2004 CHINA MATERIALS
BEIJING · CHINA

磁性材料专业论坛
Magnet Materials
文集

Sept. 23. 2004

主办单位/Organizers
北京新材料发展中心
Beijing Advanced Materials Development Center
上海新材料协会
Shanghai Society for Advanced Materials
国家新材料产业发展战略咨询委员会
National New Materials Strategical Consulting Committee

承办单位
中国金属学会功能材料分会
安泰科技 AT&M
日本应用磁学学会

专业论坛－"磁性材料专业论坛"会议日程
2004 年 9 月 23 日－24 日

时间 Date	演讲题目 Speeches Themes	演讲人 Speaker
9 月 23 日上午 8:30－10:00　　主持人：金重勋 8:30 AM －10:00 AM Sep. 23　　Presider：Jin Zhongxun		
8:30－9:00	稀土类磁体的生产与应用 Production and Application of Rare Earth Magnets	Nd 磁体株式会社（Neomax）（原住友特殊金属）Nd 磁体事业部技术部长——金子裕治 Dr. 金子裕治 Director of R&D Dept，Nd Magnet Division of NEOMAX Co.，Ltd.
9:00－9:30	稀土永磁电机的应用和进展 Application and Progresses of Rare Earth Permanent Magnets Motors	沈阳工业大学——唐任远院士 Academician Tang RenyuanShen Yang University of Technology
9:30－10:00	中国稀土永磁材料的产业现状 Industrial Development Situation of Chinese Rare Earth Permanent Magnets Materials	中科三环高科技股份有限公司高级副总裁——胡伯平 Prof. Hu Boping Executive Vice President of Beijing Zong Ke San Huan High－Tech Co.，Ltd.
10:00－10:20 茶歇 10:00－10:20 Break		
9 月 23 日上午 10:20－11:50　　主持人：周少雄 10:20 AM －11:50 AM Sep. 23　　Presider：Zhou Shaoxiong		
10:20－10:50	Nd 磁性材料的制备工艺与制造设备 Manufacturing Processes and Equipments of Nd Magnetic Materials	株式会社 ULVAC 产业机器事业部部长——加藤丈夫 Dr. Kato TakeoGeneral Manager of Industrial Equipment Division of ULVAC，Inc.
10:50－11:20	中国稀土永磁材料的技术进展 Technology Development of Chinese Rare Earth Permanent Magnets Materials	安泰科技股份有限公司功能材料事业部总经理——喻晓军 Dr. Yu XiaojunGeneral Manager of Functional Materials Division of AT&M

时间 Date	演讲题目 Speeches Themes	演讲人 Speaker
11:20 – 11:50	钕铁硼磁体的性能测试与质量控制 Performances Testing and Quality Control of NdFeB Magnets	中国计量科学研究院磁性材料测量实验室主任——林安利 Prof. Lin AnliDirector of Magnetic Materials Measuring Lab of National Institute of Metrology of China
12:00 AM – 1:30 PM 午餐 12:00 AM – 1:30 PM Lunch		
1:30 – 2:00	纳米结晶材料的应用制品的发展动向 Development Trends on Application Products of Nano – crystalline Materials	日立金属(株)FINEMET 事业推进部技术部长 – – 目黑卓 Dr. Meguro TakashiDirector of R&D Dept, FINEMET Business Development office of Hitachi Metals
2:00 – 2:30	软磁大块非晶的研究及双相耦合纳米晶永磁材料的新进展 Two – phase Nano – magnets and Bulk Ternary Fe – based Metallic Glasses	台湾清华大学教授 – – 金重勋 Prof. Jin ZhongxunTaiwan Qinghua University
2:30 – 3:10	中国金属纳米晶软磁材料的发展现状 Development of Chinese Metallic Nano – crystalline Soft Magnetic Materials	安泰科技股份有限公司副总裁——周少雄 Prof. Zhou Shaoxiong Vice President of AT&M
3:10 – 3:30 茶歇 3:10 – 3:30 Break		
3:30 – 5:30 主持人:金子裕治 3:30 PM – 5:30 PM Sep. 23 Presider:金子裕治		
3:30 – 4:00	宽温软磁材料的现状与开发 Current status of Development of wide – Temprature Mn – Zn Ferrite	横店集团东磁股份有限公司总经理——何时金 Prof. He Shijin-General Manager of Hengdian Group DMEGC Magnetics Co., Ltd
4:00 – 4:30	全球永磁材料的结构变化 Structural Changes of Global Permanent Materials	北京罗阳磁性材料科技开发公司董事长、IEEE 永磁技术委员会委员——罗阳 Prof. Luo Yang Member of IEEE T – C – 15 Voting

时间 Date	演讲题目 Speeches Themes	演讲人 Speaker
4:30 – 5:00	钕铁硼粘结永磁材料的技术新进展 Technology New Trends of NdFeB Sintered Permanent Magnetic Materials	海美格磁石技术(深圳)有限公司总经理——蒋龙 Prof. Jiang Long General Manager of High Mag (Shenzhen) Technology Co., Ltd.
5:00 – 5:30	粘结永磁材料的发展与应用 Development and Application of Sintered Permanent Materials	北矿磁材科技股份有限公司——尹有祥 Prof. Yin YouxiangB-GRIMM Magnetic Material & Technology Co., Ltd.

2004 China International Exposition & Forum
on Innovation Materials,Processes & Applications

Current situation of NdFeB sintered magnets in Japan

Dr. Yuji Kaneko

NEOMAX Co., Ltd.

NEOMAX

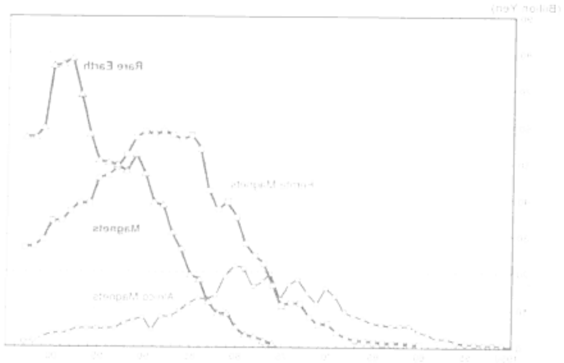
~Presentation Overview~

- Market trends of NdFeB sintered magnets in Japan
- Expanding Motor applications
- Cutting-edge technologies
- Proven surface coating technologies

NEOMAX

~Sales trends of permanent magnets in Japan~

- Sales amounts of Alnico, and Ferrite magnets have been decreasing
- NdFeB sintered magnets have been recovered in 2003

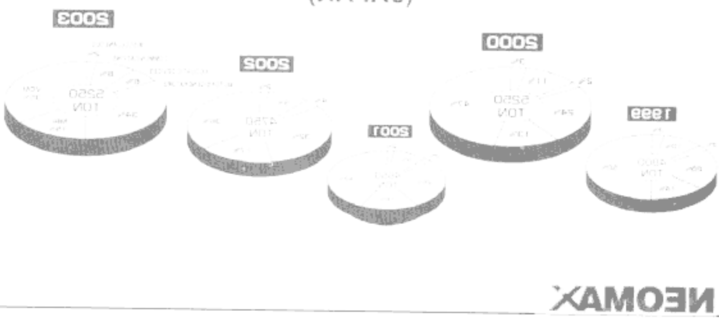


NEOMAX

~Production of NdFeB sintered magnets~

- Total weight of 2003's production probably reaches 5,250 metric tons
- The principle applications are VCM, MRI, Motors, IT devices

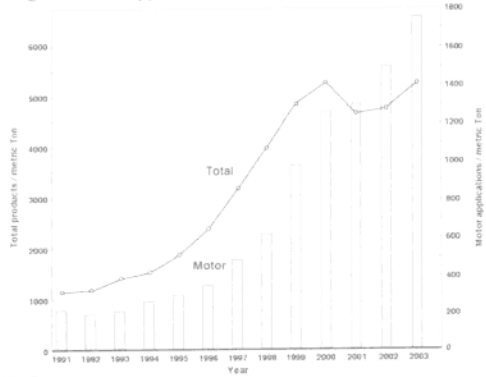
SINTERED Nd-Fe-B MAGNET PRODUCTION (JAPAN)



NEOMAX

~Expanding Motor Applications~

- Motor applications have been expanding almost 20-30% year by year.
- Total weight of motor applications probably reaches more than 1750 Ton



Trend of production amount of Nd-Fe-B sintered magnets for Motor applications.

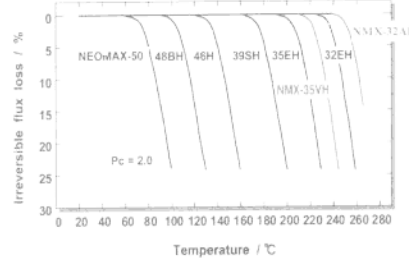
NEOMAX

~The reason why motor applications are increasing in Japan~

(1) Improving temperature stability.

(2) Improving corrosion resistance.

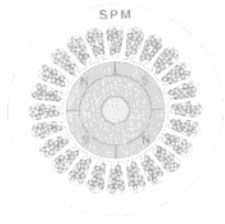
(3) Increasing merits by using NEOMAX.
saving electric power (energy)
down sizing



Improvement of thermal characteristics.

NEOMAX

~Evolution in Motor designing~



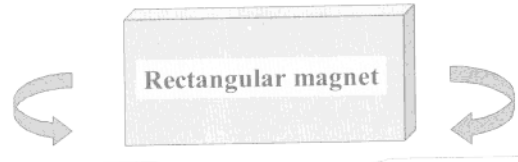
Typical rotor configurations of PM motor.

(a) SPM (Surface permanent magnet)
(b) IPM (Interior permanent magnet)

NEOMAX

~Advantages of IPM motors~

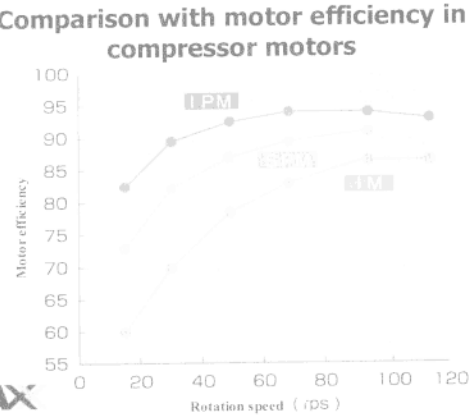
- IPM motors are used rectangular magnets
- Abundant merits are provided not only for assembler but also for magnet maker



Assembler	*Economy*	*Magnet maker*
Easily fix into yoke Hard to detach under high speed rotation Use high Br material		Economical shape Easily mass production Increase temperature stability due to design high Pc

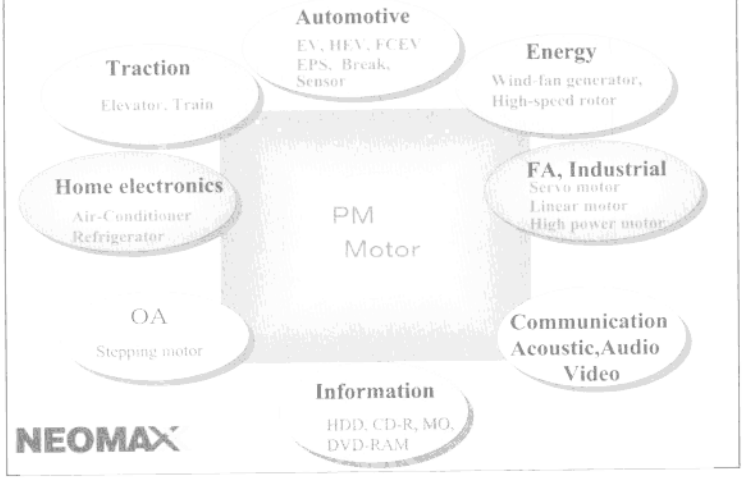
NEOMAX

~Improvement of motor efficiency~



NEOMAX

~Expanding motor applications~



NEOMAX

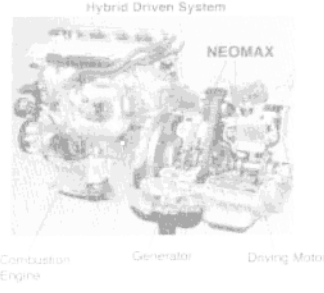
~Automobile applications :HEV~

- Nd AC-Synchronous Motor
  using NdFeB sintered magnets

  1st generation : Motor(33kW) & Generator(~6500rpm)

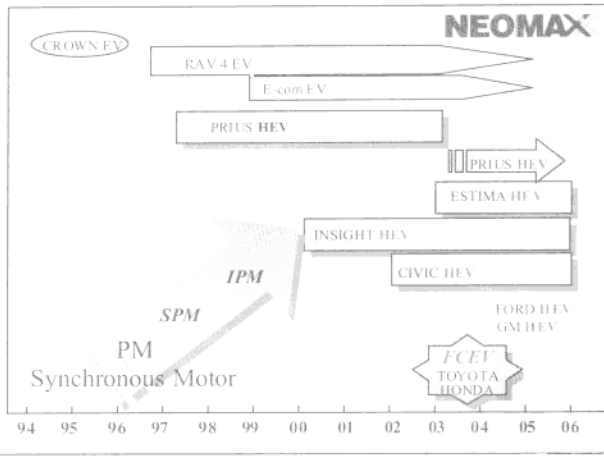
  New model :Motor(50kW) & Generator (~10,000rpm)

- Over 10,000 vehicle production per month



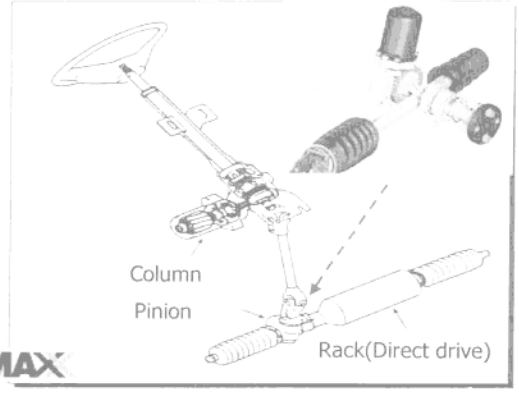
NEOMAX

Power train for the environmental-Vehicle by using Nd-Fe-B sintered magnets



Extending "X by Wire" projects

Electric Power Steering



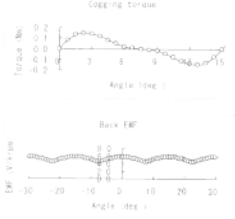
NEOMAX

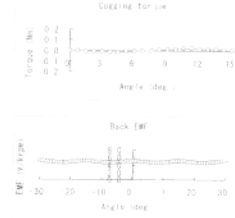
NEOMAX

~Cogging problem in EPS~

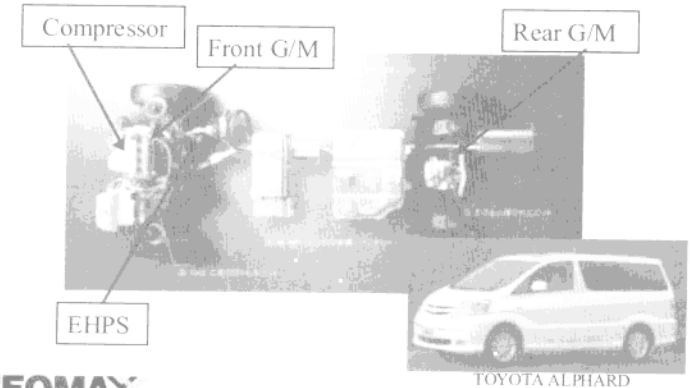
Magnet Weight
44 (g/set)

Magnet weight
36 (g/set)





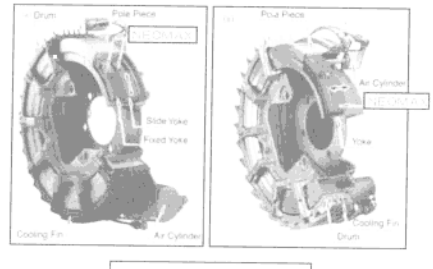
~Integrated motor applications~

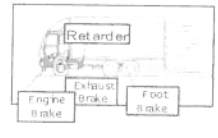


NEOMAX

~Application for Brake system : Retarder~

- ISUZU PRODUCTION SINCE 1990
- 65k ON THE ROAD
- AUXILIARY BRAKE SYSTEM FOR 4 & 10 TON TRUCK
- EDDY CURRENT
- ARC-SEGMENT NEOMAX (N-46BH)





NEOMAX

Applications and Trends of Rare Earth Permanent Magnet Machines

Tang Renyuan Liu Zhemin
Shenyang University of Technology

Abstract Rare earth permanent magnet electrical machines (REPMM) are useful for their good performance. In this paper, a brief introduction of the development of REPMM in China with the examples is presented. It also gives the trends of REPM machines.

1 Introduction

Rare earth permanent magnet (REPM) has attracted more and more people for its excellent performances, such as high remanence, high coercivity, and linear demagnetization curve. The electrical machines with REPM are characterized not only by high efficiency, high power factor, but also high power density. Many kinds of REPMM were developed for different applications[1].

China is abundant in rare earth resource. The annual production of NdFeB PM takes the top level in the world. And the high level NdFeB materials have been mass-produced in China, it is more convenient and favorable to develop and apply REPM electrical machines in China.

2 Developments and applications of rare earth permanent magnet machines in China

Since the previous decade, there have been many achievements of the development of REPMM in China. Here is a simple picture of the achievement.

2.1 REPMM for energy saving applications

Resource and environment becomes the most important problem as the industrialization. Energy saving is the way to protect resource and environment. As the induction motors consume more than 50% of the electrical energy, line-start REPM synchronous motors are developed to take the place of induction motors. Line-start permanent magnet synchronous motors enjoy high efficiency and high power factor both in rated-load and light-load, and may satisfy the specific demand of these application domains by special design.

1) Oil-well pump application

In oil-well pump application, the large locked-rotor torque is needed. A larger capacity of induction motor (IM) has to be adopted, which results in a light-load operating condition.

A series of PMSM used in oil-well pump has been developed. The performance is described in Table 1, compared with that of the same-capacity IM.

Such a 37kw PMSM owing to a high locked-rotor torque may take place of the 55kW IM in actual oil-well application and produce an active energy saving 20% and reactive energy 80% respectively.

Table 1 Performance of 37kW PMSM

	PMSM	IM
Rated efficiency (%)	95.6	91
Rated power factor	0.96	0.79
Locked-rotor (p.u.)	3.2	1.8
Pull-out (Maximum) torque (p.u.)	2.8	2.0

2) Fan and pump application

Motors for fan and pump application take about 40% of the electricity in China. Energy saving is very important. And for fan and pump application, the pull-out capacity is emphasized. The line-start high efficiency REPM synchronous motor has been developed up to 1120kW. The efficiency of the motors is about 2%~8% higher than the induction motors. The volume of the high-efficiency motors is one size smaller than the usual high efficiency motor. Following curves show the performance of the high-efficiency motor.

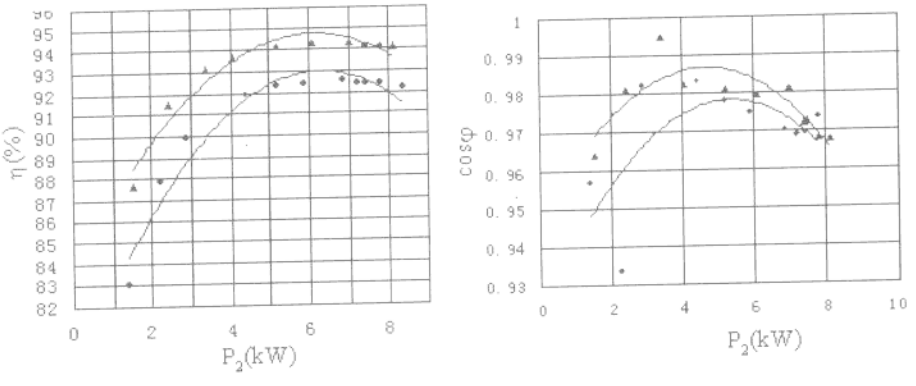


Fig.1 Performance Comparison of the High-efficiency REPMM and IM

▲ **High-efficiency REPM motor**

● **Induction motors**

The rotor magnetic structure, as show in Fig.2, has to arrange the necessary magnet, squirrel-cage and axial ventilating ducts. The magnetic field, heating and ventilating, and strength analysis must be made by finite element method. It is shown in Tab.2 that the PMSM enjoys not only high efficiency but also high overload capacity, may replace the induction motor or electric-excitation synchronous motor with a larger rated power or larger frame than the PMSM.

We assume that 3 Millions kW induction motor was replaced by high efficiency REPMM annually, at a average rate of energy saving of 10%, running 4000 hours a year, 1.2 billions kW·h energy would be saved.

2.2 AC Servo motors

2.2.1 Application to machine tool

PMSM having virtues of high efficiency and power factor, small inertia, quick response and high power (torque) density would be the important access to solve the high performance spindle drive, if it has adequate flux-weakening capability.

To meet the demands of mechanical strength, rigidity and flux-weakening, the PMSM adopts the rotor magnetic structure as shown in Fig.4.

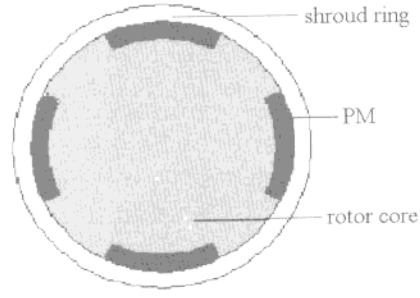


Fig.4 Rotor magnetic structure of PMSM in spindle drive application

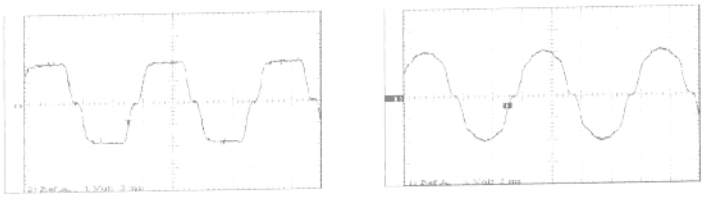
Table 4 Specification of PMSM in Machine Tool Application

Specification	Performance
Base speed (r/min)	1500
Minimum speed (r/min)	0.4
Maximum speed (r/min)	9000

2.2.2 Electric vehicle application

The PMSM plays an important role in electric vehicle (EV) drive owing to its high efficiency, low vibration and noise and high power (torque) density.

In order to improve the airgap PM magnetic field waveform of PMSM with inserted magnetic structure, the non-uniform airgap is employed. Then distinct improvement of the waveform of airgap flux density is obtained, as shown in Fig.5.



(a) uniform airgap (b) non-uniform airgap

Fig.5. the waveform of airgap flux density of PMSM

Winding switch technology adopted in PMSM can double enhanced climbing ability of electric vehicle on the premise of unchanging the inverter capacity.

The torque-speed curve is shown in Fig.6 and the efficiency is improved when in low-speed large-torque operation.

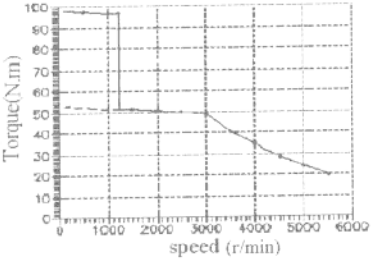


Fig.6 *T-n* curve of PMSM with winding switch in EV application

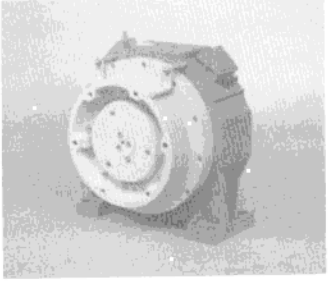


Fig.7 Gearless machine for elevator

2.2.3 Gearless direct driving system application

Low speed high torque motor for elevator direct driving system (Fig.7) was developed to meet the requirement of the increasingly demand. The geared machine has an efficiency lower than 60%. This is because most of the machines has worm gear and worm shaft with an efficiency lower than 70%. The efficiency of gearless machine is higher than 85%.

2.2.4 Ironless AC servo Motor

As there is no iron loss (no iron core) in ironless motor, the efficiency of ironless motor is very high. And the inertia of ironless motor could be very small. It would be useful in quick response system.

2.2.5 Transverse flux machine

In recent years, more and more people interest in the study and development of transverse flux permanent magnet machine (TFPMM) for the excellent feature of high power density. Many kinds of TFPMM with different topology were developed. But there are still two major shortcomings of the existing TFPMM. The

first one is low power factor. The second one is that the structure is too complex to manufacture. These shortcomings limited the application of TFPMM[2].

In China, a new topology of single side TFPMM that give an improvement solving of the problems, as shown in Fig.8, is developed. That is interior magnets transverse flux permanent magnet machine.

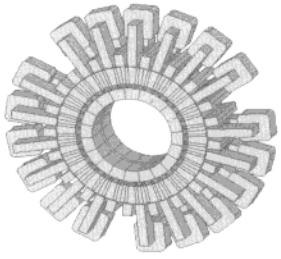


Fig.8 Structure of new TFPMM

A. Novel rotor structure

The basic structures of TFPMM were mentioned in ref.[3] and ref.[4]. It is known that the mounting of permanent magnets on the rotor is quite complex. In order to simplify the production, a new TFPMM was developed. The new TFPMM has a novel rotor structure. The rotor core is made of laminated steel as shown in Fig.9. There are permanent magnets in the slots.

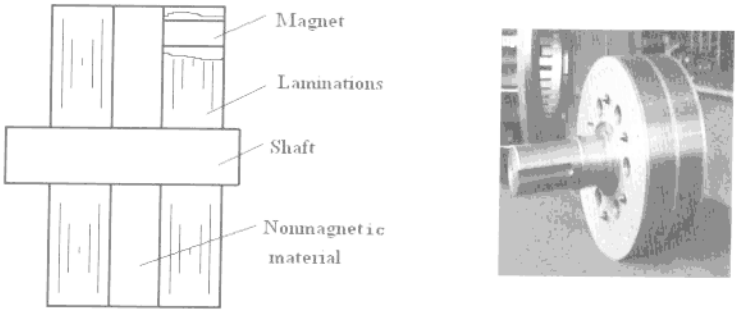


Fig.9 Rotor structure

This novel structure has some favorite features

(1) Laminated rotor iron with interior magnets. It is just like the traditional interior permanent magnet machine structure. It makes the production easy and mechanical reliability increased.

(2) The new structure makes the TFPMM be able to achieve higher airgap flux density than the former TFPMM due to flux concentration improvement.