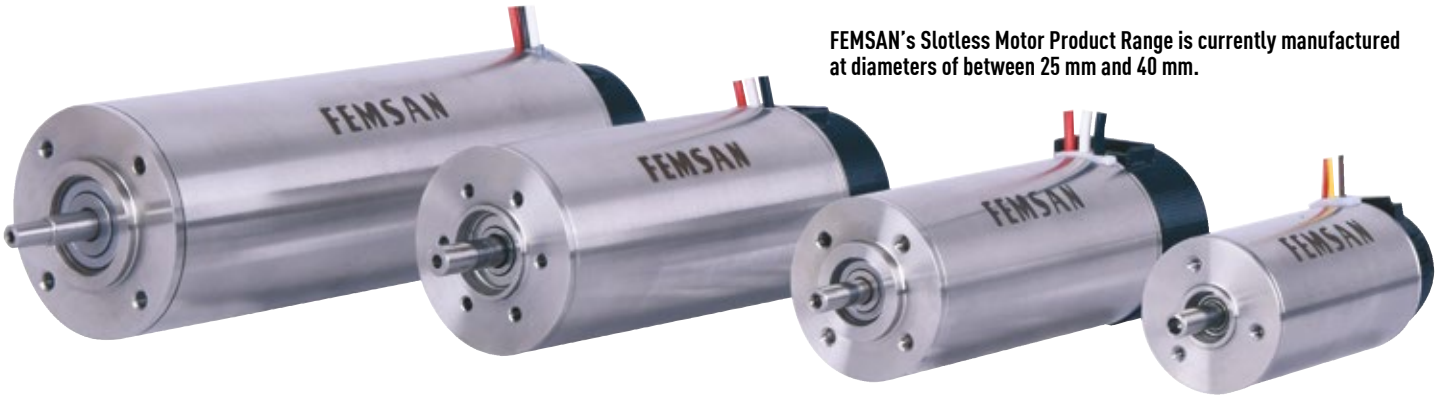


FEMSAN's Slotless Motor Product Range is currently manufactured at diameters of between 25 mm and 40 mm.

Femsan Signature on Slotless-Brushless DC Motors (BLDC), Critical Components of Defence and Aerospace Platforms

Electric motors can be counted among the critical components of defence and aerospace platforms, and the most technologically advanced and challenging variant of electric motors are Slotless-Brushless DC Motors. As a result of the development efforts of Femsan, Slotless-BLDC Motors have come to the Turkish defence and aerospace sector as indigenous products, while Femsan has added a new product to its wide range of electric motor solutions.

In defence and aerospace systems, electric motors are used:

- for moving control surfaces on platforms such as aircraft, missiles and unmanned aerial vehicles,
- for steering subsystems of such systems as radars and electro-optical sensors,
- in remote controlled weapon stations,

and in similar systems where movement is necessary. These application areas come with challenges, requiring high reliability, a need to operate under different environmental conditions, as well as being low volume and low weight.

Slotless-BLDC motors stand out in applications where low volume and low weight are of particular importance, such as in rocket, missile and unmanned aerial vehicle (UAV) applications. The advantages of these motors are as follows:

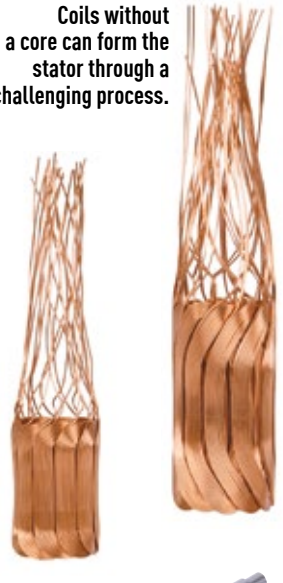
- Compact structure
- Low volume
- Low weight
- High efficiency
- Zero Cogging torque
- More precise control
- Silent operation
- Dynamic reaction
- Low EMI emission

And the common use of slotless-BLDC motors in a wide range of applications in the defence and aerospace sector is due to some, or sometimes all of these advantages. Thanks to their compact structure, these types of motors have been the first choice for many years in difficult aerospace projects in which every gram is calculated meticulously.

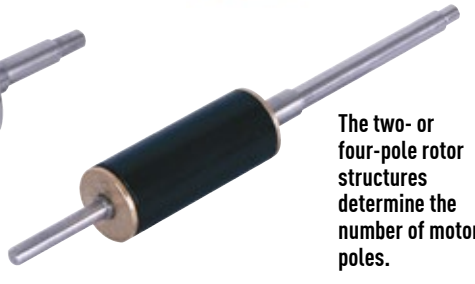
An Indigenous Solution from Femsan

Slotless-BLDC motors, which can be found in a large number of projects in Turkey, were being imported from overseas until recently. When the issue arose of the need to source these critical components domestically with an indigenous design, the solution was provided by Femsan, as the leading company in the field of electric motors. As part of a subproject under a Technology Development Liability (TDL), Femsan was commissioned to develop a range of slotless-BLDC motors within a contract signed between the Presidency of Defence Industries (SSB) and ROKETSAN.

As a result of the studies initiated in 2014, Femsan unveiled its indigenous product range, involving no



Coils without a core can form the stator through a challenging process.



The two- or four-pole rotor structures determine the number of motor poles.

All photographs: © Femsan

Electric Motor Centre of Excellence of the Sector: Femsan

Femsan has been engaged in the design and manufacture of electric motors for nearly 30 years, and has been manufacturing products for the defence and aerospace sector for the last 15 years. While Femsan's first products for the sector were Brushed Direct Current (DC) Motors Engines, different types of motors have been introduced to the company's range of solutions in order to meet market demand over time. Among these can be named Permanent Magnet (PM) Motors, AC Synchronous Servo Motors and aircraft alternators.

Femsan manufactures products and provides services in the field of electromechanics and mechatronics with the support of its R&D company MOTEK, which has 20 employees, while the total number of employees at Femsan is 160. The company's areas of business include electrical, mechanical and electronic applications. For almost all applications within these branches, it is possible to find a solution from Femsan that may be at a component level, such as sole electric motors or alternators, or components that are integrated into motors, such as actuators.

In addition, Femsan is able to manufacture the fin-drive components of a system, such as smart ammunition systems, as subsystems.

Femsan's products are used in machine gun platforms, turrets, radars, magazines, stabilizers and many other rotary and linear systems.

FEMSAN offers its slotless motors with Encoder feedback in the standard configuration.

reverse engineering. In the first stage, different electromagnetic designs were developed, after which, loss and gain analyses were carried out to select the most suitable design for application. Thermal and structural analyses were made of the designs, taking tough environmental conditions into account, and the most suitable design was chosen. Then, in what was the most important and challenging stage of the project, processes which will be used in manufacturing and which need to be customized according to products, were determined. In the final stage, the plans and results were compared through performance tests, and were recorded, showing that they are consistent with each other.

Femsan completed these studies in 2016, and throughout 2017, these products were qualified for defence and aerospace successfully. In accordance with the project setup, all processes were monitored closely by the SSB and ROKETSAN.

This led to the development of an indigenous, high-performance product family (Table 1), and Femsan was thus able to start meeting the specific requirements of Turkey's leading defence and aerospace companies. ◆

Table 1. Femsan slotless-BLDC motor product family

Diameter	Motors
40 mm	• 24 V 330 mNm 2 pole • 48 V 270 mNm 4 pole
35 mm	• 24 V 170 mNm 4 pole
30 mm	• 24 V 118 mNm 4 pole • 36 V 127 mNm 4 pole • 48 V 120 mNm 4 pole
25 mm	• 24 V 20 mNm 2 pole • 24 V 35 mNm 4 pole
16 mm	Available soon.
12 mm	Available soon.

Electric Motors and Slotless-BLDC Motors

Electric motors can be classified according to many different criteria, with one of the most basic classifications relating to the energy source. Within this classification, motors are grouped as either alternating current (AC) or direct current (DC). In addition to this basic classification, electric motors differ from each other in terms of being asynchronous-synchronous, or brushed-brushless, or based on the number of phases.

The leading difference of slotless-BLDCmotors relates to the structure of the motor itself. Slotless motors are often mistaken for coreless motors, although in both slotted and slotless motors, there is a core called a lamination. The difference between these two types is that one employs the winding of copper wires inside the slot, while the other has a core in tubular form, and cylindrical coils are wound externally. In the case of slotless motors, there are two main challenges: The technological challenge relates to the fact that optimizing the magnitude of the magnetic field in the windings without slot ends is difficult. In the manufacturing process, the challenge is in shaping the coils perfectly and locating them inside the core (called tread) tightly (Figure 1).

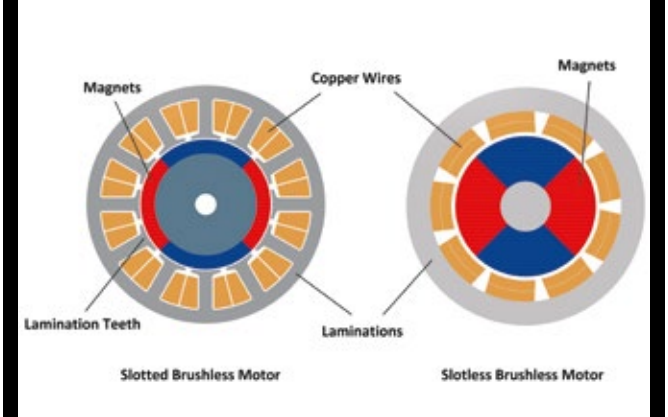


Figure 1. Slotted and slotless motor structures

In coreless motor structures, as the name implies, there is no core that interacts with the coils in any way. The windings are hardened by a chemical such as varnish or epoxy, which keeps the structure rigid.