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Use Possibilities for River Sand in Foundry

In this paper the following characteristics are studied: the chemical and mineralogical composition, the granulation and content of leachate component of different types of sands, collected from various fords of running waters in comparison to those coming from known mines and used as such in foundries for the preparation of casting mixtures. The purpose of the study starts from the premises of finding reduction possibilities of costs in part casting, keeping in mind that known deposits from our country contain increasingly reduced quantities of casting sands.

Keywords*: degree of uniformity, medium grains, basic fraction*

1. Introduction

In the machine construction industry the percentage of cast parts represents 30%, in the conditions in which the deposits of casting sands are poorer and the regeneration technologies of molding sands are more and more expensive, while inorganic binders have been replaced in foundries with artificial organic binders (used in more reduced quantities than the inorganic ones and offering a higher productivity in the realization of shapes and cores; we have been looking and still are permanently looking for possibilities of use of sands of running waters). Keeping in mind that these molding sands are used in the manual molder and in mechanized molder and that over 30% of the scrap from foundries is due these mixtures of molder, the continuous need to improve the properties of these mixtures is obvious.

The frequent use of quartz sand as casting sand is managed by economic reasons (it is found as such in nature) and by technological reasons (the silicon-quartz dioxide has a high melting temperature -1986 K).

Natural deposits of quartz sands are almost polluted with iron oxides, chalk, clays, feldspars, oxides of alkaline metals (Na_2O and K_2O), calcium and magnesium carbonates and other minerals in reduced proportions.

The pollution of sands with different chemical-mineralogical composition leads to worsen of sands quality and implicitly that of molding sands.

The properties that need to be satisfying for usual temporary molding sands are multiple, being imposed by quality conditions that need to be satisfied for the casted part; the need of realization of properties imposed to the molding sands being as high as the quantitative qualities imposed to casted parts are higher: high work temperatures, anticorrosive temperatures, high pressures, chemical resistance etc. For these reasons we mainly use a grain component of SiO_2 extracted from mines that insure the necessary properties (obviously after improvement processing after bringing it to demanded values of in force standards): granulation, refractivity, geometrical shape, low content of inorganic impurities and of a leachate component. Keeping in mind that all these operations heavily increase the costs of molding sands obtained from these sands, it is useful to find some replacements that will satisfy the conditions imposed, contributing at the same time in reducing costs for usual temporary molding sands.

The leachate component of casting sands is formed of the totality of particles smaller than 0,02 mm, having as constitutive elements clay and dust obtained from the molding sands. The leachate component has an influence on the characteristics of molding sands; the higher its value, the higher the characteristics of mechanical resistance and plasticity and the lower the gas permeability. Also, a high content of leachate component in casting sands leads to an increase of binder consumption. Thus, in order to insure optimum properties for molding sands, we must realize a compromise between resistance and permeability.

According to the content of leachate parts, casting sands are classified into eight classes, with characteristics presented in Table 1 (STAS 5609-73) presented by Gheorghe Simionescu, Constantin Cernat and Elena Ţigănilă in *Materiale tehnologice pentru turnătorii* (*Technological materials for foundries*) (analysis methods), Bren Publisher, Bucharest, 2007.

Sands from the N20 and N30 classes with a high content of leachate component that leads to a substantial reduction of gas permeability and a reduced refractivity are mainly used as adding materials in molding sands.

The sand granulation is of high importance in the appreciation of qualities and properties of molding sands. Thus, sands with uniform grains as size and with rounder grains will be the most proper for foundries, because a bigger space between grains will allow the evacuation of gas formed during casting. The sand grains are characterized by the following indicators: basic fraction, medium grains, degree of uniformity and surface and shape of grains.

Table 1. The classification of quartz sands according to the content of leachable components [1]

Class	Name	Content [%]					
		Leachate parts	SiO_2 min	CaO + MgO max	Fe_2O_3 max	$Na_2O + K_2O$ max	Sulfur as sulfides max.
N01	Quartz S I	max.0,1	97,5	0,5	0,5	0,3	missing
N02	Quartz S II	0,1 ÷ 0,2	97,5	0,5	0,5	0,3	missing
N03	Quartz I	0,2 ÷ 0,3	97,5	0,5	0,5	0,3	missing
N05	Quartz II	0,3 ÷ 0,5	97,0	0,5	0,5	0,3	missing
N1,5	Quartz III	0,5 ÷ 1,5	95,0	1,0	0,5	0,5	0,025
N10	Slab	1,5 ÷ 10	-	2,0	-	-	-
N20	Half-fat	10 ÷ 20	-	2,0	-	-	-
N30	Fat	20 ÷ 30	-	2,0	-	-	-

The basic fraction represents the maximum quantity of sand that remains on three consecutive sieves, their symbols being presented in Table 2 [1]

Table 2. Sand classification [1]

Sand name	Group	Meshes of the three consecutive sieves
Very rough	1	1,5 ; 1 ; 0,6
Rough	0,6	1 ; 0,6 ; 0,3
Big	0,3	0,6 ; 0,3 ; 0,1
Medium	0,2	0,3 ; 0,2 ; 0,1
Small	0,1	0,2 ; 0,1 ; 0,06
Fine (dust)	0,06	0,1 ; 0,06 ; tray

The medium grain sand (noted with a M50) represents the size of the theoretical mesh that will allow 50% of the sand to pass through, excepting the leachate component. The determination of medium grain is realized graphically using the grain-metric curve.

In Table 3 we can see the classification of sands from the point of view of medium grains [1].

The degree of sand uniformity represents the difference between percentage quantities of sand that would pass through the sieves 4/3 M50 and 2/3 M50.

From the point of view of the uniformity degree of grains, foundry sands are classified into five subgroups according to Table 4 [1].

Table 3. The classification of sands according to medium grains [1]

Group	Size characteristics	Medium grains, min. [mm]
(M50) 1	Large	1,0…0,61
(M50) 06	Big	0,60…0,41
(M50) 04	Half-medium	0,40…0,31
(M50) 03	Medium	0,30…0,21
(M50) 02	Half-fine	0,20…0,16
(M50) 015	Fine	0,15…0,11
(M50) 010	Very fine	0,10…0,06

Table 4. Classification of sands according to the grains uniformity [1]

Subgroup	Uniformity	Uniformity degree, [%]	Observations
(GU)>70	Very uniform	Over 70	For the N02 and N05 classes we agree to grains smaller than 0,06mm thus for (GU) > 70, max. 1%, and for (GU) < 70, max. 5%, if we don't make a special convention between the supplier and the beneficiary
(GU)70	Great uniformity	70…61	
(GU)60	Uniform	60…51	
(GU)50	Reduced uniformity	50…41	
(GU)<40	Irregular	Under 40	

According to the shape of grains, foundry sands are classified into four categories and according to the aspect of the surface, into two characteristics as shown in Table 5 [1].

Table 5. Classification of sands according to the shape of grains and according to the aspect of their surface [1]

Category	Shape of the sand grain	Type	
		1	2
		Surface of the grain	
a	round	smooth	harsh
b	with round edges and corners		
c	with sharp edges and corners		
d	splintered		

Spherical shaped sands and with a smooth surface insure the best permeability, but those with an irregular shape and rough, insure a high mechanical resistance.

Foundry sands can be characterized completely on the basis of a chemical and mineralogical analysis (the proportions of silicon dioxide, iron oxides, aluminum oxides and other impurities are determined) and of the physical analysis that contains the determination of humidity, grain density, pH, CO_2 , etc.

2. Experimental results

In Table 6 we can see the mineralogical composition of the sand from Timiş river, which is muscovite-granitic, in its mineralogical composition entering over 80% SiO_2 and 3,5% other constitutive minerals with a melting temperature higher than 1400ºC, the rest of 16,5% being minerals with a melting temperature smaller than cu 1400ºC, from which approximately 11% have a melting temperature between 1200ºC and 1250ºC, and 5,5% between 1000 and 1100ºC

Table 6. Mineralogical composition of the sand from the Timis river

Mineralogical composition	%	Melting temperature [ºC]
A. Basic constitutive materials		
Quartz (SiO_2) (metamorphic + magnetic, rolled) Partially colonized	80	1710
Feldspar ($KAlSi_3O_8$,$NaAlSi_3O_8$)	3	1200
Muscovite KAl_2 $(OH_3F)_2(AlSi_3O_{10})$	5	1260
Garnet-Almandine $Fe_3Al_2(SiO_4)_3$		
Spessartine $(Mn,Fe)_3Al_2(SiO_4)_3$	3	1010
B . Secondary materials		
Biotite, partially with chloride $K(Mg,Fe,Mn)_3(OH_3F)_2AlSi_3O_{10}$	2	1200
Chlorite $(Mg,Al)_3OH_2(AlSi_3O_{10})Mg_6(OH)_6$	1	1200
Magnetite (Fe_3O_4)	2	1100
Ilmenite ($FeTiO_3$)	1	1100
Apatite $CaF(PO_4)_3$	0,5	1400
Titan $CaTi(SiO_3)$	0,5	1400
Rutile (TiO_2)	0,3	1560
Tourmaline $NaFe_3Al_6(OH)_4(BO_3)_3Si_6O_{13}$	0,5	1000
Hornblende	0,5	1090…1270
Zircon Zr $(SiO)_4$	0,2	2000
Cyanide Al_2 (SiO_3)	0,5	1850

Even if the chemical composition cannot be decisive in the appreciation of sand quality, mainly depending on the mineralogical composition, for a comparison to the conditions imposed, in Table 7 we can see the chemical composition of sands from the Timis river.

Table 7. Chemical composition of the sands from Timis river

Chemical composition	%	Melting temperature [ºC]
SiO_2	80,29	1710
Al_2O_3	10,48	1750…1800
Fe_2O_3	3,43	1350
CaO	1,72	1350
MgO	1,70	1350
Alkalis (by difference)	1,07	1350
C.L. (calcinations losses)	1,31	1350

In Table 8 the chemical composition of the sands from Timiş-Prisaca river, of the sand from the Timiş-Lugoj river and of the Timiş-Şag river are presented.

Table 8. Mineralogical composition of sands from the Timis-Lugoj and Timis-Sag rivers

Mineralogical composition [%]	Material		
	Sand from the Timiş-Prisaca river	Sand from the Timiş-Lugoj river	Sand from the Timiş-Şag river
Quartz (SiO_2)	82	79	80
Feldspars	2,553	34,53	35,3
Biotite $K(Mg,Fe,Mn)_3(OH_3F)_2AlSi_3O_{10}$	1,5	2,5	2
Chlorite $(Mg,Al)_3OH_2(AlSi_3O_{10})Mg_6(OH)_6$	1	1,5	2
Magnetite (Fe_3O_4)	1,5	2	2
Ilmenite ($FeTiO_3$)	-	1	1
Apatite $CaF(PO_4)_3$	0,4	0,5	0,5
Titan $CaTi(SiO_3)$	0,4	0,6	0,5
Rutile (TiO_2)	0,3	-	0,3
Tourmaline $NaFe_3Al_6(OH)_4(BO_3)_3Si_6O_{13}$	0,6	0,4	0,5
Hornblende	0,6	0,4	0,5
Zircon $Zr\ (SiO)_4$	-	-	0,2
Cyanide $Al_2\ (SiO_3)$	-	-	0,5

The chemical composition of sands form the rivers Timiş-Lugoj, Timiş-Prisaca, Timiş-Şag, Făget and of the sand from the Jupa mine, after the application of the calcinations treatment at a temperature of 1000ºC for an 1h, is presented in Table 9.

Table 9. The chemical composition of sands from the rivers Timis-Lugoj, Timis-Prisaca, Sag, Faget and Jupa

Mat.	Chemical composition [%]								
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	P.C.
Timiş - Prisaca	76,5	9,75	3,58	0,40	1,47	0,75	3,37		1,15
Timiş - Lugoj	73,2	12,4	3,19	0,54	1,54	1,0	3,64		2,10
Timiş - Şag, < 1mm	85,2	-	1,27	-	1,78	0,36	1,73		1,1
Jupa mine	75,9	10,3	3,68	0,63	1,47	0,80	3,37		1,39
Făget (Field)	96,8	1,51	0,56	0,39	0,04	0,05	-		0,23
Făget (washed and sieved)	95,7	2,23	0,19	0,11	0,20	0,03	0,59	0,34	0,35

In the case of the grain-filter-Făget quartz, for the sort with the granulation 0,5…2 mm and with a content of 98,02% SiO_2 and 0,21 % Fe_2O_3 we obtained a content of leachate parts L.P. = 0,3%

Table 10. Characterisitics of sands of Timis-Prisaca, Timis-Lugoj, Timis-Sag, Jupa, Faget rivers

Material	Content [%]				
	Leachate parts	SiO_2	CaO + MgO	Fe_2O_3	Na_2O + K_2O
Timiş-Prisaca river sand		76,5	2,22	3,58	3,37
Timiş –Lugoj river sand	<1 ,5	73,2	2,54	3,19	3,64
Timiş-Şag river sand, under 1mm	1,62	85,2	2,14	1,27	1,73
Jupa mine sand		75,9	2,27	3,68	3,37
Făget sand (Fel.)	0,3	96,8	0,09	0,56	-
Făget sand (washed and sieved)		95,7	0,23	0,19	0,62

Table 11. Contents of leachate parts of river sands

Name of the sand used	Content of leachate parts (L.P.)	Name of the foundry sand	Sand class
Timiş sand	< 1,5	Quartz III	N1,5
Făget sand	0,3	Quartz I	N03
Şag sand	1,62	weak	N10

The determining of the grain density (grain-metric composition) of river sands was realized by mechanical sieving of dry sand samples, for 5…10 minutes, through a set of standard sieves, after which the residues from every sieve was weight, thus obtaining the results from Table 12 and from Table 12.

Table 12. Grain-metric analysis of sands from the Timis river

Size of the meshes [mm]	Residue on the sieve [%]	Cumulative passing [%]	Basic fraction [%]
1,4	-	100	-
1,0	-	100	-
0,63	0,6	99,4	-
0,32	53,1	46,3	53,1
0,20	42, 7	3,6	42,7
0,10	1,1	2,5	1,1
0,063	1, 7	0.8	-
Tray	0,8	-	-
Total	100	-	96,9

The results of the grain-metric analysis indicate very homogenous sand with a basic fraction of 0,32/0,1_=96,9%. We can observe that the residue on the sieve of 0,2 mm and the passing through the sieve of 0,32 mm represent a percentage of 66%.

The sand grains have a harsh surface and a shape that presents round edges and corners. The tendency of rounding attracts the possibility of a greater degree of taping and thus of superior mechanical resistances due greater contact surfaces, due to a higher homogeneity and permeability of the sand from the Timiş river, in a natural state, the values of K are bigger than 500.

The grain-metric analysis of the sand from Văleni, Făget and Şag is presented in Table 13.

Table 13.The grain-metric analysis of the sand from Valeni, Faget and Sag

Size of the mesh	Residue on the sieve [%]			Cumulated passing through the sieve [%]		
	Văleni	Făget	Şag	Văleni	Făget	Şag
1,0	-	-	5,21	100	100	94,79
0,8	0,8	1,8	11,8	99,2	98,2	82,99
0,63	0,8	4,4	7,1	98,4	93,2	75,89
0,40	3,2	3,2	30,89	95,2	90,6	45
0,32	4,6	16,0	21	90,6	74,6	24
0,20	32,4	18,0	13	58,2	56,6	11
0,16	26,8	16,6	5	31,4	40	6
0,10	26,2	21,8	4	5,2	18,2	2
0,04	5,2	16,0	1,4	-	2,2	0,6
Tray	-	2,2	0,6	-	-	-
Total	100	100	100	-	-	-
Basic fraction Văleni:	F_b = 0,20/ 0,10=32,4+26,8+26,2 = 85,4 [%]					
Basic fraction Făget:	F_b =0,20 / 0,10 = 18,0 + 16,6 + 21,8 = 56,4[%]					
Basic fraction Şag:	F_b =0,4/ 0,2 = 30,89+21+ 13 = 64,89 [%]					

Table 14. Grain-metric analysis of the sand Quartz of Faget

Size of the mesh	Residue on the sieve [%]	Cumulated passing through the sieve [%]
1,0	-	100
0,8	-	100
0,63	-	100
0,40	1,5	98,5
0,32	27	71,5
0,20	50,7	20,8
0,16	9,9	10,9
0,10	10,4	0,5
0,04	0,5	-
Tray	-	-
Total	100	-

On the basis of determining the cumulated passing through the sieves we may draw cumulative curves of the grains of sands from the rivers Văleni, Făget, Şag and Timiş, thus being able to determine for the sands analyzed the medium grains M50 respectively the size characteristic of the sand.

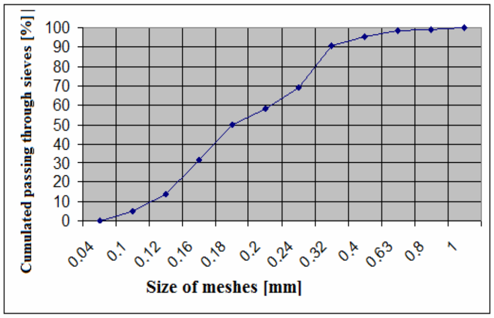

Figure 1. The cumulative curve of sands from Văleni

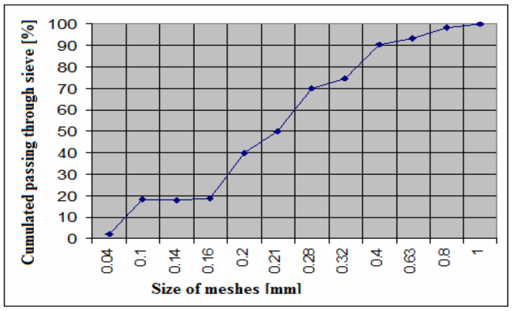

Figure 2. Cumulative curve of sands from Făget 1

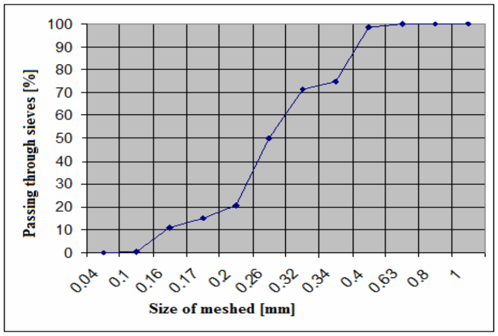

Figure 3. Cumulative curve of sands from Făget 2

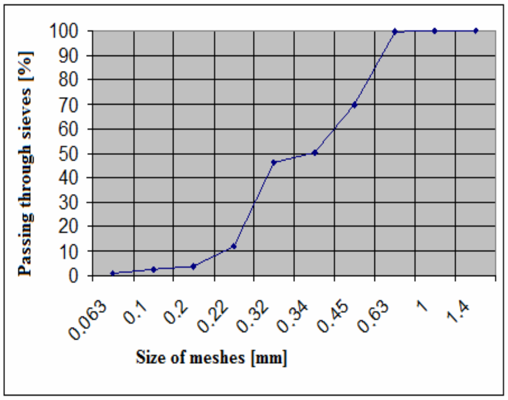

Figure 4. Cumulative curve of sands from Timiş

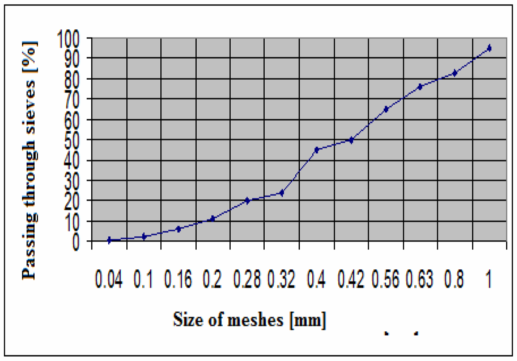

Figure 5. Cumulative curve of sands from Şag

Table 15. Medium grains M50 of river sands and their characteristics

Name of the sand used	Medium grain of sands [mm]		Sand group	Size characteristic
	Determined (M50)	Standardized min.		
Făget 1 river sand	0,21	0,30...0,21	M50(03)	Medium
Făget 2 river sand	0,26	0,30...0,21	M50(03)	Medium
Văleni river sand	0,18	0,20...0,16	M50 (02)	Half-fine
Timiş river sand	0,34	0,30...0,21	M50(03)	Medium
Şag river sand	0,42	0,60...0,41	M50 (06)	Big

4. Conclusion

If we compare the melting temperature of consecutive minerals of sands from the Timiş river (Table 5) with the vitrifying temperatures (1150ºC) and the refractory ones (1410ºC) we can see a string dependence between them.

The condition imposed to sands, to be able to be used in foundries, of having the vitrifying temperature of 900ºC in the casting of light non-ferrous alloys, of 1200ºC for cast irons and heavy non-ferrous alloys and over 1410ºC for steel, is satisfied only partially for the sands studies.

The content of leachate parts of the sand from Timiş is under 1,5%. The content of SiO_2 smaller than 90% of the sand (Table 6) situates it in the category of weak sands. If we keep in mind that the basic minerals $SiO_2 + Al_2O_3$ are over 90%, then the sand can be classified as being Quartz cu feldspar.

From Tables 12, 13 and 14, keeping in mind the basic fractions obtained for the sands analyzed we may conclude that the sands from Văleni, Făget and Timiş are middle sands from the group 0,2 and the Şag sand is a sand from the big group 0,3.

In general, we may say that the sand from the river Timiş can be used with good results in casing parts from alloys with low melting temperatures.

A supplementary treatment of these types of sands: washing, elimination of organic impurities and reduction of oxide contents of alkaline metals and alkaline-soil metals, a corresponding passing through sieves, may offer them superior characteristics. These technological characteristics offer them capacities of use on a large scale in foundries in order to prepare molding sands

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