On the scaling of pinning force in ceramic MgB_2

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We present an investigation of the field dependence of the pinning force of MgB_2-based superconducting composites as obtained by spark plasma sintering with different ingredients which are designated to enhance the pinning force F. Generally, the latter quantity, scaled to the maximum pinning force F_{max}, obeys a scaling law as a function of the scaled field h when the irreversibility field H_{irr} is considered as scaling field. The scaled function is described in terms of a generalized scaled function $h^p(1-h)^q$. However, in our samples the scaling is absent. In addition, the peak of the scaled function shifts to higher reduced fields h when the temperature increases. Depending on the level of doping and the nature of the nanosized particles used to built the superconducting composites, we found that the scaled force can be depicted either with a combination of generalized scaled functions with different exponents or with a single function but multiplied with an envelope, usually an exponential factor. The former dependence is present in the samples with high amount of nanoparticles and mirrors two types of pinning of close weights. The presence of the exponential factor in the latter dependence is attributed to the combined effect of the intrinsic anisotropy of MgB_2 and the random orientation of the grains relative to the magnetic field.