

Comparison of comprehensive performances of various permanent magnets

According to the characteristics of permanent magnetic materials, Different kinds of permanent magnets can be obtained by using different production processes. At present, the commonly used permanent magnet mainly have [AlNiCo magnets](#), ferrite permanent magnet, [SmCo magnets](#)(including SmCo5 and Sm2Co17),[sintered NdFeB](#),bonded neodymium-iron-boron(NdFeB) and [magnetic rubber](#). The magnetic properties and other parameters of different types of permanent magnets are different.These types of permanent magnet characteristics and performance parameters are introduced as following:

(1) Aluminium- nickel-cobalt ([AlNiCo magnets](#))

The magnetic properties of AlNiCo belong to medium low level, and the maximum energy product of AlNiCo magnets can reach 8~103 kJ/m³, that is, 1~13 MGOe.Because its Curie temperature is $T_c=890$ degrees Celsius, the maximum temperature can be as high as 600 degrees Celsius, and the temperature coefficient is very low, -0.02%/ degrees Celsius. AlNiCo magnet has better oxidation resistance and corrosion resistance.The machinability of AlNiCo is outstanding in permanent magnet materials, because the hardness and brittleness of permanent ferrite and rare earth permanent magnet are much larger than that of AlNiCo magnets.In addition, in some cases, Alnico is used to make compact and miniaturized complex shape permanent magnet components, and its cost is almost the lowest.Because of its excellent mechanical properties, Alnico can be used as a structural part of complex magnetic circuit, while rare earth permanent magnet and ferrite permanent magnet can only be used as functional materials.In addition, Alnico can also be directly with plastic, nylon and powder metallurgy parts to realize the integration of high temperature (600 DEG C) processing and combination, shows good processability of

AlNiCo magnets. Because the AlNiCo contains Ni and Co which are strategic metal, its price is higher than that of ferrite, at a moderate level. The disadvantage of AlNiCo magnets is that the coercivity is very low (typically less than 160 kA/m), so the AlNiCo magnets although are easy to be magnetized, also easy to demagnetization.

(2) permanent magnetic ferrite/ceramic magnets

The magnetic property of the permanent ferrite is low, and the maximum energy product is about 0.8~5.2 MGOe. But it has abundant raw materials, low average price, cost-effective, anti-demagnetizing properties, no oxidation problems. The curie temperature of the permanent ferrite is about 450 degrees centigrade, and the maximum temperature is 300 degrees Celsius. Because of its brittleness, its machinability is normal.

(3) Samarium Cobalt magnets: SmCo1:5 type (SmCo₅) and SmCo 2:17 type (Sm₂Co₁₇)

Magnetic performance of SmCo magnets belong to the medium to upper level, The magnetic properties of type SmCo₅ magnets are lower than those of type Sm₂Co₁₇ magnets. The magnetic energy of the two kinds of SmCo magnets currently produced are 15~24 MGOe and 22~32 MGOe. The Curie temperature of the two is 740°C and 926°C, The maximum service temperature is 250 and 550, respectively. The 2:17 type samarium cobalt magnet is much higher than the 1:5 type samarium cobalt magnet. SmCo magnets development in recent years is mainly 2:17 type magnet, Because of its high Curie temperature and small coercivity temperature coefficient, it is the best choice for high temperature applications to maintain high magnetic performance in high temperature environment. SmCo magnets with anti-oxidation and corrosion resistance is very strong, so it does not need the coating for use. Because the SmCo magnets of high brittleness, the machining performance is in general. SmCo magnets because of containing high

amounts of rare earth elements in small deposits of Sm and strategic metal Co, so that the SmCo magnet price is the most expensive of all permanent magnets.

(4) [Sintered neodymium-iron-boron](#) (sintered NdFeB magnets/sintered neodymium magnets)

The magnetic properties of sintered NdFeB are the highest in all magnets, so there is the title of "magnetic king".The maximum magnetic energy product of current produced sintered NdFeB magnets is 30~52 MGOe.Sintered NdFeB magnets is similar with hard ferrite magnets and SmCo magnets, brittleness is relatively large, so that the machining performance in general.The Curie temperature of sintered NdFeB is only 310 degrees centigrade, which makes the use temperature very low and the maximum is only 230°C, which has seriously affected its application in some special fields.At the same time, it is particularly easy to be oxidized and corrosion, so it is necessary for surface treatment during production, to increase the coating to prevent oxidation.The price of sintered NdFeB magnet is at a moderate level, which makes it a constant substitute for many other permanent magnets in many fields.

(5) **Bonded neodymium magnets (bonded NdFeB magnets)**

Bonded NdFeB magnet is the permanent magnet obtained by mixing NdFeB magnetic powder and epoxy resin.The magnetic performance is stable, and the maximum energy product is up to 3~13 MGOe. The magnet has good consistency and the performance fluctuates within 5%.Its Curie temperature is 350°C and the operating temperature is up to 150°C.Its product size precision is high, the shape freedom is big, may manufacture each kind of complex special-shaped products.The product surface treatments are with epoxy resin and parylene coating, excellent corrosion resistance, smooth surface appearance, can be used for a long time in daily or harsh environments.The price is lower than that of sintered NdFeB magnets, can replace sintered NdFeB magnets and permanent magnet ferrite in some fields.

(6) Flexible rubber magnets

Rubber magnet is made of ferrite, magnetic powder and synthetic rubber, and then processed by a certain process. Its maximum energy product is 0.60~1.50 MGOe, the maximum use temperature of 100 degrees Celsius. Rubber magnets have flexibility, elasticity . They can be made into flexible magnetic coils, [magnetic sheets](#), magnetic bars, [magnetic strips](#), magnetic blocks, magnetic rings and various complex shapes by proper process. Its surface can also be coated with PVC, coated paper, double-sided adhesive, coated with UV oil, or color printing, die-cutting into various shapes. Because the magnet is coated with organic material, it has good oxidation resistance and corrosion resistance. Flexible rubber magnets price is the lowest in all permanent magnets, but it is widely used in our daily life.

By introducing the characteristics of all kinds of permanent magnets and the introduction of performance parameters, we can get a general idea of different types of permanent magnets. By comparing the magnetic parameters of various types of magnets and other non magnetic parameters and prices, the understanding of various types of permanent magnets can help to select the permanent magnets according to the actual application requirements. In addition, for the magnets of the same type, according to the different grades of products, there are great differences in performance, understanding the performance parameters of different grades of magnets also helps to accurately select the appropriate grades. About the grades and its detail properties of all kinds of permanent magnets, please know it by clicking products then clicking magnetic material, there are detail information.

The below table summarizes the comprehensive performances of all types of permanent magnets

Permanent Magnet Types	Maximum Magnetic Energy $(BH)_{max}$ (MGOe)	Curie Temp. T_c (°C)	Maximum working Temp. (°C)	Oxidation resistance and corrosion resistance	Machining property	Price
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AlNiCo	1.2-13	890	600	good	preferably	medium
Hard Ferrite	0.8-5.2	450	300	good	normal	cheap
SmCo ₅	15-24	740	250	good	normal	Expensive
Sm ₂ Co ₁₇	22-32	926	550	good	normal	Expensive
Sintered NdFeB	30-52	310	230	Poor	normal	medium
Bonded NdFeB	3-13	350	160	good	good	medium
Rubber Magnets	0.6-1.5	-----	100	good	good	cheap