Recycling of Industrial Waste Containing Iron in Magnetorheological Suspensions

Sahiba Kalaeva, Vladimir Makarov, Nadejda Markelova, Ramil Kalaev

Yaroslavl State Technical University, 150023 Yaroslavl, Russia

doi: https://doi.org/10.21467/abstracts.93.77

ABSTRACT

One of the ways to solve the problem of environmental protection against industrial waste containing iron is to use it as raw material in magnetorheological suspensions. A magnetorheological suspension (MRS) is a specially prepared mixture of iron particles of about 10 μm in size in a carrier fluid with stabilizing and special additives. The viscosity of such a suspension can increase one hundred-fold when the magnetic field increases, in contrast to magnetic fluids, the viscosity of which increases by 10—30 %.

At the moment, such colloidal systems, which are stable nanoparticle clouds of magnetic metals and ferrites in the corresponding carrier fluids (dispersion media), can be used as working media in dampening devices and in the processes of magnetic separation of non-magnetic materials (ores), as well as lubricating and sealing materials, and thermal media, the behavior of which can be controlled with the forces of an external magnetic field.

The purpose of this work was to obtain magnetorheological suspensions for technical purposes which would be stable in gravitational and magnetic fields. We have obtained several samples of oil-based MRS containing industrial by-products with some concentration of iron (a sediment resulted from deferrization of drinking water, dust from electrostatic precipitators (ESPs) of metallurgical plants, galvanic sludge), as well as with various systems of magnetic nanoparticles stabilization in different media. The composition of iron-containing industrial waste is given in Table 1.

Table 1 – Iron-containing waste composition, (%)

Component name	Waste of PJSC "Severstal" ($FeSO_4$)	Waste of PJSC "Severstal" (dust from ESPs)	Sediment from the underground potable water deferrization station	Galvanic sludge from PJSC "Yaroslavl Shipbuilding Plant"
FeO	47.0±5.60	3.4±0.50	-	-
Fe_2O_3	1.6±1.00	76.96±0.77	62.3±5.00	55.7±2.8
Fe_{met}	-	0.34±0.03	-	-
MnO	0.1±0.06	0.4±0.04	-	-
CaO	0.09±0.05	2.75±1.34	13.20±2.50	8.1±1.2
MgO	-	2.63±1.05	6.90±2.50	-
K_2O	-	0.06±0.001	-	-
Na_2O	-	0.14±0.07	-	-
ZnO	-	4.47±0.76	7.80±1.60	2.60±0.7
PbO	-	1.07±0.09	-	-
C_{total}	-	0.943	-	-
CuO	-	0.22±0.01	0.58±0.30	0.10±0.06

DOI: 10.21467/abstracts.93

Al_2O_3	-	1.10±0.09	0.48±0.20	-
S	-	0.232	-	-
P_2O_5	-	0.15±0.008	-	-
SiO_2	-	2.09±0.35	5.60±0.50	-
$H_2SO_{4\ free}$	0.3±0.09	-	-	-
Cr_{total}	-	-	-	2.9±1.2
NiO	-	-	0.15±0.10	0.41±0.3
Insolubleresidue	0.2±0.07	22.40-±4.6	1.20±0.10	5.53±0.3

The oil-based magnetorheological suspension was obtained in several stages:

1) synthesis of highly dispersed magnetite from iron-containing industrial waste, mother liquor separation; additional dryingwith acetone;

2) magnetite stabilization (industrial oil was heated to 60–80 ºC in a water bath and oleic acid and cup grease were added into it with constant stirring; the heated oil mixture was then poured onto the dried magnetic mass and stirred for one hour with a mechanical disperser).

As the temperature decreased, the magnetic pseudo-homogeneous mass increased its viscosity. At very high viscosity, additional 20-30 ml of industrial oil were added to the system, and the mass was mixed again.

Thus, we have developed technologies to recycle industrial waste containing iron in magnetorheological suspensions. Samples of magnetorheological suspensions were obtained from iron-containing waste with various (straw) mineral oil-based and glycerol ethylene-glycol-based technologies.

Properties of the obtained MRS samples were identified. It was noted that MRS made of industrial waste has properties equivalent to MRS made of pure components (reactive materials): density — 1200-1650 kg/m^3, saturation magnetization 25-40 kA/m.

DOI: 10.21467/abstracts.93