scale) 5.5
Classification — acid-base .... basic
Percent lineal change after 2730F (1500C) firing ....0 to -3
Sintering point (Dietert) 2552F (1400C)
Wettability to molten metal ....resistant
Apparent heat transfer compared to silica ....very high

Typical Chemical Analysis (Percent)

SiO_2	1.34	Al_2O_3	21.34	CaO	0.94
MgO	8.75	Fe_2O_3	19.50	TiO_2	0.03
Cr_2O_3	45.80				

FLY ASH

(INORGANIC)

Typical Color . . . . gray
Purpose . . . . increases flowability
Typical Sizing . . . . Fineness: mean particle diameter, 6.3 microns
pH 9.0
% Volatile @ 1800F (982C) 2.73
Carbon 1.83
% Total Combustibles 4.56
Effect on:
Green Compression Strength . . . . increases
Dry Compression Strength . . . . increases
Hot Compression Strength . . . . increases

Miscellaneous Data or Observations

Permits castings to peel easier from sand cores. Fly ash is used more widely in aluminum core sand mixtures than for casting ferrous alloys.

Typical Chemical Analysis (Percent)

SiO_2	43.9
R_2O	34.8
MgO	2.3
SO_3	1.6

IRON OXIDE
(INORGANIC)

Description .... hematite ore
Color .... red brown
Purpose .... increases hot plasticity and reduces or eliminates veining, metal penetration, burn on, or pinhole porosity. Also used as a coloring agent.
Bulk Density .... flour, 73.6 lb/ft^3
granular, 90.0 lb/ft^3
Typical Sizing .... 200 mesh
pH .... 8.2 (20% H_2O solution)
Fusion Point 2850F (1565C)
% Volatile @ 1800F (982C) 2.25 as loss on ignition
% Total Combustibles 2.25
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... increases

Miscellaneous Data or Observations
Specific gravity 5.24
Bulk density ...... 73.6 lb/ft^3 2.4 lb/qt; 37 lb/solid gal
Hardness (Moh scale 6
Classification — acid-base .... acid or basic
Wettability to metal .... not easily
Apparent heat transfer
compared to silica .... average

Typical Chemical Analysis (Percent)

Fe_2O_3	60.0-86.6	CaO	0.10-11.0	Mn	0.24-0.41
SiO_2	7.4-8.4	MgO	0.18-2.56	S	0.006-0.01
Al_2O_3	2.1-9.5	P	0.09-0.3	H_2O	nil

OLIVINE FLOUR

(INORGANIC)

Typical Color .... green
Purpose .... reduces or eliminates metal penetration and improves casting finish
Bulk Density .... 91 lb/ft³
Typical Sizing .... 200 mesh
pH .... 9.2-9.5 (20% in H_2O)
Fusion Point 3400F (1870C)
% Volatile @ 900F (482C) 1
% Volatile @ 1800F (982C) 1.35 as loss on ignition
% Total Combustibles 1.35
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... increases

Miscellaneous Data or Observations

Specific gravity 3.3
Hardness (Moh scale) 6.5-7.0
Thermal exp (in./in.) 0.0083
Classification — acid-base .... basic
Sintering point 2507F (1375C)
% Lineal change after 2732F (1500C) firing .... -2.0
Wettability to molten metal .... not easily
Apparent heat transfer compared to silica .... low

Typical Chemical Analysis (Percent)

MgO	49.4	Al_2O_3 + MnO + CaO	1.8
SiO_2	41.2	CaO	0.2
Fe_2O_3	7.1	H_2O	0.5

SILICA FLOUR

(INORGANIC)

Typical Color .... white to light yellow
Purpose .... increases hot and dry strengths and reduces or eliminates metal penetration
Bulk Density .... 63.2 lb/ft^3
Typical Sizing .... 200* mesh
pH .... 6.8-7.8 (10% in H_2O)
Fusion Point 3110F (1710C)
% Volatile @ 1800F (982C) 0.070 as loss on ignition
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... increases

Miscellaneous Data or Observations

Specific gravity 1.59-2.66
Hardness (Moh scale) 6.00-6.50
Thermal exp (in./in.) 0.018
Classification — acid-base .... acid
Sintering point 2510F (1375C)
% Lineal change after 2732F (1500C) firing .... +0.5
Wettability to molten metal .... easily
Apparent heat transfer compared to silica .... average

*140 mesh to 400 mesh available.

Typical Chemical Analysis (Percent)

SiO_2	99.820	Fe_2O_3	0.019
MgO	0.031	CaO	0.006
Al_2O_3	0.049	TiO_2	0.012

STAUROLITE FLOUR

(INORGANIC)

Typical Color .... reddish brown
Purpose .... increases hot plasticity and reduces or eliminates veining
Bulk Density .... 100 lb/ft^3
Typical Sizing .... 95% through USA Sieve 200
Fusion Point 2800F (1538C)
% Total Combustibles 0
Effective Temperature of Destruction 2800F (1538C)
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... increases

Miscellaneous Data or Observations

Specific 3.6
Hardness (Moh scale) 7
Different grinds available

Typical Mineral Composition (Percent)	
Staurolite	77
Tourmaline	10
Titanium minerals	4
Kyanite	2
Zircon	3
Quartz	4

Typical Chemical Analysis (Percent)	
Al_2O_3	45 (min.)
Fe_2O_3	18 (max.)
ZrO_2	3 (max.)
TiO_2	5 (max.)
Free silica	5 (max.)
Combined silicates	balance

ZIRCON FLOUR

(INORGANIC)

Typical Color .... white, tan
Individual Characteristics .... calcined
Purpose .... increases sand mix refractoriness, reduces or eliminates metal penetration and improves casting surface finish
Bulk Density .... 114 lb/ft^3
Typical Sizing .... 200-325 mesh
pH .... 5.7-6.4 (10% in H_2O)
Fusion Point 3800F (2100C)
% Volatile @ 900F (482C) 0.10
% Volatile @ 1800F (982C) 0.10 as loss on ignition
% Total Combustibles .... .10
Effective Temperature of Destruction 4100F (2260C)
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... increases

Miscellaneous Data or Observations

Specific gravity 4.4-4.7
Hardness (Moh scale) 7.0-7.5
Thermal exp (in./in.) 0.003
Classification — acid-base .... acid
Sintering point 2552F (1400C)
% Lineal change after 2732F (1500C) firing .... -2.0
Wettability to molten metal .... resistant
Apparent heat transfer compared to silica .... high

Typical Chemical Analysis (Percent)

SiO_2	33.50	Fe_2O_3	0.02
ZrO_2	66.50	TiO_2	0.14

SAND ADDITIVES
Starches-Solubles (Cereals)

- **Solubles**
- Bran Flour (kepek unu)
- British Gum
- Corn Flour
- Dextrin
- Lignin Sulfate
- Molasses (pekmez – melas)
- Sodium Silicate
- Wheat Flour

- They include corn flour, dextrine, and other starches, are adhesive when wetted and therefore act as a binder.

- They stiffen the sand and improve its ability to draw deep pockets. However, use of cereals makes shakeout more difficult, and excessive quantities make the sand tough and can cause the sand to form balls in the muller. Because cereals are volatile, they can cause gas defects in castings if used improperly.

BRAN FLOUR

(ORGANIC)

Description .... cereal binder
Purpose .... green strength additive
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... decreases
Hot Compression Strength .... decreases

Miscellaneous Data or Observations

Similar to corn, wheat and rye flours.

BRITISH GUM

(ORGANIC)

Description . . . . form of dextrin that has high tack characteristics

Typical Color . . . . .light to dark brown

Purpose . . . . bonding agent in green sand molding with a wide range of properties

Effect on:

Green Compression Strength . . . . . slight increase

Dry Compression Strength . . . . .increases

Hot Compression Strength . . . . .increases

Chemical Formula . . . . $C_6H_{10}O_5$

Miscellaneous Data or Observations

Little or no acid is used in preparation. Longer baking time used in preparation; otherwise similar to dextrin. Highly soluble. Very gummy when mixed with water. British gum solutions are quite stable and have good film-forming properties.

CORN FLOUR

(ORGANIC)

Description .... highly gelatinized cereal binder produced from a corn dry milling process
Typical Color .... light to dark yellow
Purpose .... additive for green sand mold facing mixes, decreases buckles, rat tails, scabs, erosion; increases green deformation
Bulk Density ... heavy weight 37 lb/ft^3, 5.00 lb/gal
light weight 19 lb/ft^3, 2.6 lb/gal
pH 4.4-6.5
% Volatile @ 1800F (982C) 99
% Total Combustibles 99.5
Effective Temperature of Destruction 600-700F (316-371C)
Effect on:
Green Compression Strength .... increases
Dry Compression Strength .... increases
Hot Compression Strength .... increases up to 500F (260C
decreases 2000-2500F (1093-1371C)

Miscellaneous Data or Observations

Increases green deformation 0-2% with or without change in green strength. Decreases spalling, scabbing. Increases gas. Decreases permeability. Used 0.4-1.3% by weight in facing sands. Increases toughness and plasticity. Quick drying in oven. High moisture absorption. Increases sag and overhead properties in core mixes. Increases collapsibility. Reduces rate of drying out of fireclay and bentonite bonded sands.

Typical Analysis (Percent)

Moisture	4-9	Water Soluble	10-27.5
Ash	0.3-0.5	Dextrin	18-24

DEXTRIN

(ORGANIC)

Description .... a soluble gummy carbohydrate formed by the decomposition of starch by heat, acid or enzymes

Typical Color or Characteristics .... from white to canary, dependent on amount of acid and degree of heat used in its preparation

Purpose ....dry binder in foundry binder compounds and foundry core washes. Reduces brittleness and friability in molding sand mixes. Increases dry compression strength. Improves surface hardness.

Bulk Density ....31.5-41.5 lb/ft³ dependent on degree of packing

pH 3.5-5.0

% Total Combustibles......................99.2

Effective Temperature of Destruction

starts decomposing at 350-430F (176-221C)

completely decomposed at 650-750F (343-399C)

Effect on:

Dry Compression Strength ....increases

Dry Shear Strength ....increases

Hot Compression Strength ....no change or increased slightly

Green Strength ....no change

Miscellaneous Data or Observations

Decreases flowability if used in excess. Decreases scabbing. Increases smoothness. Causes sand to be more tacky. Used 1/8 to 1-1/2% by weight. Reduces drying out in the mold. Tends to soften in damp atmosphere. Variable amount of gas produced. Soluble dextrin material migrates toward outer edges producing a high dry sand hardness on the surfaces. Hardens in bag in humid storage.

Typical Analysis (Percent)

Moisture	3-6
Water soluble.....	98
Reducing sugar as dextrose ..... (of soluble)	4

LIGNIN SULFATE

(ORGANIC)

Description . . . . a sulfite pulp byproduct binder (sulfite lye) (lignin liquor)
Typical Color . . . . . . if dried — light brown powder
Individual Characteristics . . . . .dark liquid 60-70% solids.
Purpose . . . . binder for clay materials. Surface hardener for oil sand cores.
Bulk Density . . . . 54 lb/ft³ dry.
Fusion Point 1900-2700F (1037-1482C)
Melting Point 482-527F (250-275C)
% Volatile @ 275F (135C) 50
Effective Temperature of Destruction 212-400F (100-205C)
Effect on Dry Compression Strength . . . . increases
Typical Chemical Analysis . . . . a form of $C_{41}H_{32}O_6$

Miscellaneous Data or Observations

Binding power for open sands is poor. The higher the moisture, the harder the core. High moisture promotes concentration at the surface and gives a slight shell structure to the core. Avidity for moisture makes dry storage advisable. Causes sand to fuse. Forms hard mold edges or forms a surface shell. Usually contains lime; fairly collapsible. Bad odor, low in gas. Used in the range of 0.2-1.0% by weight. Grade is partly dependent on the process procedure used to manufacture. Completely soluble in water. Non-fermentable (stable in storage). As a mold spray dilute 1:1 with water or 1:20. Has high binding power for clay materials.

MOLASSES
(ORGANIC)

Description......... product of refining cane and beet sugar (cane or blackstrap molasses)
Typical Color............................black
Individual Characteristics .... syrup usually diluted with water
Purpose.................. increases dry strength, usually torch dried or can be air dried
Effective Temperature of Destruction 212-750F (100-399C)
Effect on Dry Compression Strength....increases

Miscellaneous Data or Observations
60-70% solids. Used diluted with water 1:15 by volume. Holds the last traces of moisture tenaciously. Molasses spray provides a superficial crust. Never used alone.

RYE FLOUR
(ORGANIC)

Description . . . . cereal binder
Purpose . . . . green strength additive
Bulk Density . . . . 45 lb(ft[3]
Effect on:
Green Compression Strength . . . . increases
Dry Compression Strength . . . . increases
Hot Compression Strength . . . . decreases

Miscellaneous Data or Observations
Reduces expansion without increasing deformation as much as corn cereal. Increases permeability. Increases gas.

SODIUM SILICATE

(INORGANIC)

Description .... (water glass) a viscous liquid which when mixed with powdered fireclay forms a refractory cement. Compositions of sodium oxide and silica in varying proportions.

Individual Characteristics .... clear liquid; powder form can contain 0-17% H_2O.

Purpose .... secondary binder in clay-bonded sand. Reduces brittleness and friability in molding sand mixtures.

Bulk Density .... 11.6-13.0 lb/gal @ 60F (16C)

pH 10.8-12.8

Effect on:

Green Compression Strength .... increases

Dry Compression Strength .... increases

Typical Chemical Analysis

xNa_2OySiO_2	H_2O
Ratio $SiO_2:Na_2O$	1.6 to 3.3
Ratio $SiO_2:H_2O$	0.46 to 0.63

Miscellaneous Data or Observations

Can be hardened with CO_2 or by air setting. Tends to allow fusion of the sand. Sugar acts as hygroscopic agent in sodium silicate systems. Solid hydrates of low ratio sodium silicates dissolve quite readily. Has a tendency to spall. Has poor shakeout characteristics. Most common method of manufacture is to heat mixtures of sodium carbonate and silica sand in open hearth type furnaces. Viscosities comparable to light-to-heavy syrups are produced with $SiO_2:Na_2O$ ratios from 1.6 to 3.75. Sand mixtures are quite sticky. Over milling of sand mix causes progressive stickiness and compacted molds tend to become friable after gassing. Silicate bonded sand has high chilling power. Propensity to hot tears not any greater with CO_2 process compared to conventional materials. If $SiO_2:Na_2O$ ratio is above 3, then the bond is weak and friable. The lower the $SiO_2:Na_2O$ ratio, the longer the gassing time required.

WHEAT FLOUR

(ORGANIC)

Description . . . . cereal binder
Purpose . . . . green strength additive, reduces expansion
Bulk Density . . . . 28 lb/ft^3 loose, 47 lb/ft^3 compacted

Effect on:
Green Compression Strength . . . . increases

Miscellaneous Data or Observations

Reduces expansion without increases in deformation as much as corn cereal. Increases permeability. Increases gas.

Sand Reclamation

- The economics of a foundry operation require sand reclamation to reduce the costs associated with new sand and the costs of landfill use, and to reduce the problems associated with the control of environmentally undesirable contaminants in the discarded sand.

- In addition, tangible operational advantages result from sand reclamation. These begin with the ability to select the best sand for the casting process, knowing that most of it will be reclaimed during operation. In addition, the use of reclaimed sand reduces the number of variables that must be controlled, and provides operational consistency over a period of time.
- Sand grain shape and distribution and binder system bonding are more uniform, thus reducing sand defects. A properly designed sand reclamation system begins with green sand and converts it to a product very similar to new sand. Figure 5 shows the appearance of sand before casting, after molding, and after reclamation.

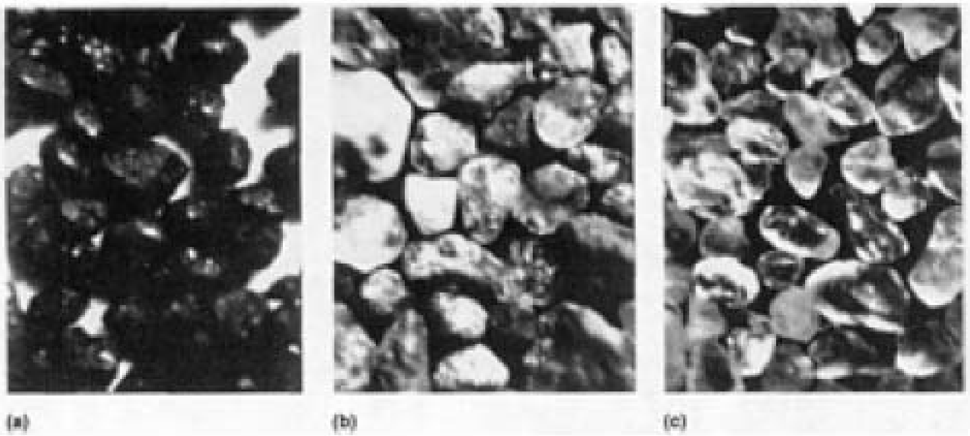


Fig. 5 Influence of sand reclamation on the appearance of green sand. (a) After molding (no reclamation). (b) After thermal reclamation. (c) New sand.

- Sand reclamation begins with the removal of tramp and foreign materials, such as core rods, metal spills, slag, and paper, and the disintegration of lumps of sand. Then organic and inorganic binders are removed by attrition (scrubbing) and/or thermal methods. Dead clay is removed as fines. The sand is then brought up to specification by the addition of new sand, clay, and other sand additives.

- Sand reclamation systems must be selected with regard to their cost, the specifications for the system sand, system capacity, compatibility with the sand system, metal being poured, and core mixes being used. It is important for the foundry to have a clear understanding of its needs in sand reclamation before calling in vendors. A variety of reclamation systems are described below.

Wet Washing/Scrubbing

- The cores of large castings can be removed by high-velocity jets of water. In the process, the cores are broken down into grains, and some binder is removed. Excess molding sand can be added and washed simultaneously. If the shakeout system is dry, the sand is charged into an agitator system where the solid content is held between 25 and 35%. Excess molding sand may be blended with the core knockout material. A similar system uses intensive scrubbing with a solids content of 75 to 80% and units in series.

- This latter method is superior because of closer and more frequent grain-to-grain contact. After washing, the sand is classified and may be used either wet (naturally drained to 4 to 5% moisture) and added to a system sand, dried for cores, or used for facing sand.
- Facing sand mixes derive their name from the fact that they are used in limited quantities against the face of the pattern or core box. They have properties usually different from those of the backup or system sand and contain additives not otherwise present. Facing sands are designed to perform special functions, such as providing higher green strength for lifting deep pockets, higher deformation for limited draft patterns, and special carbons that enhance skin drying.
- The wet system has limitations in that only a portion of the binder, clay, and carbon is removed. The product, however, isexcellent for use as a makeup sand in systems.

Dry Scrubbing/Attrition

- This method is widely used, and there is a large variety of equipment available in price ranges and capacities adaptable to most binder systems and foundry capacities. Dry scrubbing may be divided into pneumatic, mechanical, and combined thermal-calcining/thermal-dry scrubbing systems

In pneumatic scrubbing

- ***In pneumatic scrubbing,*** grains of sand are agitated in streams of air normally confined in vertical steel tubes called cells. The grains of sand are propelled upward and rub and impact each other, thus removing the binder. In some systems, grains are impacted against a steel target. Banks of tubes may be used depending on capacity and degree of cleanliness desired. Retention time can be regulated, and fines are removed through dust collectors.

In mechanical scrubbing

- ***In mechanical scrubbing,*** the equipment available offers foundrymen a number of techniques for consideration. An impeller may be used to accelerate the sand grains at a controlled velocity in a horizontal or vertical plane against a metal plate. The sand grains impact each other and metal targets, thereby removing the binder. The speed of rotation has some control on impact energy. The binder and fines are removed by exhaust systems, and screen analysis is controlled by air gates and/or air wash separators.

Thermal-Calcining/Thermal-Dry Scrubbing Combinations

- These systems offer the best reclamation for the organic and clay-bonded systems. Grain surfaces are not smooth; they have numerous crevices and indentations. The application of heat with sufficient oxygen oxidizes the binders or burns them off. In attrition, only because there is no contact in the crevices, the binder remains. Heat offers the simplest method of reducing the encrusted grains of molding sand to pure grains. Both horizontal and vertical rotary kiln and fluidized bed systems are available.

- In the horizontal rotary kiln, material is fed into one end (usually the cold one) and moved progressively through the heat zone by rotation assisted by baffles, flights, or other mechanical means. Some mechanical scrubbing also occurs. Some systems incorporate heat exchanger technology to considerably reduce the energy required. The latest technology also includes provision for recovery of metal entrained in the sand and collection and detoxification of the process wastes for suitable nonhazardous waste disposal.

- Several fluidized bed system designs are available. Some use preheating chambers and hot air recuperation. A drying compartment may also be added. Sand is introduced into the top (preheating) chamber of the reactor and is lifted by the hot air stream from below until it assumes some of the characteristics of a fluid. The hot air coming in contact with the sand grains burns the organics and calcines the clay. At the same time, some attrition takes place. A correct pressure differential must be maintained between the compartments if more than one is used in order to ensure downward flow of sand; otherwise gravity flow must be provided. Fluidizing is a very good method for cooling sand when using cool air.

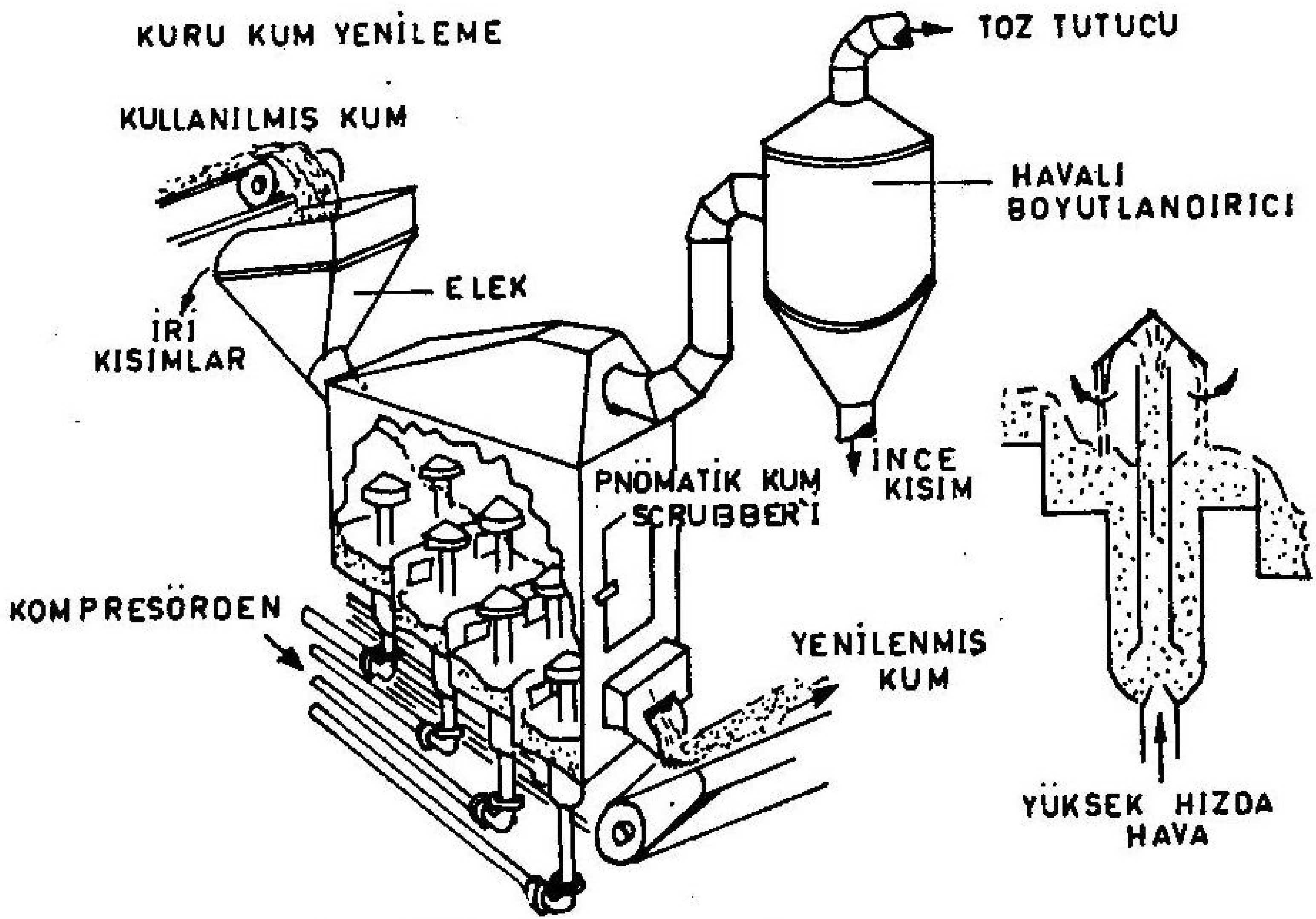
Multiple-Hearth Furnace/Vertical Shaft Furnace

- The multiple-hearth furnace consists of circular refractory hearths placed one above the other and enclosed in a refractory-lined steel shell. A vertical rotating shaft through the center of the furnace is equipped with air-cooled alloy arms containing rabble blades (plows) that stir the sand and move it in a spiral path across each hearth. Alternate hearths are "in" or "out." That is, sand is repeatedly moved outward from the center of a given hearth to the periphery, where it drops through holes to the next hearth. This action gives excellent contact between sand grains and the heated gases.

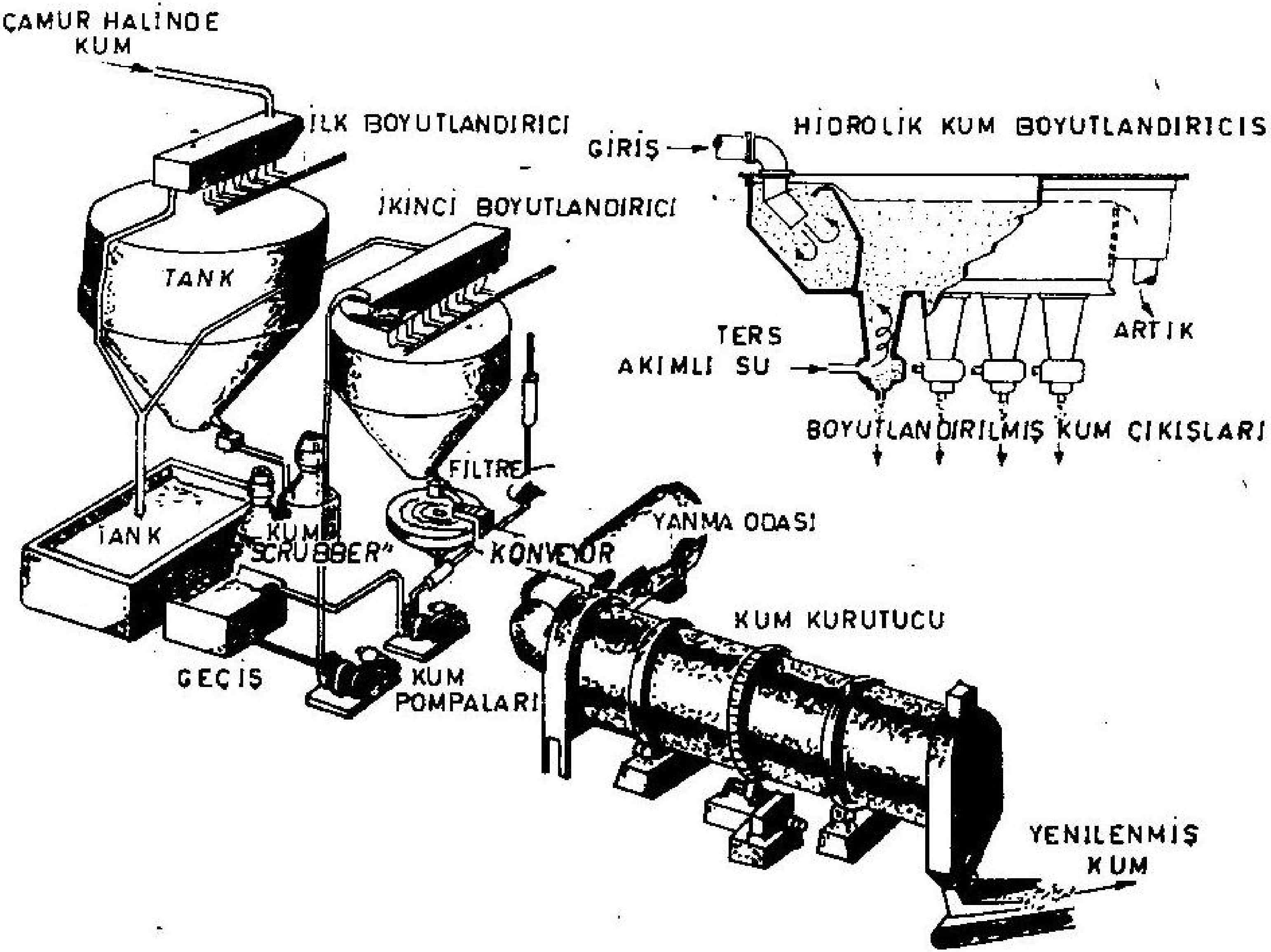
- Material is fed into the top of the furnace. It makes its way to the bottom in a zigzag fashion, while the hot gases rise counter currently, burning the organic material and calcining clay, if one or both are present. Discharge can be directly from the bottom hearth into a tube cooler, or other cooling methods may be used The units are best suited to large tonnages, that is, five tons or more. They are extremely rugged and relatively maintenance free.

Combinations of systems

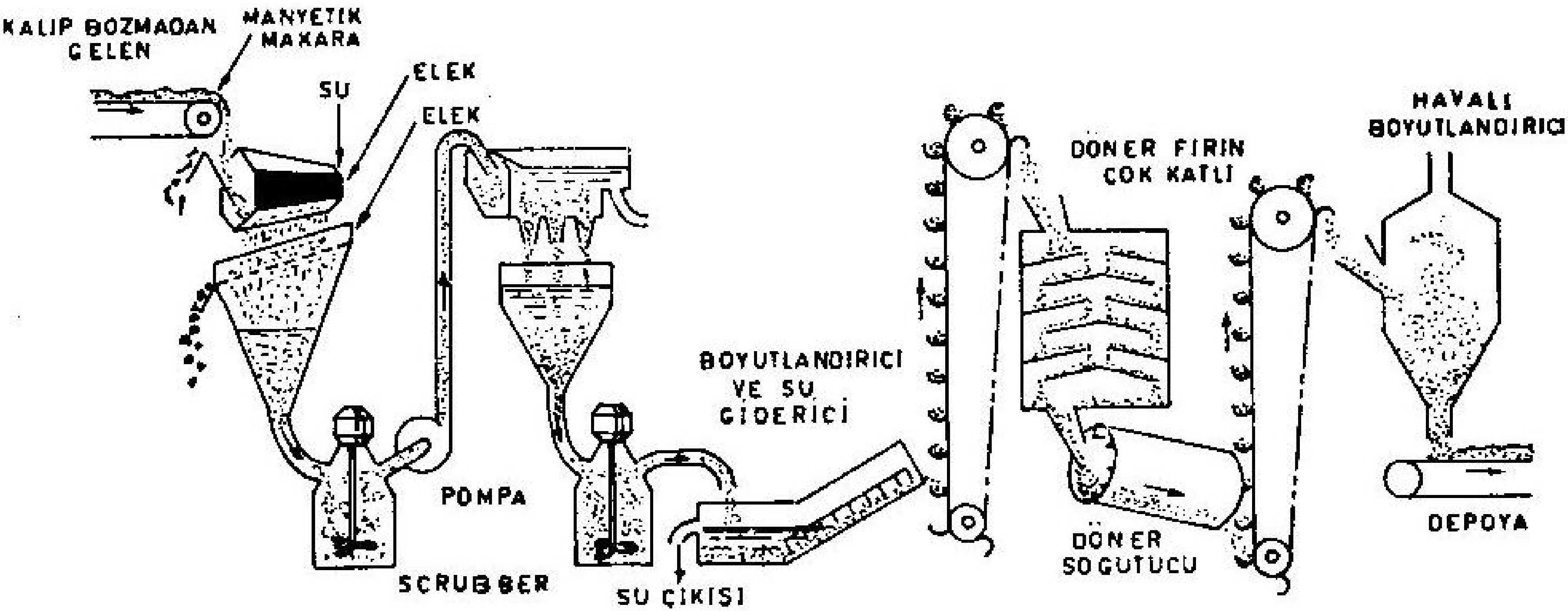
- **Combinations of systems** may also be used, for example, thermal methods followed by dry attrition scrub to remove calcined clay from molding sand or undesirable chemicals and oxides from core processes. Also, commercial centers for sand reclamation are in operation and may be used by smaller foundries.



Şekil 3.15 Kuru kum yenileme sistemi[4].



Şekil 3.16 Yaş kum yenileme sistemi[4].



Şekil 3.17 Yaş - Isısal kum yenileme sistemi[4].

Sand testing

Regular testing of the properties of the sand is essential. One or two sand tests do not truly indicate the condition of the whole sand system, since a sand sample weighs only about 1 kg and cannot represent the whole 200 tonnes or so of the system. At least 5 samples should be taken per shift and measured for moisture, green strength, compactability and permeability. LOI and volatiles should be measured once per day. Active clay, twice per week.

Records of additions should also be kept:

Weight of clay, coal dust and new sand added each day
Number of moulds made
Weight of metal poured
Weight of used sand removed from the system each day

Control graphs

Individual figures mean rather little, but daily average sand properties should be plotted together with weekly figures of active clay and average additions of clay, coal dust and new sand. After a few weeks of plotting the data, it will be possible to draw control lines. Variation within the lines is permissible but if results appear outside the control lines, then action must be taken such as increasing or reducing clay or coal or new sand. If action is

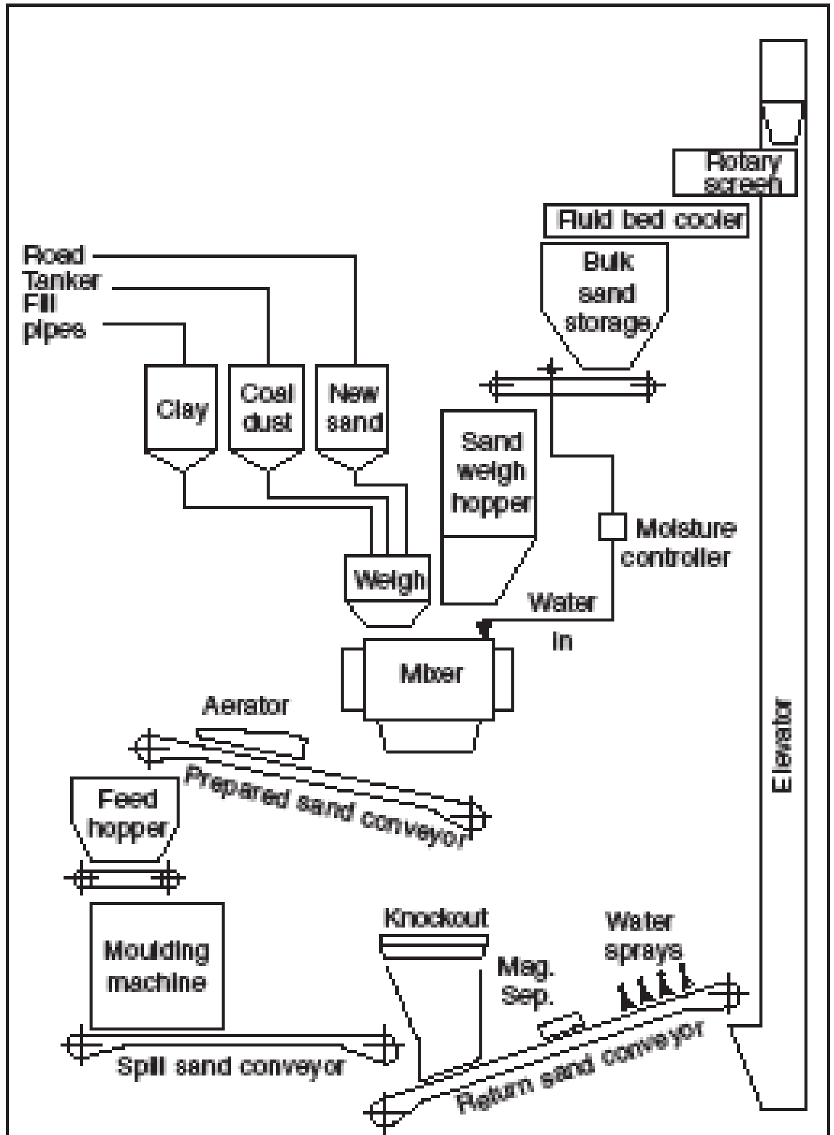


Figure 12.3 *Flow diagram for a typical green sand plant. (From* Foundryman, *March 1998, p. 102. Courtesy Foundry and Technical Liaison Ltd.)*

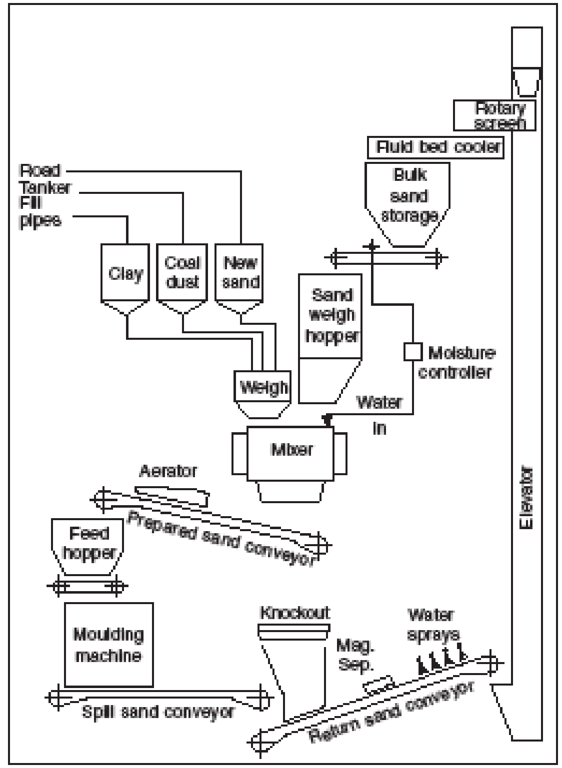


Figure 12.3 *Flow diagram for a typical green sand plant. (From* Foundryman, *March 1998, p. 102. Courtesy Foundry and Technical Liaison Ltd.)*

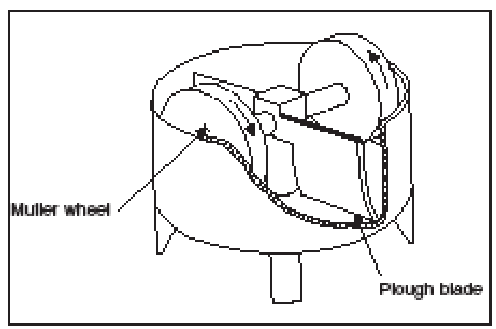


Figure 12.4 *Vertical wheel batch muller. (Sixth Report of Institute Working Group T30, Mould and Core Production.* Foundryman, *Feb. 1986.)*

Kuvars Kumu

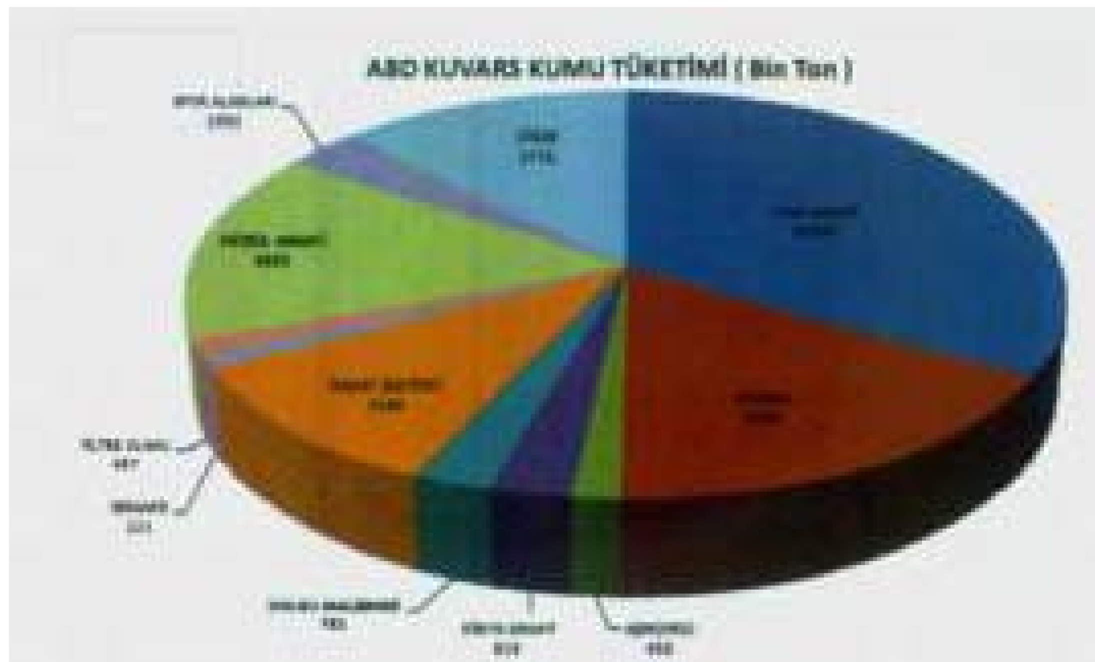
ATİLLA UÇAR
KUMSAN A.Ş. ŞUBAT 2008

Kullanıldıkları sanayi dalı ve tabiatta bulunuş kalitesine göre değişiklik gösteren Kuvars kumları, genel olarak Cam ve Döküm sanayinde kullanılmakla beraber inşaat, boya ve plastik sanayinde ayrıca yapı kimyasalları ve aşındırıcıların üretiminde de kullanılmaktadır.

Kuvars kumları kuvarsça zengin magmatik, metamorfik kayaçların ayrışması sonucu oluşan, 2 mm'den küçük kuvars (SiO2) tanecikleridir. Kuvars kumları beyaz renklidir, demir oksit içerme durumlarına göre renkleri pembeden kızıla veya kahverengine kadar değişebilir. Silisten oluşan (SiO2) kuvars kumu, az miktarda kil, feldspat, demir oksitler, karbonatlar ihtiva edebilir.

Doğada saf olarak bulundukları gibi istenmeyen safsızlıklar ile karışmış olarak ta bulunabilirler. Döküm sanayiinde kullanılan Kuvars kumları maden sahalarının içerisinde % 95'in üzerinde (SiO2), % 7-15 kil, ihtiva eden ve sinterleşme sıcaklığı 1500 °C'nin üzerinde bulunan kumdur.


DÜNYA KUVARS ÜRETİMİ (Bin Ton)


ABD KUVARS KUMU TÜKETİMİ (Bin Ton)

Döküm sektöründe kullanılan Kuvars Kumları, doğada daha serbest taneler halinde bulunup, daha gevşek karakterli yapıya sahiptirler.

Dünya Kuvars kumu üretim kapasitelerinin 150 Milyon ton seviyelerinde olduğu bilinmektedir. Dünya Kuvars kumu rezervlerinin ise sıhhatli bir şekilde hesaplanamamasına rağmen, rezervlerin, rezerv sırasına göre;

Avrupa: Belçika, Almanya, Hollanda, Fransa, İngiltere, İspanya, İtalya, Avusturya, Rusya

Amerika: Kuzey Amerika'da A.B.D, Kore, Güney Amerika'da, Arjantin, Brezilya, **Asya:** Filipinler, Hindistan, Afrika, Mısır, Güney Afrika Cumhuriyeti'nde olduğu bilinmektedir .

ÜLKE	TÜKETİM (Bin ton)
Rusya	10.800
A.B.D	5.470
Almanya	2.745
Fransa	1.428
İtalya	1.245
Brezilya	871
Çekoslovakya	860
İngiltere	853
Kore	837
Polonya	755
Romanya	609
Tayvan	561
Meksika	508
İspanya	501
Kanada	450
Türkiye	450
Avusturya	151
Belçika	146

Kuvars kumu üretimi içinde yer alan Dünya Genelinde Dökim kumu tüketimleri ilk sıralara göre yandaki tabloda gösterilmiştir;

Sektörde üretim yapan önemli kuruluşlar:
Avrupa'da SCR Sibelco SA (Belçika) firması dört kıtada 120 Tesisi ile Dünyada kuvars kumu üretiminde lider konumdadır.

Dünyada Kuvars kumu üretimini ve pazarını aşağıdaki firmalar kontrol altında tutmaktadır. Amerikan Firmaları: Unimin,US Silica, Fairmount Minerals, Oblegay Norton Industrial Sands, Badger Mining, Nugent Sand, Simplot Industries, Owens-İllinois, Construction Aggregates, W.R. Bonsal.

Avrupa Birliği Firmaları: SCR-Sibelco (Belçika), Quarzwerke GmbH (Almanya), Hepworth Minerals ve Chemicals Ltd.(İngiltere), Saint – Gobain (Fransa), Samin (Fransa), Sifraco (Fransa)

Türkiye'de Durum:

Türkiye'de çökel kayaların ayrışmasıyla serbest hale gelen kuvars taneleri , akarsularla taşınma sırasında, bir miktar kil ile beraber karasal havzalarda çökelmişlerdir.

Şile ve Zonguldak Yöreleri kuvars kumu

yataklanmaları açısından çok zengin olup, Türkiye'nin en önemli maden havzalarındandır.

Bölge ekonomik olarak kuvars kumu haricinde Linyit, kil ve alüminyum yataklarına da sahiptir. Bölge ruhsat durumlarının karışık olması, farklı madenler için verilen ruhsat sahalarının birbirine girik olması, sahadaki madencilik çalışmalarını düzensiz hale getirebilmektedir.

Elemanları orta ve ince taneli kuvars yada kuvarsitten ibaret olan silis kumları, yörede üst kotlarda geniş bir yayılıma sahip oldukları için aranıp bulunması kolay olduğu gibi işletmecilik ve çevre açısından sorunları en az olan hammaddedir.

Özellikle Şile Bölgesinde büyük bir yataklanma gösteren kuvars kumları gerek jeolojik yapıları gerekse işletme tesislerinde uygulanan ileri teknoloji nedeni ile Döküm Sanayi Kuruluşlarının taleplerine uygun ürün niteliğindedir ve Türkiye döküm kumu tüketiminin tamamını karşılamaktadır.

Rezervler : İstanbul Şile yöresinde;

- Görünür rezerv	55 Milyon Ton
- Muhtemel rezerv	23 Milyon Ton
- Toplam	78 milyon tondur .

Zonguldak bölgesinde ; tüm bölgede rezerv açısından hesaplanmış veri yoktur. Havza çok büyük olup kömür rezervleri ile içiçe geçmiş vaziyettedir. Şile Bölgesinin kuvars kumu rezervleri, Siltaş A.Ş , Kumsan A.Ş, Çeliktaş A.Ş ve Cam-İş Madencilik A.Ş ve diğer şahıslara ait sahalarda bulunmaktadır .

ÜRETİM

Kuvars kumu üretimi açık işletme metodu ile yapılmaktadır. Üretim yapılacak alanların izin ve ruhsatları Enerji Bakanlığı ve Çevre Orman Bakanlıkları tarafından verilmektedir.

Üretimde Dozer, Loder ekskavatör, Kamyon ve Konveyörler kullanılır. Ekonomik olarak kum üretilebilmesi için, kumun üzerindeki kaldırılacak olan örtü tabakasının kalınlığının, örtü/kum 1/4 seviyesinde olması öngörülür.

Üretim yapılacak alanda 20-30 m eninde ve 50-100 m boyunda, panolar seçilmekte olup, önce paletli kepçeler vasıtası ile 2-4 m kalınlığında örtü tabakası alınmakta, daha sonra aynı makine techizatı ile döküm kumu üretimi yapılarak damperli kamyonlara yüklenilmekte ve bu kamyonlar vasıtası ile Entegre Döküm Kumu Hazırlama Tesislerine taşınmaktadır.

Ocaktan üretilerek Tesislere getirilen ham kum lastik tekerlekli kepçeler ile silolara beslenmekte, eleklerden su ile karışım sağlandıktan sonra pompalar vasıtası ile, siklonlardan geçirilerek yıkama, karıştırıcı, tasnif ünitelerine taşınmakta daha sonra dinlendirilerek rutubeti % 7 seviyelerine getirilip mamul silolarına aktarılmaktadır.

Fiyatlar:

Kuvars kumu fiyatları sınıflandırma, kullanım yeri, kalite açılarından büyük farklılıklar içermektedir. Buna rağmen standartlar ve kullanım alanlarına bağlı olarak oluşan fiyat seviyeleri aşağıda verilmiştir.

	Türkiye, Avrupa Fob $/ton	ABD Fob$/ton
Cam Sanayi	10-15	17
Döküm Sanayi	18-22	14
Seramik Sanayi	20-100	53
Yapı Kimyasal	18-25	19
İnşaat ve Diğer	---	--

Kum fiyatlarının en önemli noktası navlun fiyatlarının kum fiyatlarından yüksek olabilmesidir. Avrupa'da Döküm Kumlarının önemli miktarı kurutulmuş pazarlandığından yukarıdaki fiyatlar yaş fiyatlar olup yaklaşıktır.

İHRACAT

İhracat açısından navlun fiyatlarının kuvars kumu maliyetlerinin üstünde seyretmesi, ayrıca rezerv sıkıntıları ve kalite gibi nedenler dolayısı ile kuvars kum ihracatında iddialı olduğumuz söylenemez.

Sınıflandırma:

Entegre Döküm Kumu Hazırlama Tesislerinden elde edilen döküm kumlarının fiziksel, kimyasal ve teknolojik özellikleri şöyledir;

Sinterleşme Sıcaklığı: 1500 °C üzerinde

Yanma Kaybı (%): 0,011 - 0,30

Kil Oranı (%): 0,16 - 1,27

Kuvars Kumu Tane Boyu Sınıflandırması (Wentworth)

A.B.D STANDART ELEK NO	mm	Mikron	Ø	KIRINTI	
5	4		-2	İNCE ÇAKIL	ÇAKIL
6	3.36				
7	2.83				
8	2.38				
10	2.00		-1.0		
12	1.68		-0.75	ÇOK İRİ KUM	
14	1.41		-0.50		
16	1.19		-0.25		
18	1.00		+0.25		
20	0.84		0.25	İRİ KUM	
25	0.71		0.50		
30	0.59		0.75		
35..........1/2	0.50	500	1.00		
40	0.42	420	1.25	ORTA BOY KUM	
45	0.35	350	1.50		KUM
50	0.30	300	1.75		
60.......1/4	0.25	250	2.00		
70	0.210	210	2.25	İNCE KUM	
80	0.177	177	2.50		
100	0.149	149	2.75		
120.......1/8	0.125	125	3.00		
140	0.105	105	3.25	ÇOK İNCE KUM	
170	0.088	88	3.50		
200	0.074	74	3.75		
230...1/16	0.0625	62.5	4.00	İRİ MİL	ÇAMUR
325	0.044	44	4.50		

Kum Köşeliği: 1,25 - 1,27

Öğülme (%): 40,8

H_3PO_4' te yanma kaybı (%): 0,1

Kızdırma Kaybı (%): 0,36

SiO_2: % 97 - 99

Al_2O_3: % 0,5 - 1,2

Fe_2O_3: % 0,015 - 0,30

MgO: % 0,015 - 0,030

K_2O: % 0,03 - 0,08

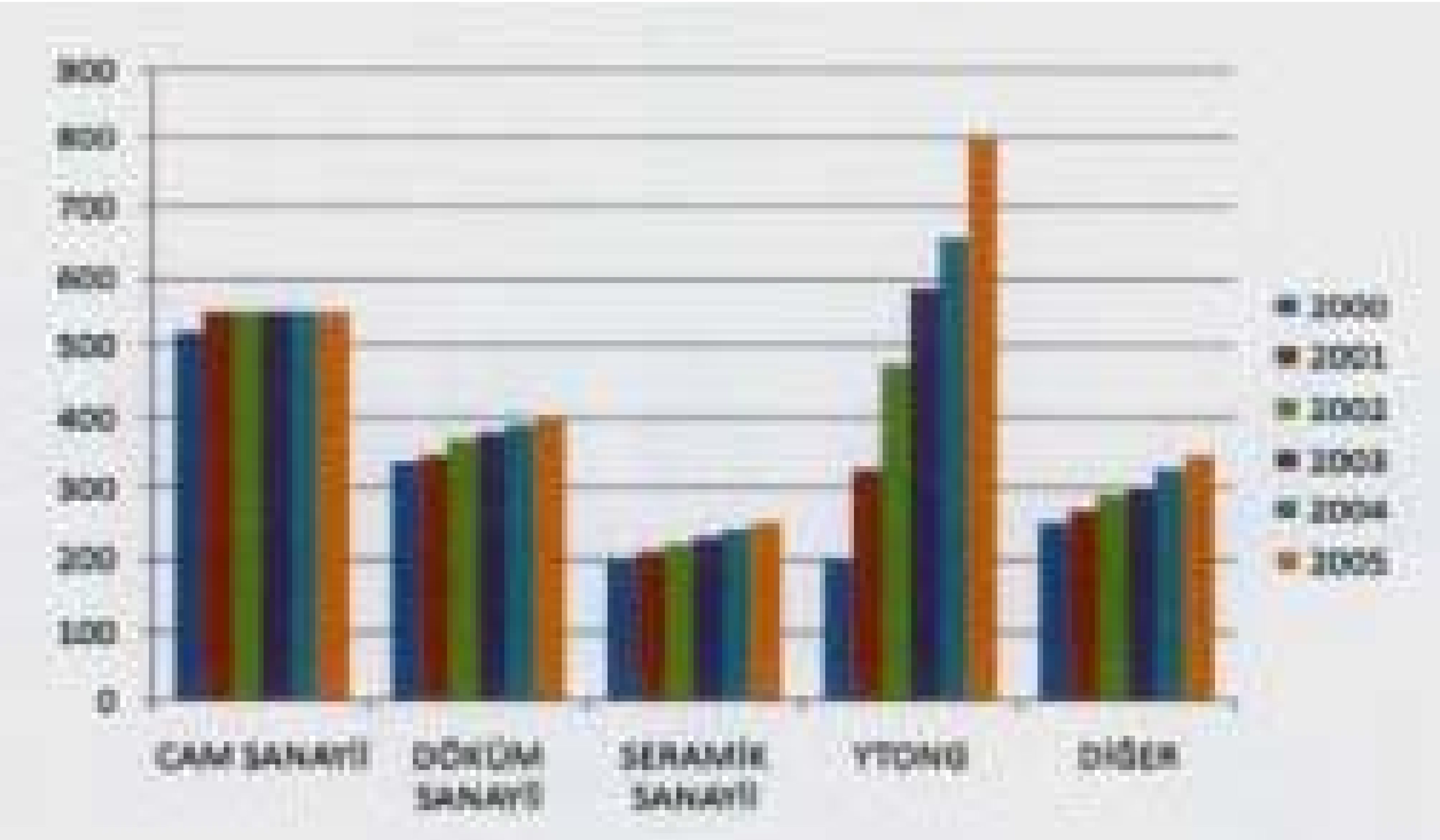
Na_2O: % 0,02 - 0,09

TiO_2: % 0,01 - 0,04

Türkiye'deki kuvars kumu üretimi mülkiyeti

Kuvars Kumu Üreten Önemli Kuruluşlar

Kuruluşun Adı	Yeri	Üretim Konusu	Kapasitesi (Binton/yıl)
Cam iş Madencilik A.Ş .	Yalıköy	Cam Kumu	1000
Cam iş Madencilik A.Ş .	Kırklareli	Cam Kumu	1000
Siltaş A.Ş .	İstanbul	Döküm Kumu	300
Kumsan A.Ş .	İstanbul	Döküm Kumu	250
Çeliktaş A.Ş .	İstanbul	Döküm Kumu	150
Erbatu A.Ş .	İstanbul	Döküm Kumu	80
Trakya Silis A.Ş .	İstanbul	İnş aat,Dolgu	200
Marmara Silis A.Ş .	İstanbul	İnş aat,Dolgu	110
Matel A.Ş .	Bilecik	Seramik Kumu	40
Esan A.Ş .	Bilecik	Seramik Kumu	20
Kale Maden	Ş ile	Seramik Kumu	100
Diğ er	-	Seramik Kumu	90



900
800
700
600
500
400
300
200
100
0
ÇAM SANAYİ
DÖKÜM SANAYİ
SERAMİK SANAYİ
YTONG
DİĞER
2000
2001
2002
2003
2004
2005

özel sektöre ait olan tesislerde gerçekleştirilmektedir. Kuvars kumu üretiminde faaliyette bulunan yabancı sermayeli bir şirket yoktur.

Döküm, Cam, Seramik, Boya sanayilerinin kuvars kumu ihtiyaçlarını karşılayan kuruluşların Listesi aşağıdadır.
Türkiye Kuvars Kumu üretiminin büyük bir kısmını yukarıda belirtilen bu firmalar karşılamaktadır. Bu firmalardan Siltaş A.Ş.'nin Şilede 2, Kumsan'ın Şile ve İstanbul Tuzla'da birer tesisleri, Çeliktaş firmasının ise Şile'de bir tesisi mevcuttur.

KUVARS KUMU YURTİÇİ TALEP PROJEKSİYONU (Bin Ton)

Döküm sektöründeki artan talep, buna bağlı fabrikaların döküm üretimi kapasiteleri artmasına rağmen, kum üreticileri mevcut kapasiteleri ile bu talepleri karşılayabilecek düzeydedirler.

Döküm fabrikalarının önemli bir atığı olan proses sonrası oluşan atık kum, son yıllarda bilindiği gibi bu fabrikaları çevresel baskıların odağı haline getirmiştir. Bir çok önemli döküm üreticisinin kumun geri kazanımını sağlayan rejenerasyon yatırımlarına yönelmesi, artan

Son yılların önemli bir gelişmesi de inşaat kolundadır. Özellikle Yapı Kimyasalları, Seramik Fayans Yapıştırıcıları yüksek oranlarda döküm sektörü ile aynı sınıflandırma kategorilerine sahip kuru kum talebinde bulunmaktadırlar. Bu talep çok önemli bir şekilde büyümekte olup, Döküm üreticileri talebinin çok üzerinde seyretmektedir.

Bu çerçevede kum üreticileri, kapasitelerinin önemli bir kısmını Yapı Kimyasalları ve inşaat sektörüne ayırmakta ve katma değeri yüksek kuru kum vermektedirler. Yapı Kimyasallar ve İnşaat sektöründe artarak devam eden bu talep, Döküm sektöründe üretim yapan firmaları döküm kumu tedariki ve maliyet acısından ciddi sıkıntılara sokabilir.

Şile Bölgesi özellikle Döküm ve İnşaat sektörü üreticilerinin talebine uygun tane aralığına sahip rezervlere sahiptir.

Döküm Kumunun kullanıldığı Döküm yolu ile üretilen mamullerin sınıflandırılması:

	KULLANICI SEKTÖR	MAL TANIMLARI
1	Otomotiv Sanayi	Otomobil, Traktör, Kamyon, Otobüs, Çekici Minibüs, Treyler üretiminde kullanılan döküm parçalar.
2	İnşaat Sanayi	Fittings, Radyatör, kazan, Küvet, Soba, Kanalizasyon ızgarası v.s.
3	Makine İmalat Sanayi	İş Makinaları ,Takım Tezgahları, Tarım aletleri ve makinaları, Çimento, Tuğla ve Refraktör İmalat Sanayi, Kaldırma Makinaları, Pompa,Vana Kimya Sanayi Parçaları, Dişli ve Makaralar, Kompresör v.s.
4	Çelik Sanayi	Ingot Kalıbı, Merdane Taban Plakaları v.s.
5	Basınçlı Döküm Boru	Pik ve Sfero Döküm Boruları
6	Diğer	Enerji Nakil Sanayi, dayanıklı Tüketim Malları Sanayi, El Aletleri, Elektrik Motorları, Cam Kalıpları v.s.

Dö-

küm sektörünün ihtiyaç duyduğu 50-55 AFS dağılımı kum Şile Bölgesinin özellikle sahile yakın bölgelerde rezervlerin önemli bir kısmını teşkil etmektedir.

ÜRETİM

Sorunlar:

Döküm kumunun da dahil olduğu Kuvars kumu üreticilerinin sorunlarını 3 ana başlıkta toplamak gerekir.

- Artan talebe ve üretime bağlı olarak İstanbul-Şile Bölgesi kuvars kumu sahalarının rezervlerini azalımı
- Özellikle kil üretimine paralel Maden

	KULLANICI SEKTÖR	MAL TANIMLARI
1	Otomotiv Sanayi	Otomobil, Traktör, Kamyon, Otobüs, Çekici Minibüs, Treyler üretiminde kullanılan döküm parçalar.
2	İnş aat Sanayi	Fittings, Radyatör, kazan, Küvet, Soba, Kanalizasyon ızgarası v.s.
3	Makine İmalat Sanayi	İş Makinaları ,Takım Tezgahları, Tarım aletleri ve makinaları, Çimento, Tuğ la ve Refraktör İmalat Sanayi, Kaldırma Makinaları, Pompa,Vana Kimya Sanayi Parçaları, Diş li ve Makaralar, Kompresör v.s.
4	Çelik Sanayi	İngot Kalıbı, Merdane Taban Plakaları v.s.
5	Basınçlı Döküm Boru	Pik ve Sfero Döküm Boruları
6	Diğ er	Enerji Nakil Sanayi, dayanıklı Tüketim Malları Sanayi, El Aletleri, Elektrik Motorları, Cam Kalıpları v.s.

sahalarında yaratılan tahribat ve bu sahaların rehabilitasyonu

- Çevresel baskılar ve bunun neticesiyle ilgili Bakanlıklarda bekleyen ve verilmeyen izinler Atığın (çamur + su) bertarafı veya yeniden kazanımı bunun için ortaya çıkan çevresel ve mali sıkıntılar.

Bilindiği gibi madenler yenilenemeyen hammadde kaynaklarıdır ve yeryüzünde eşit dağılmamıştır ve madenlerin bulundukları yerde işletilme zorunlulukları vardır. Sanayileşmenin ve üretimin baş döndürücü bir şekilde artışı maden rezervlerinin çok hızlı bir şekilde tüketilmesini de beraberinde getirmektedir.

Kuvars kumu sanayinin Cam, Döküm, İnşaat ve bir çok sanayi kolunda hammadde olarak kullanılması ve çok büyük oranlarda talebin olması kum rezervlerini önemli bir şekilde azaltmakta , yeni rezerv ve sahaların bulunmasını zorunlu hale getirmektedir.

Madenciliğin doğada milyonlarca yıl süren bir zaman dilimi içerisinde doğal olarak ve sınırlı miktarda Jeolojik şartların uygun olduğu ortamlarda oluşabildiği ve bulunabildiği yerde çevre, ekonomi dengesini gözeterek çıkarılmaları gerekir.

Madencilikte kullanılan alanların rehabilite edilerek ekosisteme kazandırılması ve sektörde bertaraf, arıtma yeniden kazanım teknolojilerinin gelişmiş olması, madenciliğin sürdürülebilir kalkınma prensiplerine uygun bir faaliyet dalı olmasını sağlar.

İstanbul Şile Bölgesi kuvars kumu rezervleri, uzun yıllardır sanayinin ihtiyacı olan kum talebini karşılamış ve karşılamaya devam etmektedir . Bu bölgede özellikle kuvars kumu üretimi dışında yapılan kömür, taş ve kil gibi çeşitli madenlerin üretimi için çevrede yaratılan tahribat, Enerji ve Orman Bakanlıkları tarafından verilen izin ve ruhsatlardaki sıkıntıyı'da beraberinde getirmiş bulunmaktadır.

Şile Bölgesinde kum üreticilerinin en büyük sorunu ruhsatlı sahalarda Çevre ve Orman Bakanlığı tarafından bekletilen izinlerdir. Bekleyen bu izinler çerçevesinde bölgede faaliyette bulunan kum üreticilerinin mevcut sahalarının kum stokları hızla erimekte ve üretim yapamaz duruma gelmektedirler.

Türk Otomotiv yan sanayi, cam ve diğer sektörlerin en önemli girdisi olan kuvars kumu maden sahalarında yaşanan bu sıkıntının kısa vadede mutlaka aşılması gerekmektedir.