

ICSC 2017

CAE for virtual product
CAE for innovation
CAE for process transformation

IDAJ CAE Solution Conference

Jmag Designer在有刷直流汽车起动 电机设计上的应用

IDAJ中国
技术部 JMAG产品组

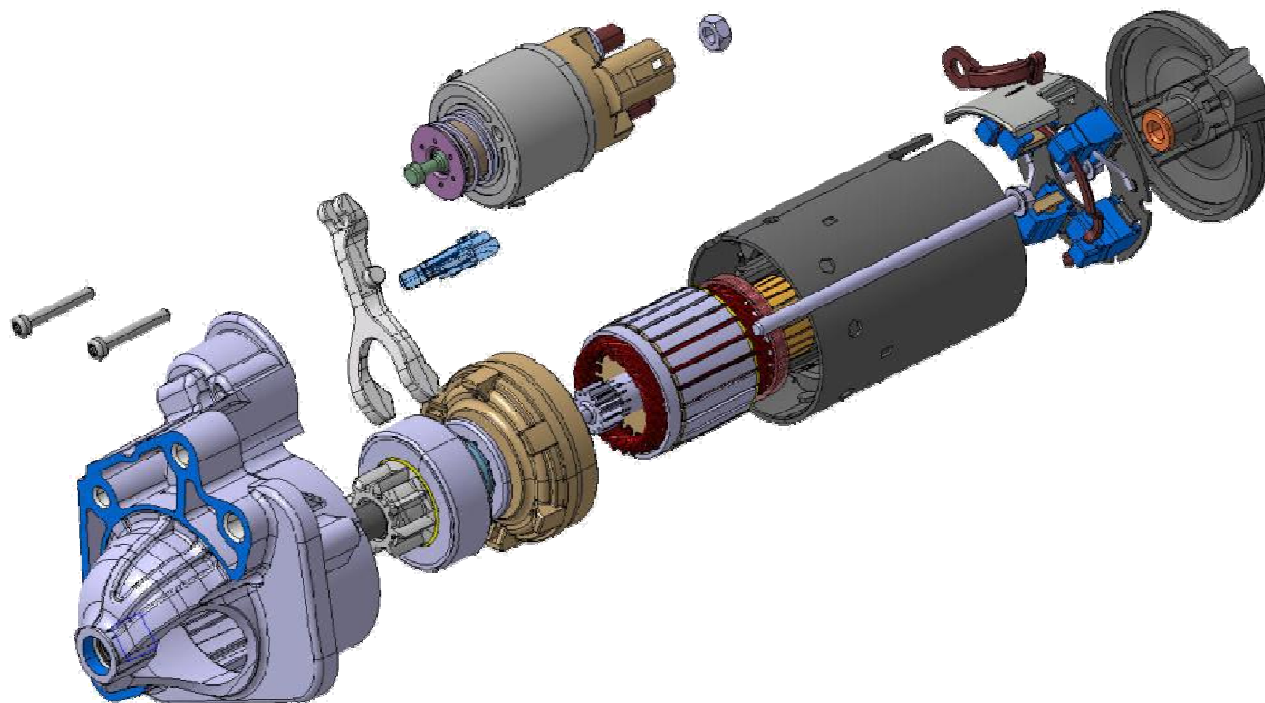
上海法雷奥汽车电器
CAE, 孙韬
tao.sun@valeo.com



SMART TECHNOLOGY
FOR SMARTER CARS



JMAG[®]
Simulation Technology for Electromechanical Design



BRUSHED DC MOTOR DESIGN FOR ICE STARTER IN JMAG DESIGNER



Date

CONFIDENTIAL

AGENDA

-  Company introduction 公司简介
-  Introduction of starter motor 起动机介绍
-  Calculation of brushed PM-type starter 永磁型起动机的计算
-  Computation of brushed wound-type starter 绕线励磁式起动机的计算
-  Conclusion 结论

公司简介

COMPANY INTRODUCTION



Company introduction 公司简介



Introduction of starter motor 起动机介绍



Calculation of brushed PM-type starter 永磁型起动机的计算



Computation of brushed wound-type starter 绕线励磁式起动机的计算



Conclusion 结论

公司简介

COMPANY INTRODUCTION

Valeo in China 法雷奥中国

Today



15,000 Employees

26 Production sites

13 R&D centers

1 Distribution center

All Product Groups

24 % of Valeo's total order intake

end 2013

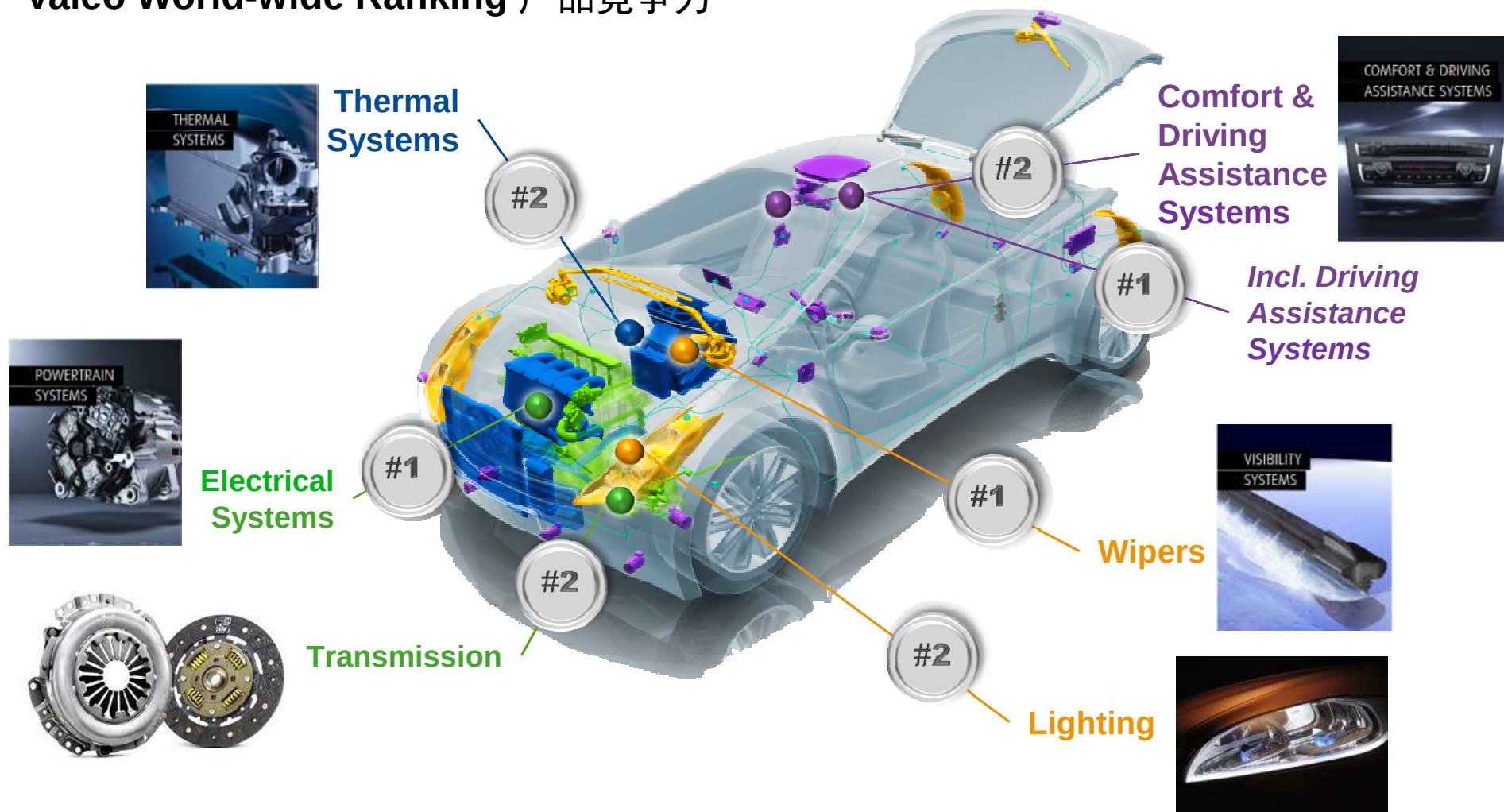
Tomorrow

- By 2014: 1st country in terms of number of employees
- Between 2011 & 2015: sales will double
- By 2016: 1st country in terms of sales

公司简介

COMPANY INTRODUCTION

Valeo World-wide Ranking 产品竞争力

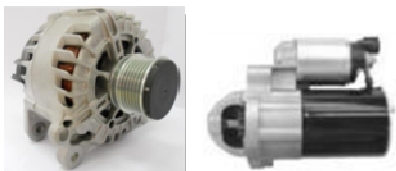


COMPANY INTRODUCTION

Powertrain Electrical Systems (PES) 电气系统

Conventional Systems

Starters and alternators

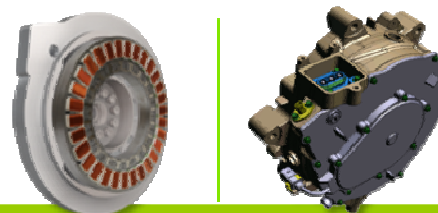


Belt-driven starter-generators: i-StARS



Mild / Full Hybrids

Crankshaft motor generator: CMG



Hybrid4All



High efficiency alternator

Micro Hybrids



Reinforced starters



Belt Starter Generator: iBSG



Gearbox Motor Generator: GMG



Drivetrain Motor Generator: DMG

公司简介

COMPANY INTRODUCTION

Our Customers 客户基础



For 90 years the
automobile has been
inspiring us

公司简介

COMPANY INTRODUCTION

PES Worldwide 公司分布



Alternators
Etaples France



Starters
Isle d'Abeau France



Advanced R&D
Creteil France



Alternators
Bursa Turkey



Alternators/Starters
Kyongju Korea



Starters
Czechowice Poland



Aftermarket
Czechowice Poland



Alternators/Starters
Shanghai China



Alternators/Starters
Campinas Brazil



Alternators
San Luis Potosi Mexico



Alternators/Starters
Pune India

公司简介

COMPANY INTRODUCTION

Shanghai Valeo Electrical System 上海法雷奥汽车电器系统有限公司

➤ #1 in China, 25% passenger vehicle market share

➤ Shareholding: 50% VALEO  / 50% Huayu (SAIC Group) 

➤ Headcount: 2,007 (Dec. 2016)



<i>In Mln units</i>	Yr 2012	Yr 2013	Yr 2014	Yr 2015	Yr 2016
Alternator Production	5.1	6.0	6.9	7.3	8.8
Starter Production	4.2	4.6	4.3	3.8	4.4

+ 1,3 Mln + 0,6 Mln + 0,12 Mln + 2.1 Mln

Valeo's biggest plant worldwide with a constructive area of > 53,000sqm

COMPANY INTRODUCTION

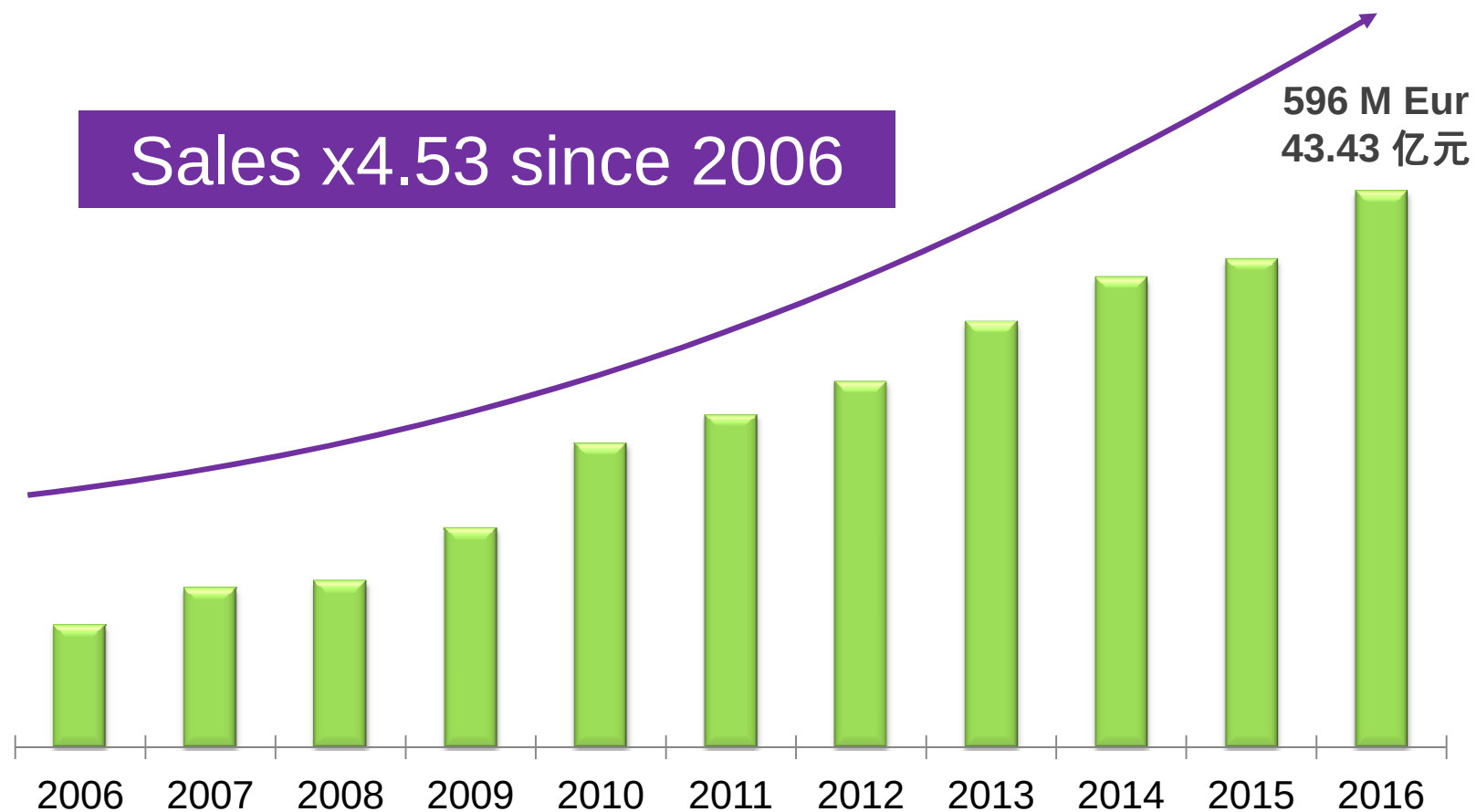
Shanghai Valeo Event 上海法雷奥发展

➤ 2016	Decision to localize 48V Beltless E-machine
➤ 2014	Decision to localize 48V Mild Hybrid i-BSG
➤ 2013	New Plant in Pudong Jinqiao Localization RSM14, NRG11
➤ 2012	Localization ESW22, ESW24
➤ 2011	Localization FGt, Mechatronics, ESM14, FS18, FG20+, FG23
➤ 2009	Localization VALEO Products FG
➤ 2007	Localization VALEO Products D7R
➤ Mar. 2005	Localization VALEO Products TG/TS
➤ Dec. 2003	VALEO increased share to 50%
➤ Aug. 2001	Localization VALEO Products SG
➤ Mar. 1998	New Plant in Pudong Zhangjiang Hi-Tech Park
➤ Jan. 1997	Localization VALEO Products VI/D6RA
➤ Feb. 1995	Setup of JV

公司简介

COMPANY INTRODUCTION

Strong Growth 年销售额



起动机介绍

INTRODUCTION OF STARTER MOTOR



Company introduction 公司简介



Introduction of starter motor 起动机介绍



Calculation of brushed PM-type starter 永磁型起动机的计算



Computation of brushed wound-type starter 绕线励磁式起动机的计算

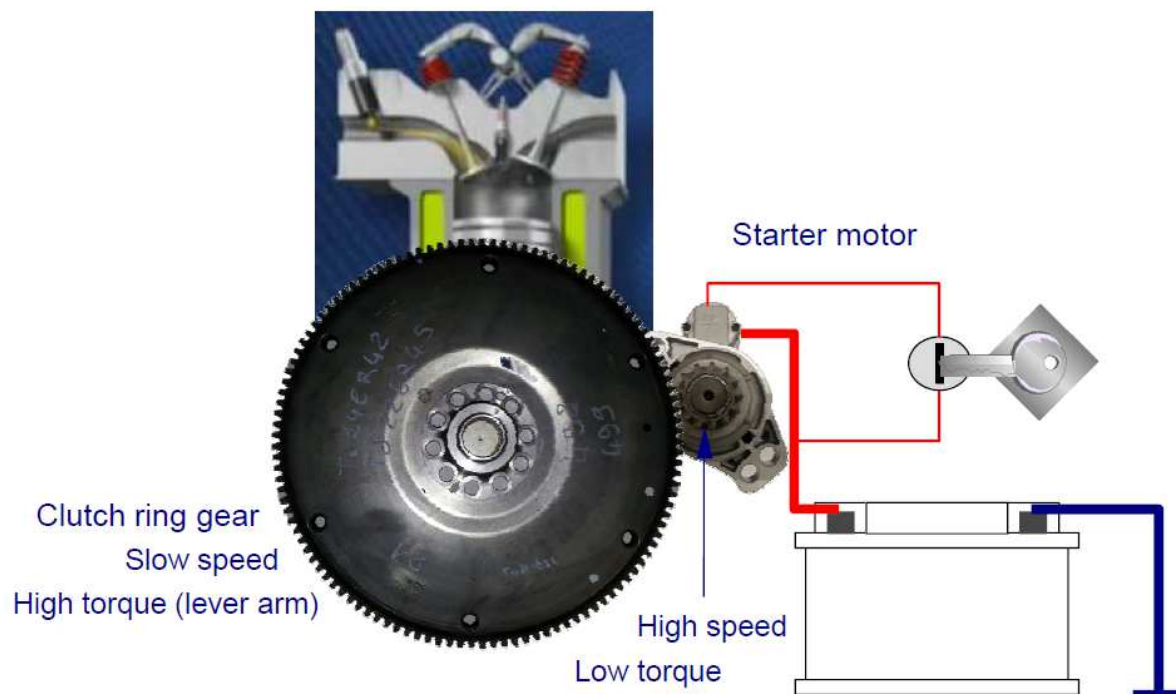
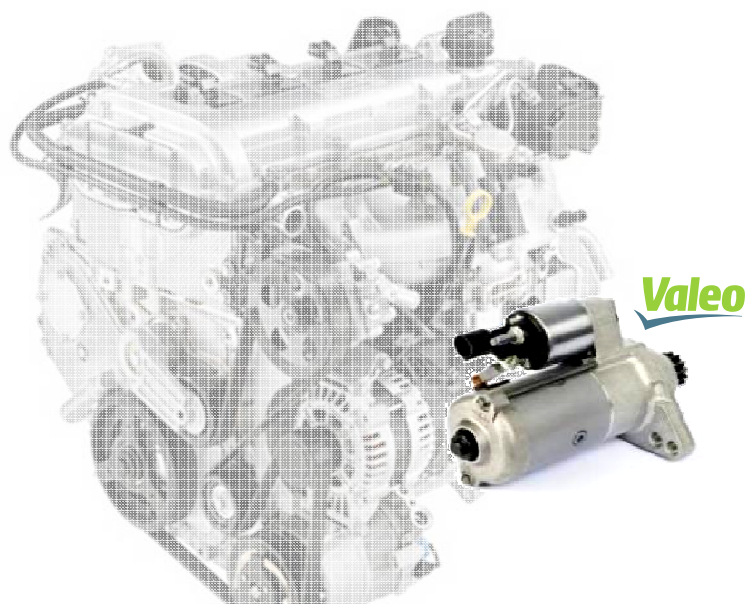


Conclusion 结论

起动机介绍

INTRODUCTION OF STARTER MOTOR

Starter for ICE 内燃机起动机

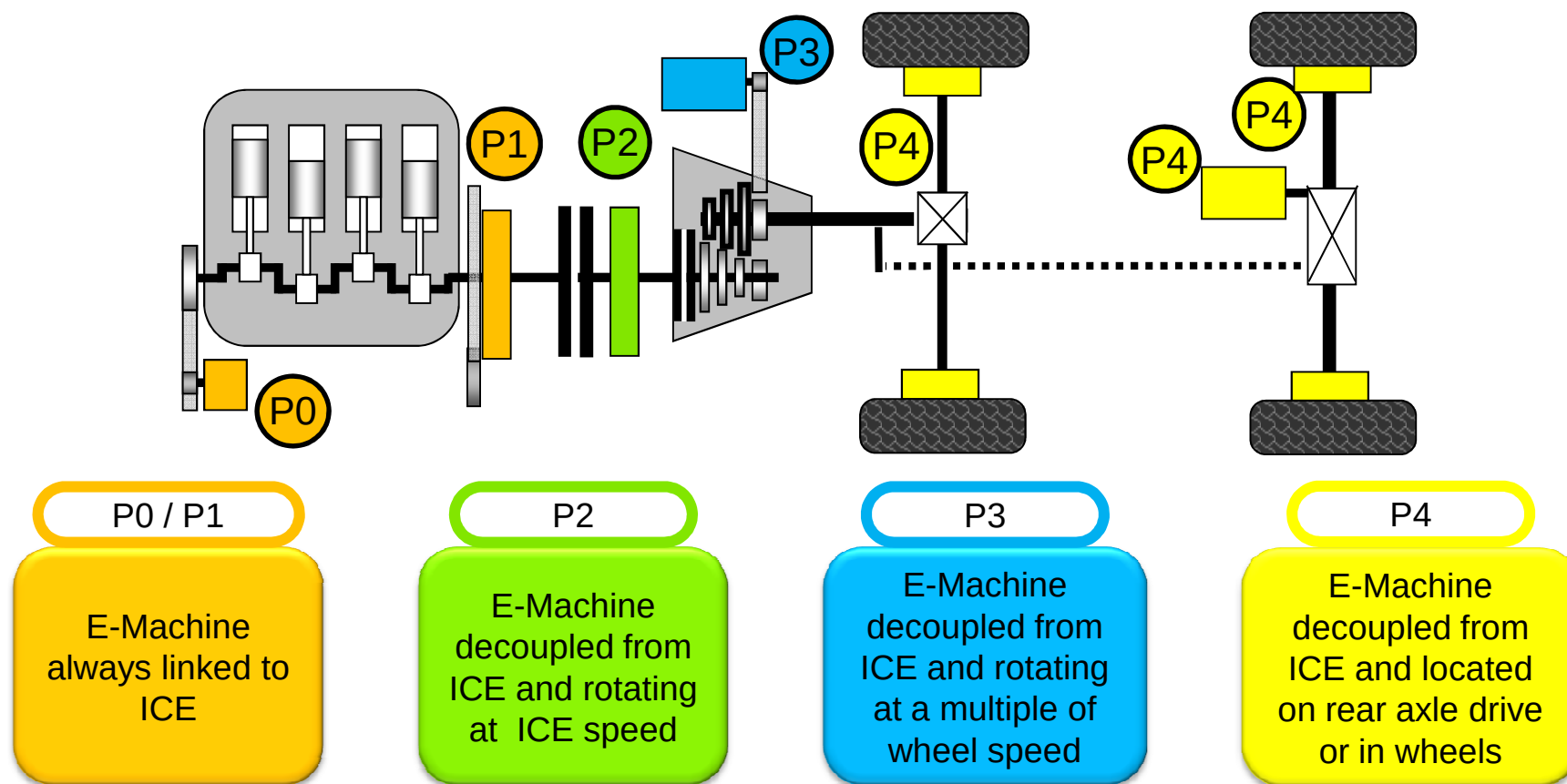


- The Starter is used to start the combustion engine to run at spec. speed at which the combustion engine can autonomous run
- 起动机是用来将汽油或者柴油发动机起动至其可自主运行的转速的装置

起动机介绍

INTRODUCTION OF STARTER MOTOR

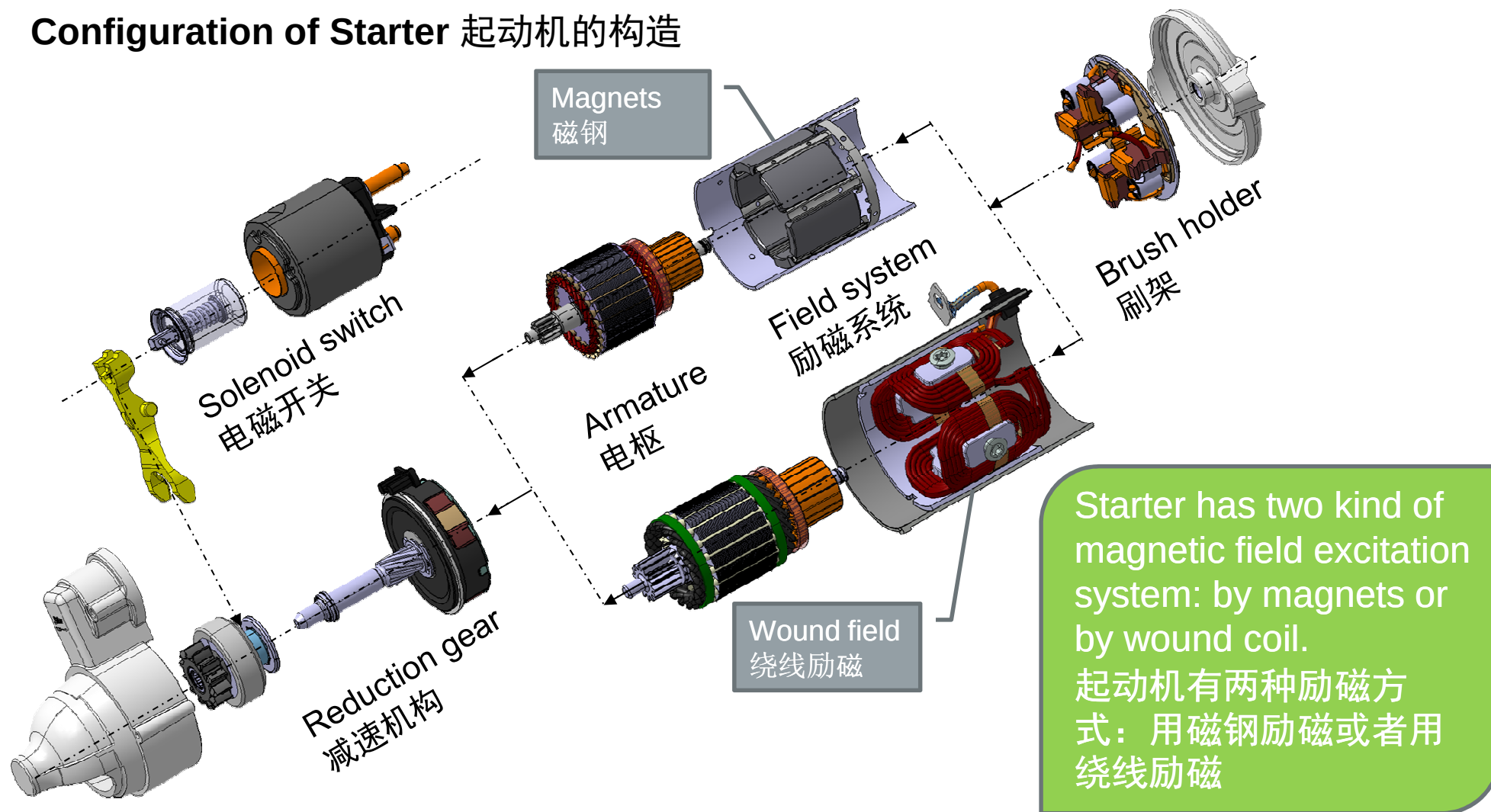
Starter in Hybrid Vehicle 混合动力汽车用的起动机



Except P1 type, all other hybrid topologies still need starter to start the ICE engine

INTRODUCTION OF STARTER MOTOR

Configuration of Starter 起动机的构造

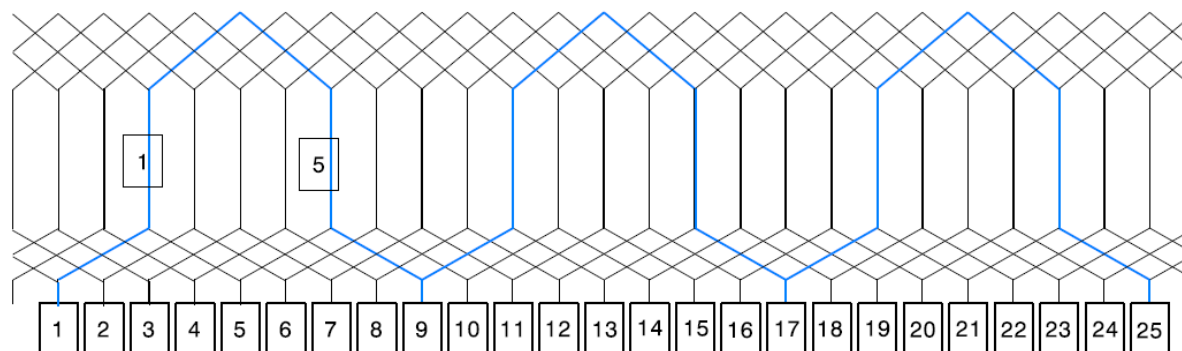


INTRODUCTION OF STARTER MOTOR

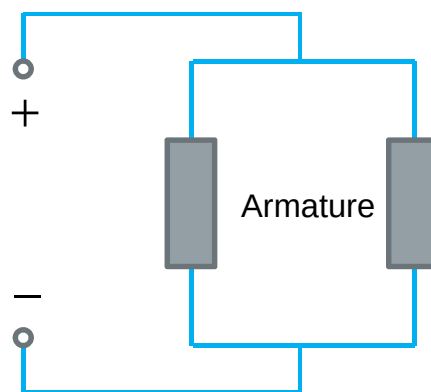
Winding and Circuit 绕组和电路



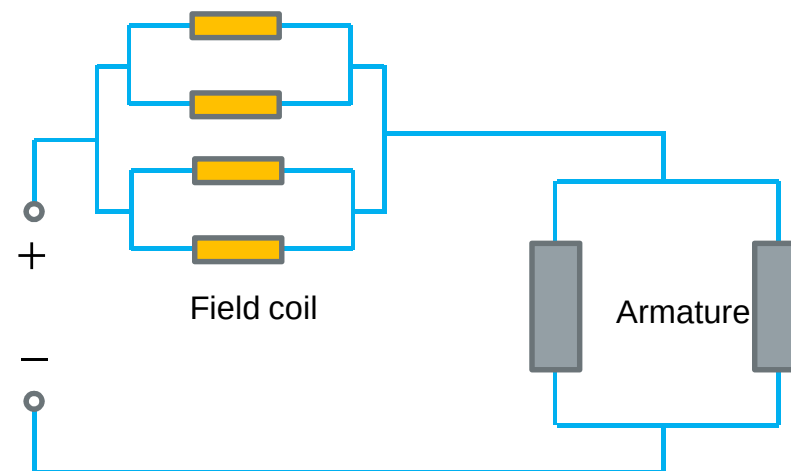
Armature
电枢



Wave winding 波绕组



PM type circuit

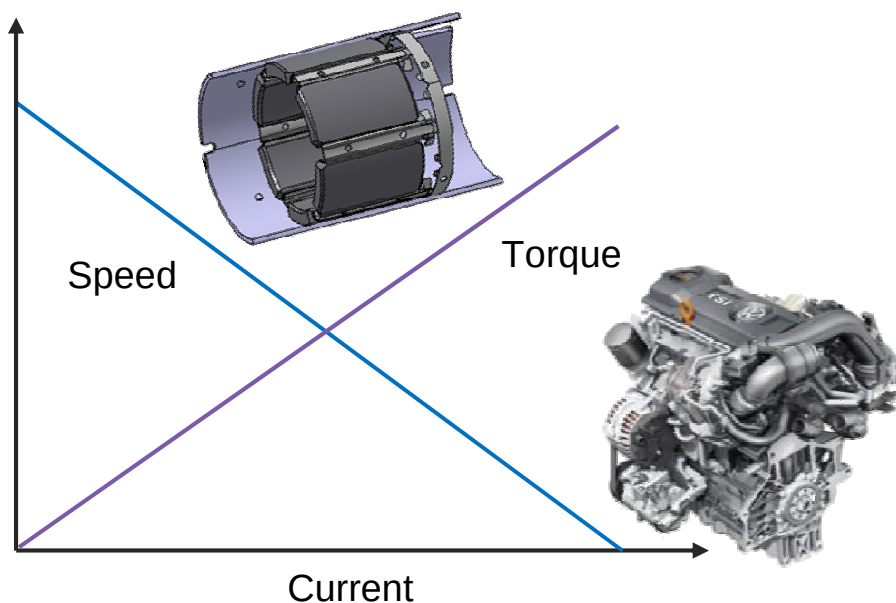


Wound-field type circuit

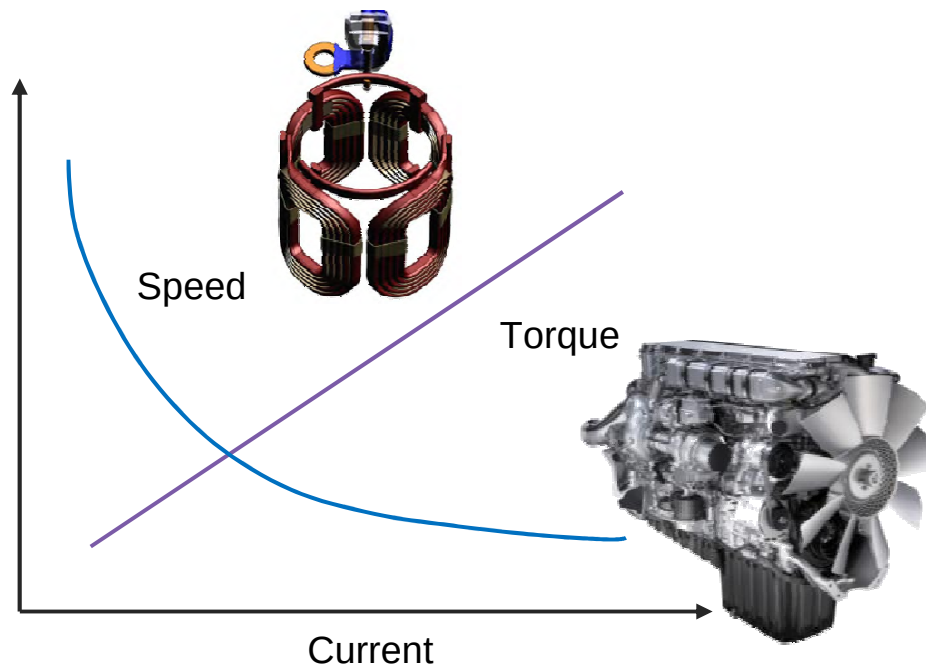
起动机介绍

INTRODUCTION OF STARTER MOTOR

Typical Performance 典型的性能曲线



PM type performance curve



Wound-field type performance curve

- PM type motor → Passenger car 永磁式主要用于乘用车
- Wound-field motor → Heavy duty vehicle 绕线励磁式主要用于重型汽车

永磁型起动机的计算

CALCULATION OF BRUSHED PM-TYPE STARTER



Company introduction 公司简介



Introduction of starter motor 起动机介绍



Calculation of brushed PM-type starter 永磁型起动机的计算



Computation of brushed wound-type starter 绕线励磁式起动机的计算

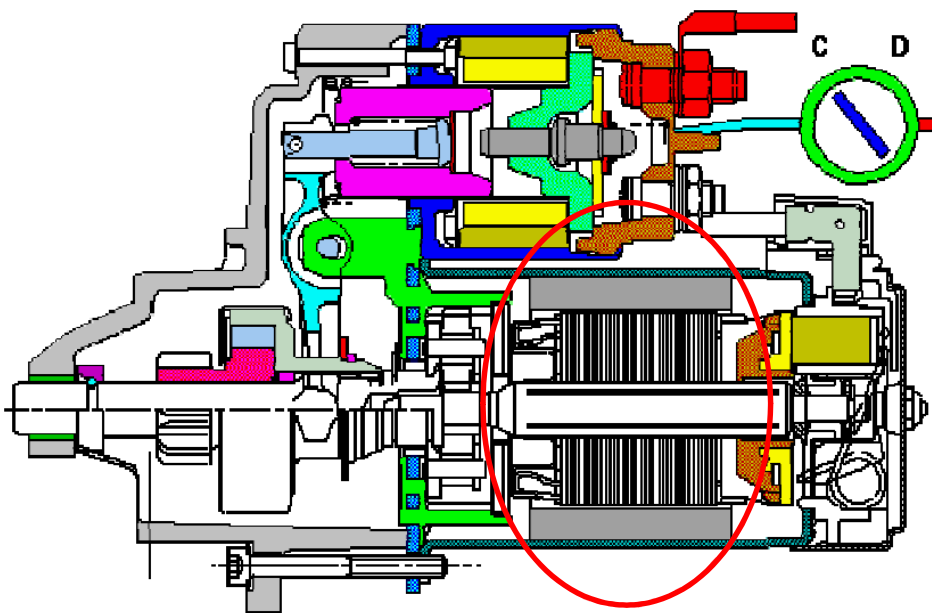


Conclusion 结论

永磁型起动机的计算

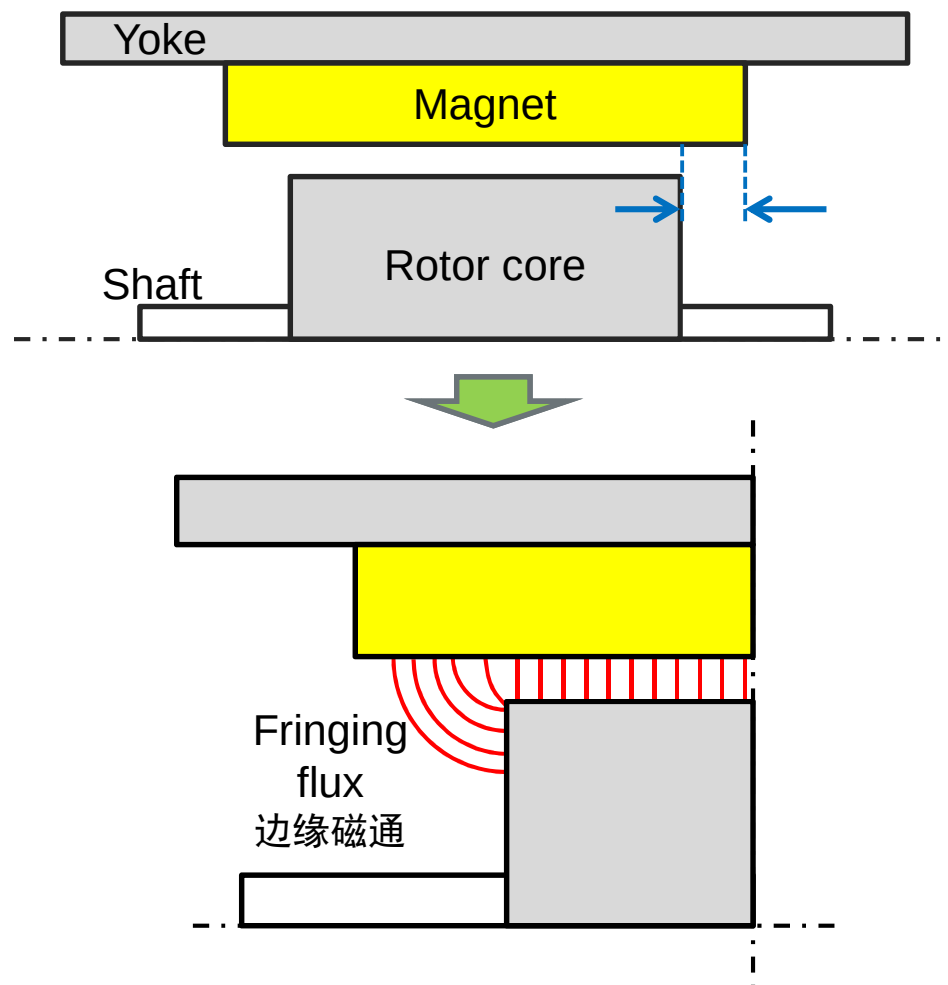
CALCULATION OF BRUSHED PM-TYPE STARTER

Overhang Structure of Starter Motor 起动机电机的悬长结构



Cross-section of PM-type starter

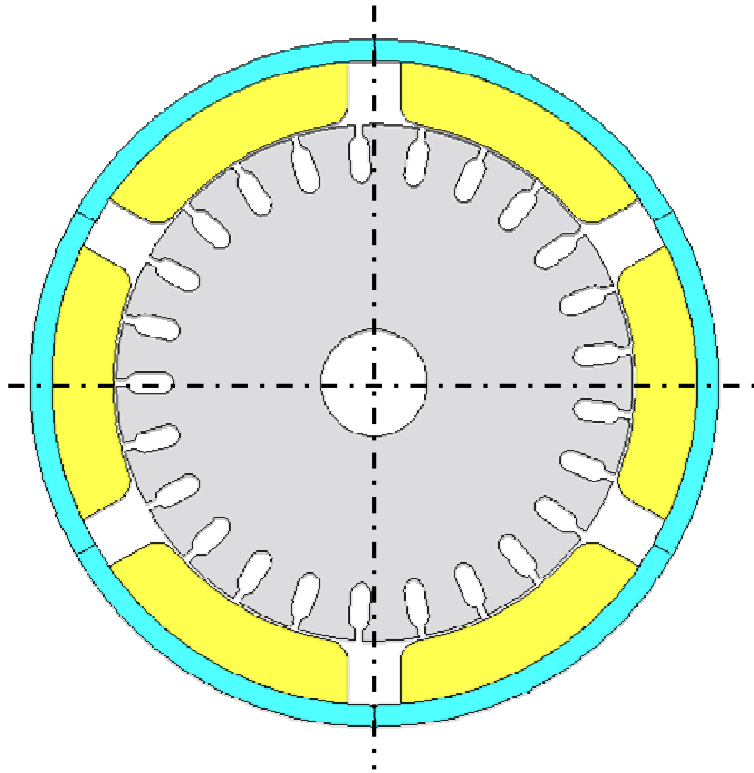
In order to maximize the PM application and compact the volume
为了最大化磁铁利用率，最小化电机体积



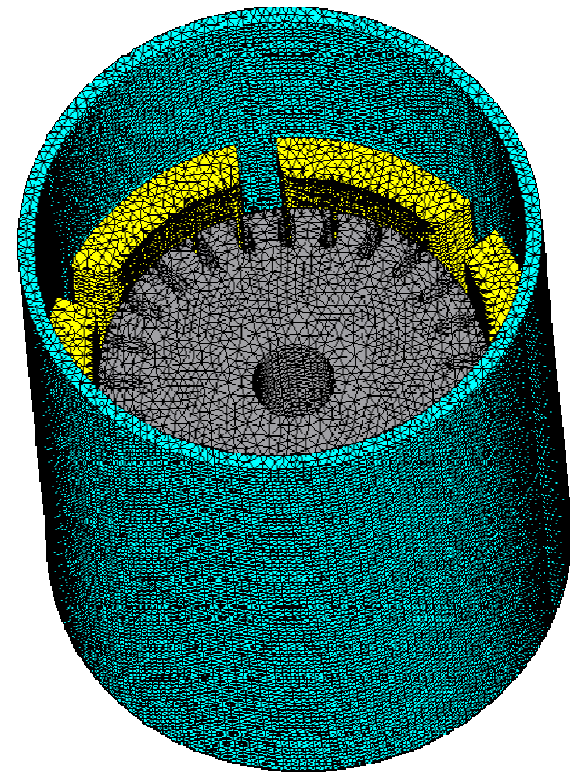
永磁型起动机的计算

CALCULATION OF BRUSHED PM-TYPE STARTER

Restriction of 3D FEA 3D仿真的限制



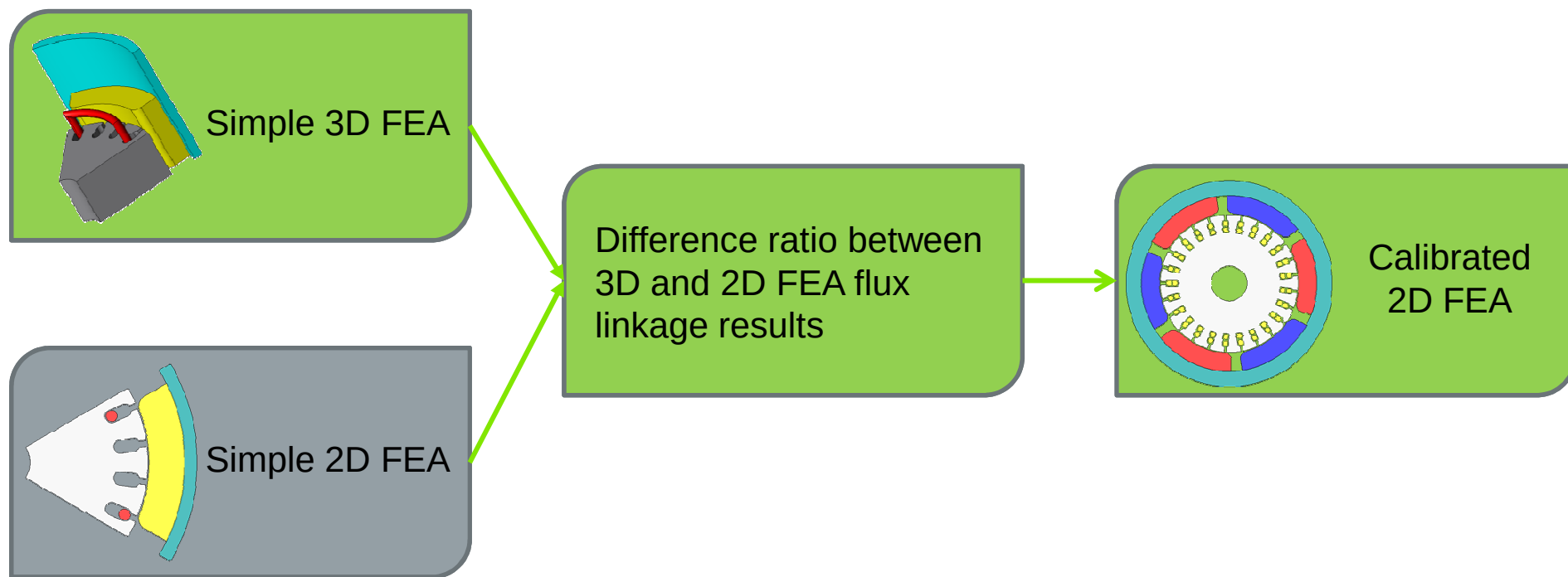
A 6-pole/25-slot motor



Elements No. $\approx$ 1 million

CALCULATION OF BRUSHED PM-TYPE STARTER

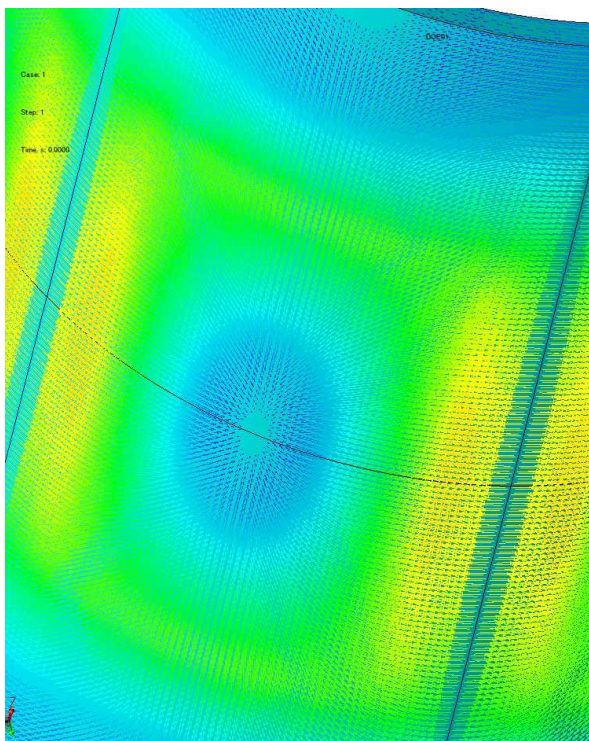
Equivalent Method Considering Overhang Effect 考虑悬长效果的等效方法



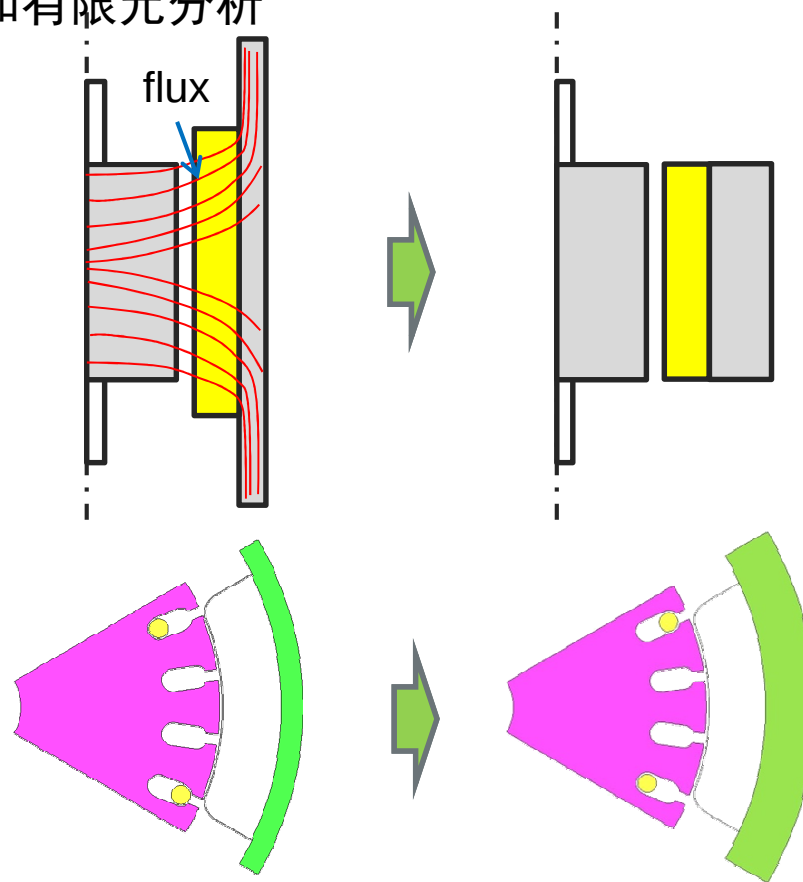
永磁型起动机的计算

CALCULATION OF BRUSHED PM-TYPE STARTER

Simple 2D Model and FEA 简单的2D模型和有限元分析



3D field distribution in yoke
在磁轭部的3D磁场分布

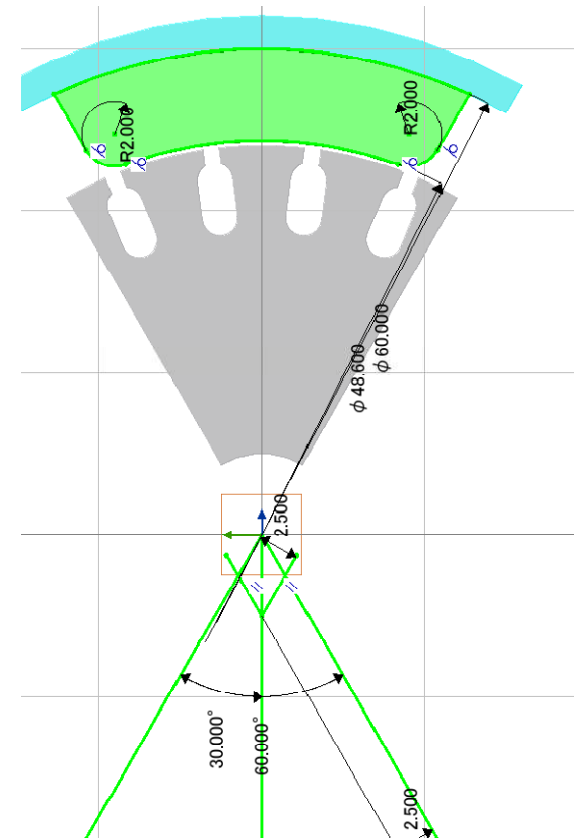
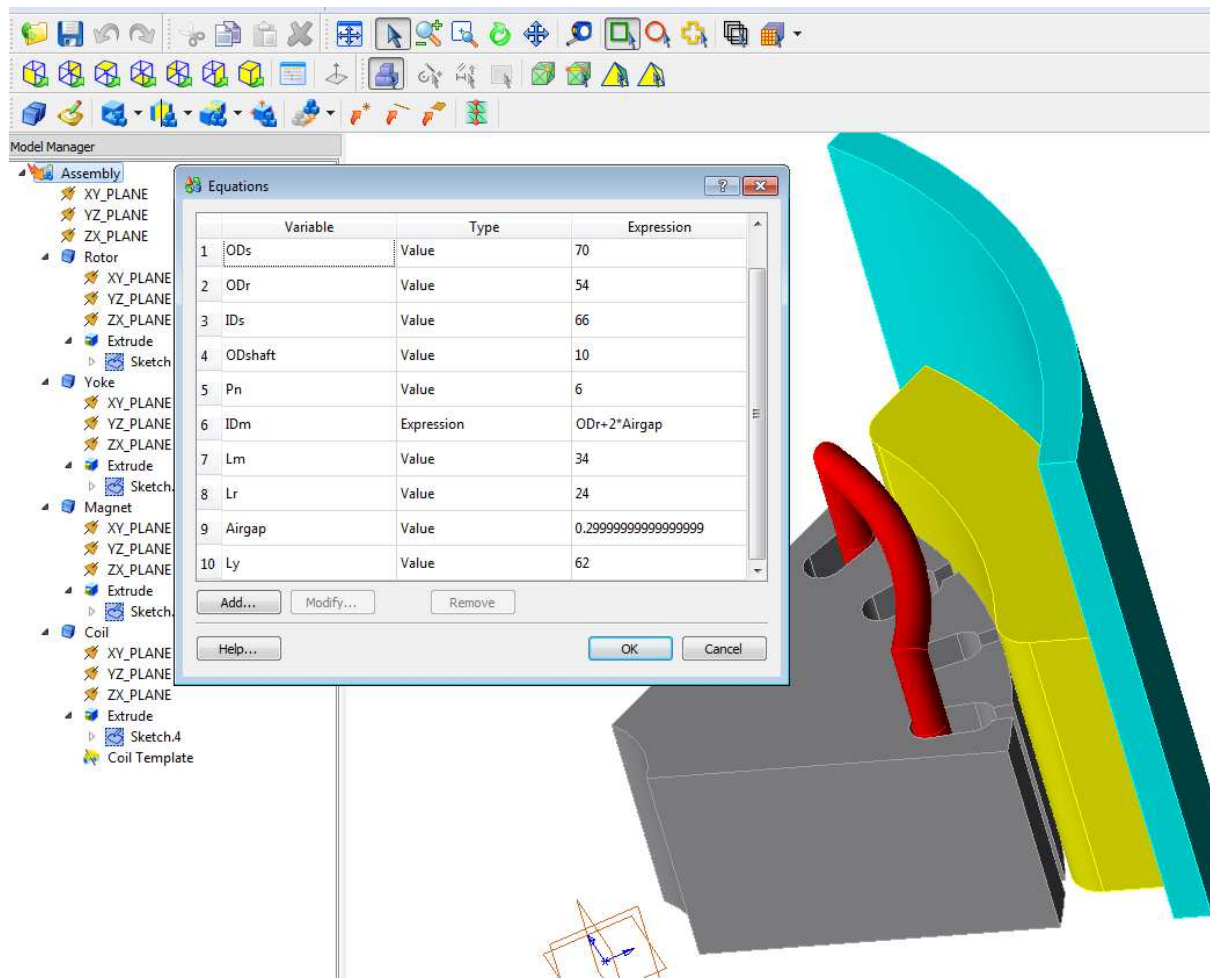


Keep the same yoke volume, an unreal one-pole model is built with the same stack length

永磁型起动机的计算

CALCULATION OF BRUSHED PM-TYPE STARTER

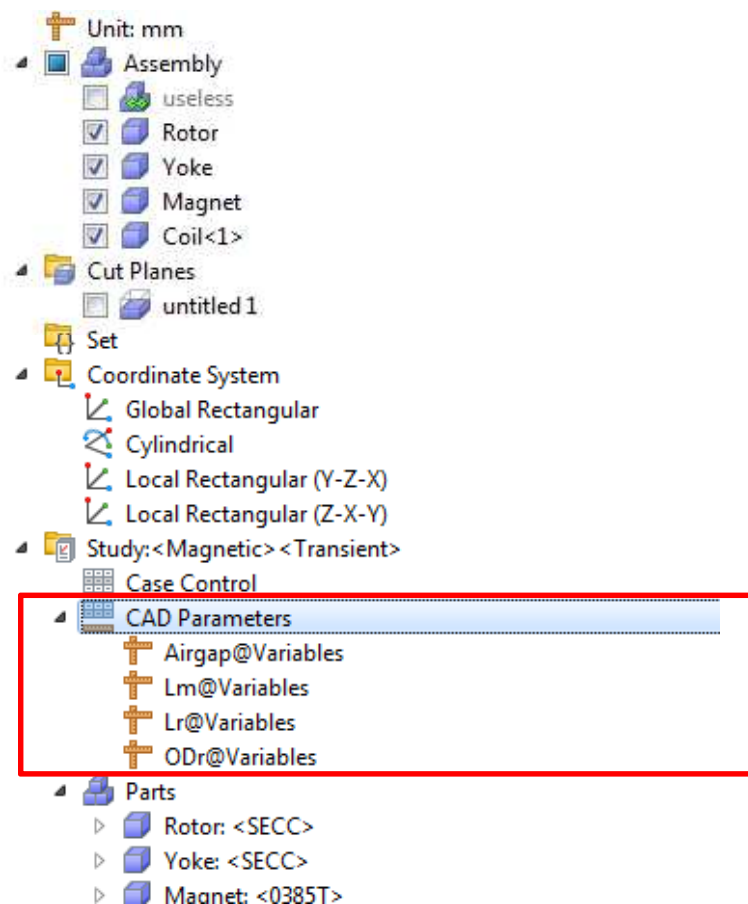
Parametric 3D Model in Jmag Designer 在Jmag Designer中的参数化3D建模



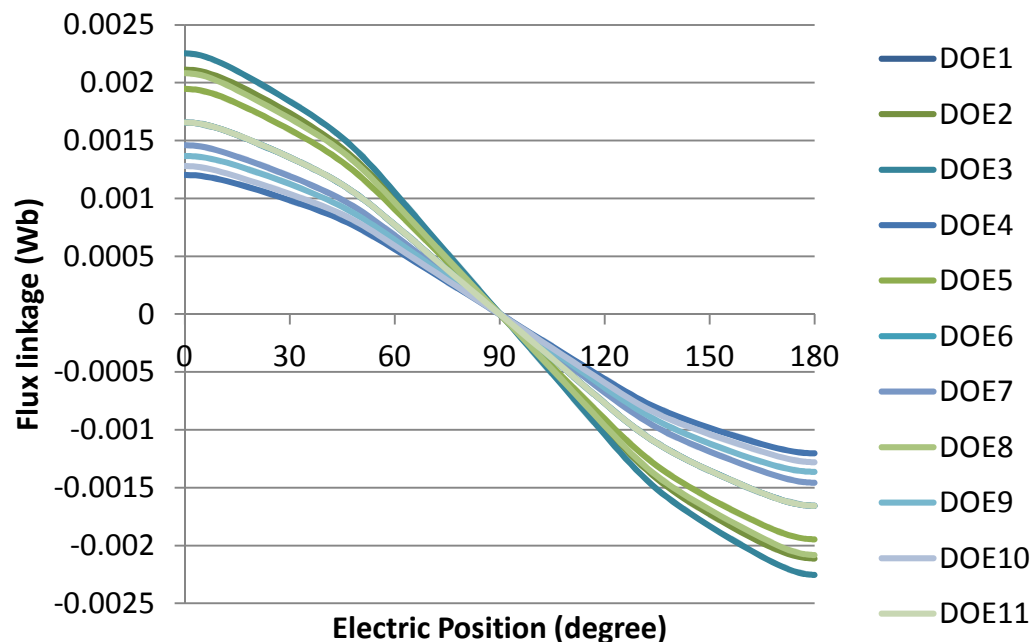
永磁型起动机的计算

CALCULATION OF BRUSHED PM-TYPE STARTER

DOE and 'Case Control' Application 'CASE Control'在DOE中的应用



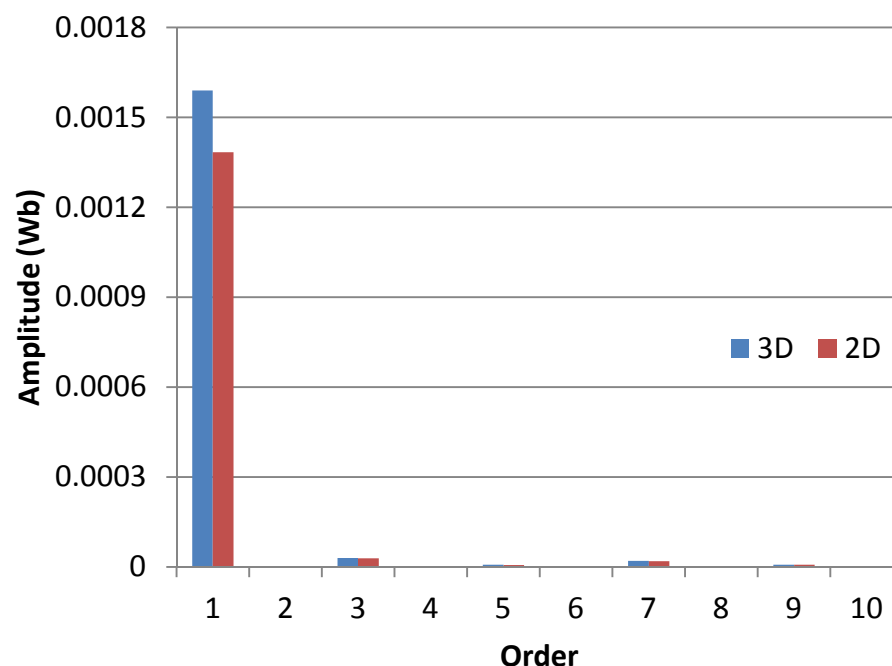
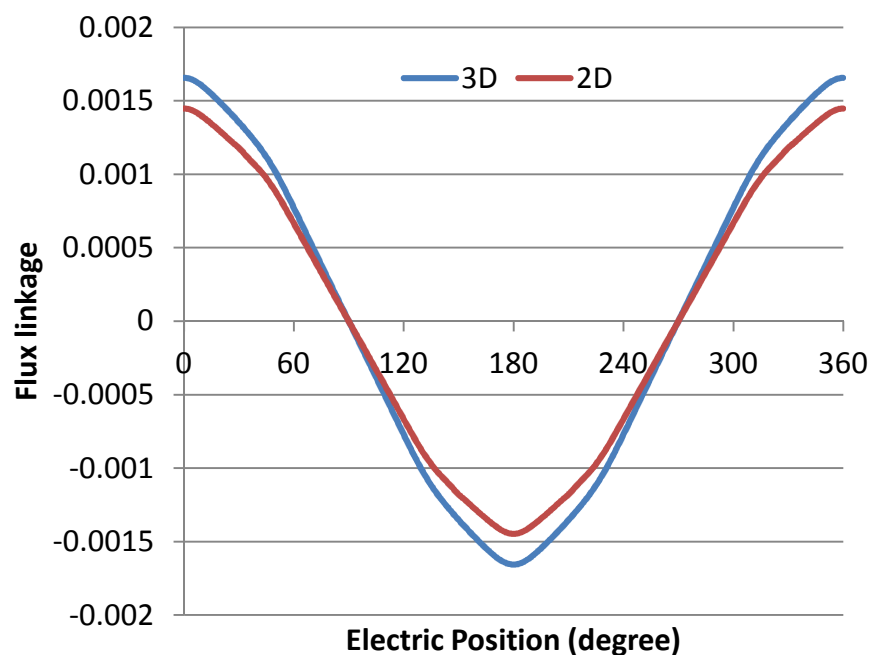
Setting the dimension as the 'CAD Parameters' to get different 3D model automatically.
3D Modeling and pre-process time is saved!



永磁型起动机的计算

CALCULATION OF BRUSHED PM-TYPE STARTER

Difference between 3D and 2D 3D与2D分析结果的对比

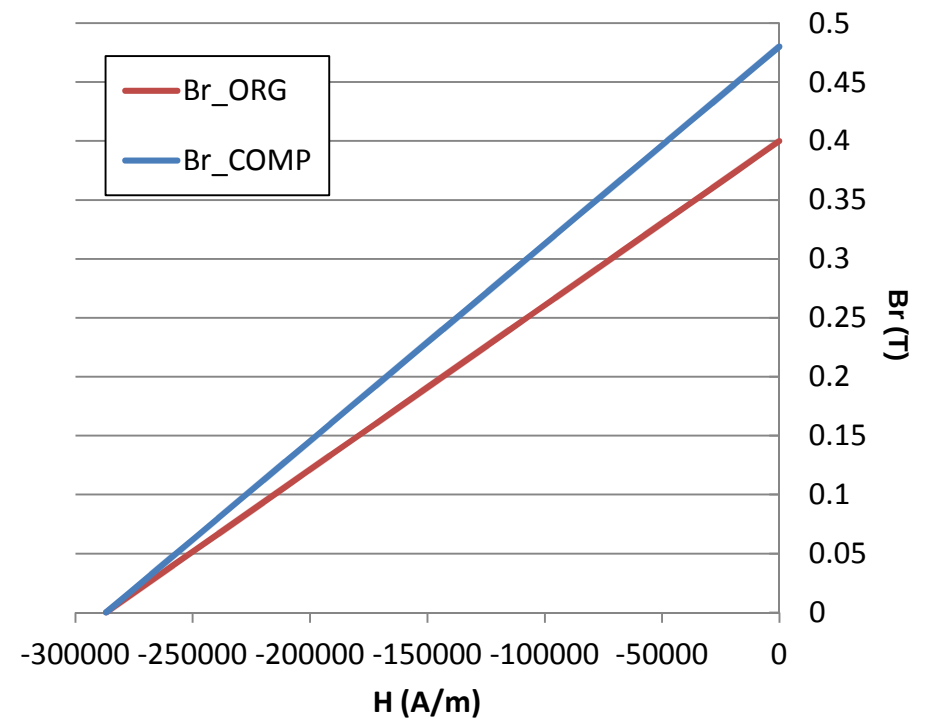
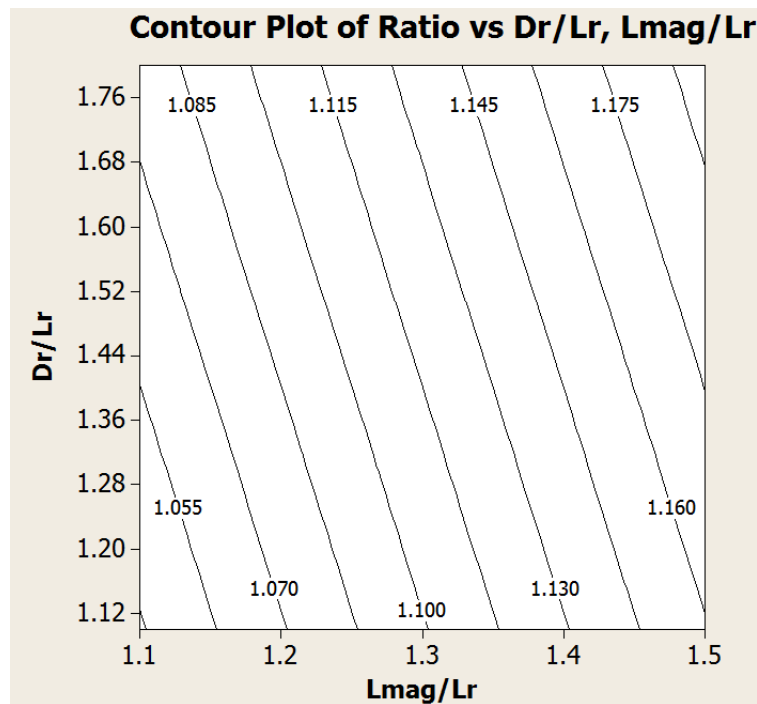


After FFT, the fundamental component is obtained and compared

永磁型起动机的计算

CALCULATION OF BRUSHED PM-TYPE STARTER

3D/2D Relationship 3D与2D的关系

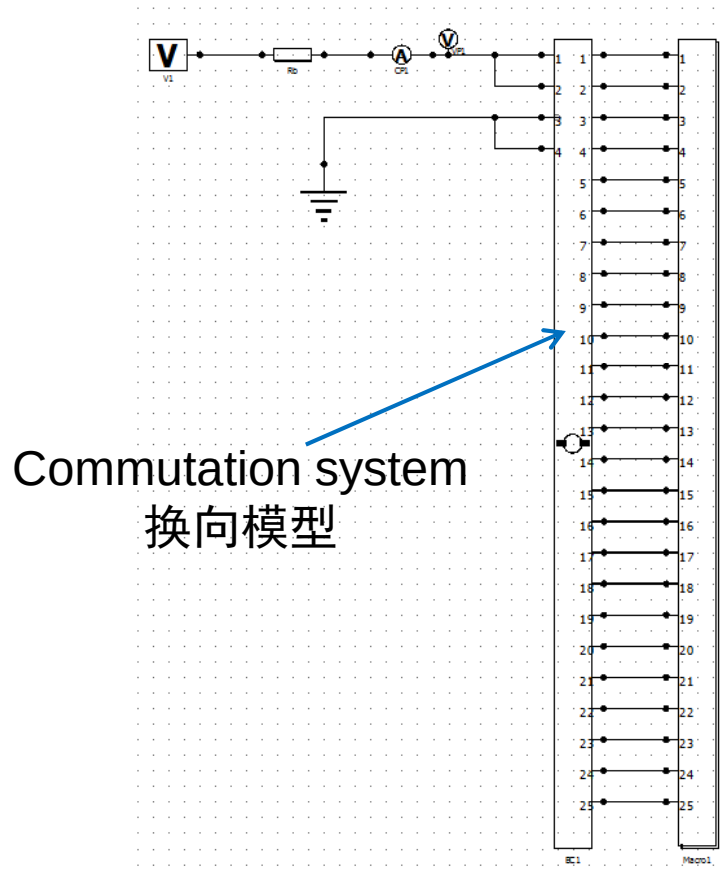


According to the obtained ratio, make compensation on the magnet BH curve

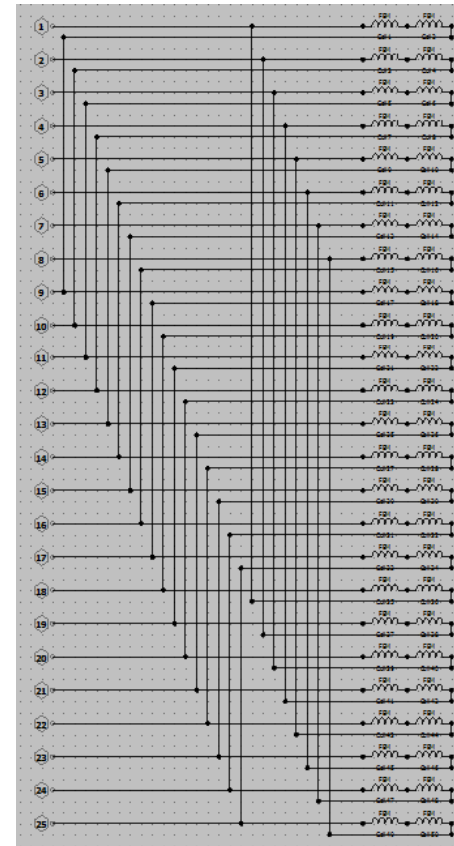
永磁型起动机的计算

CALCULATION OF BRUSHED PM-TYPE STARTER

Circuit Model 电路模型



Motor Circuit
电机电路

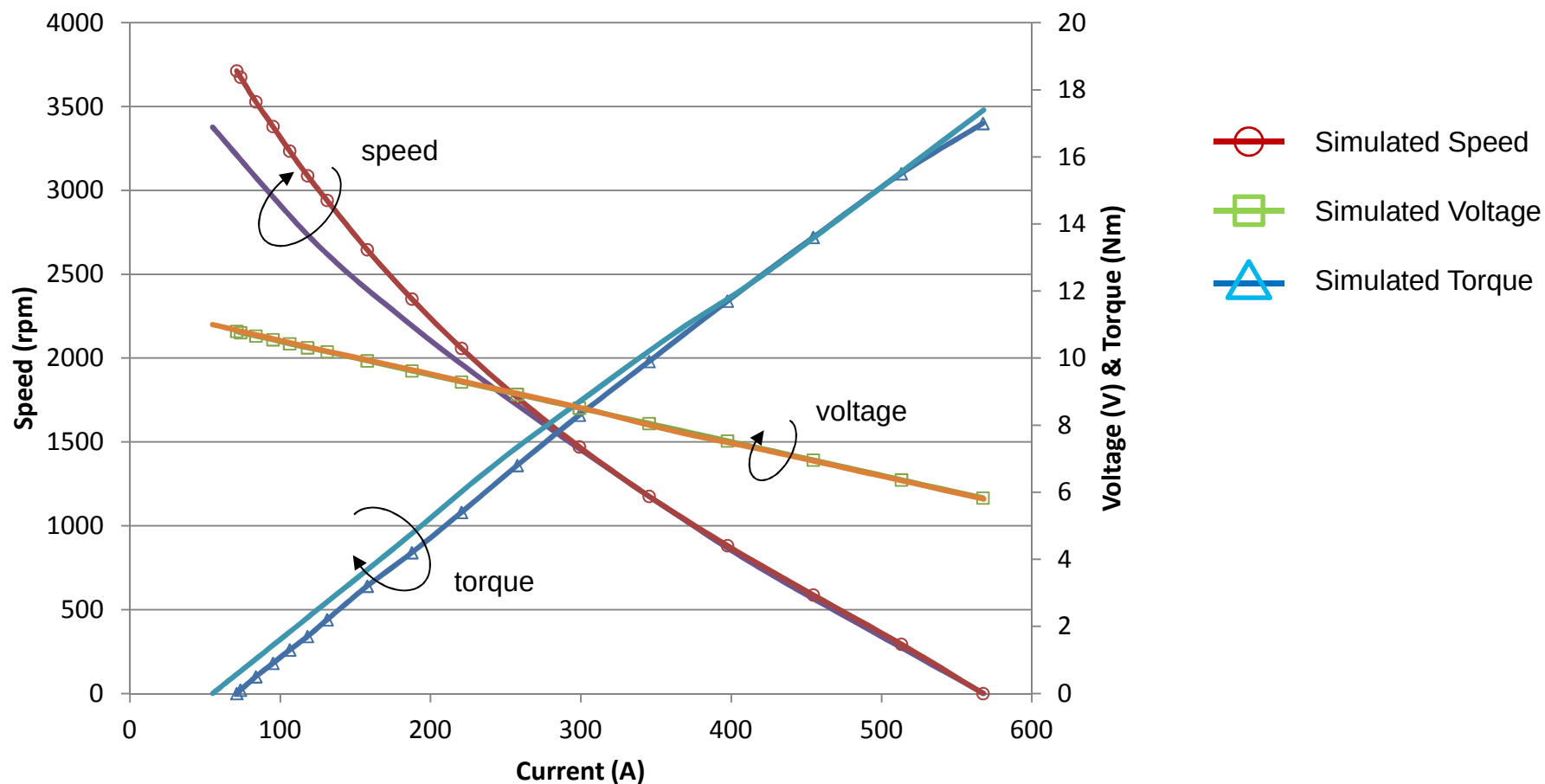


Wave-winding model
波绕组模型

永磁型起动机的计算

CALCULATION OF BRUSHED PM-TYPE STARTER

Measurement vs. Simulation 实测与仿真值的对比



绕线励磁式起动机的计算

COMPUTATION OF BRUSHED WOUND-TYPE STARTER



Company introduction 公司简介



Introduction of starter motor 起动机介绍



Calculation of brushed PM-type starter 永磁型起动机的计算



Computation of brushed wound-type starter 绕线励磁式起动机的计算

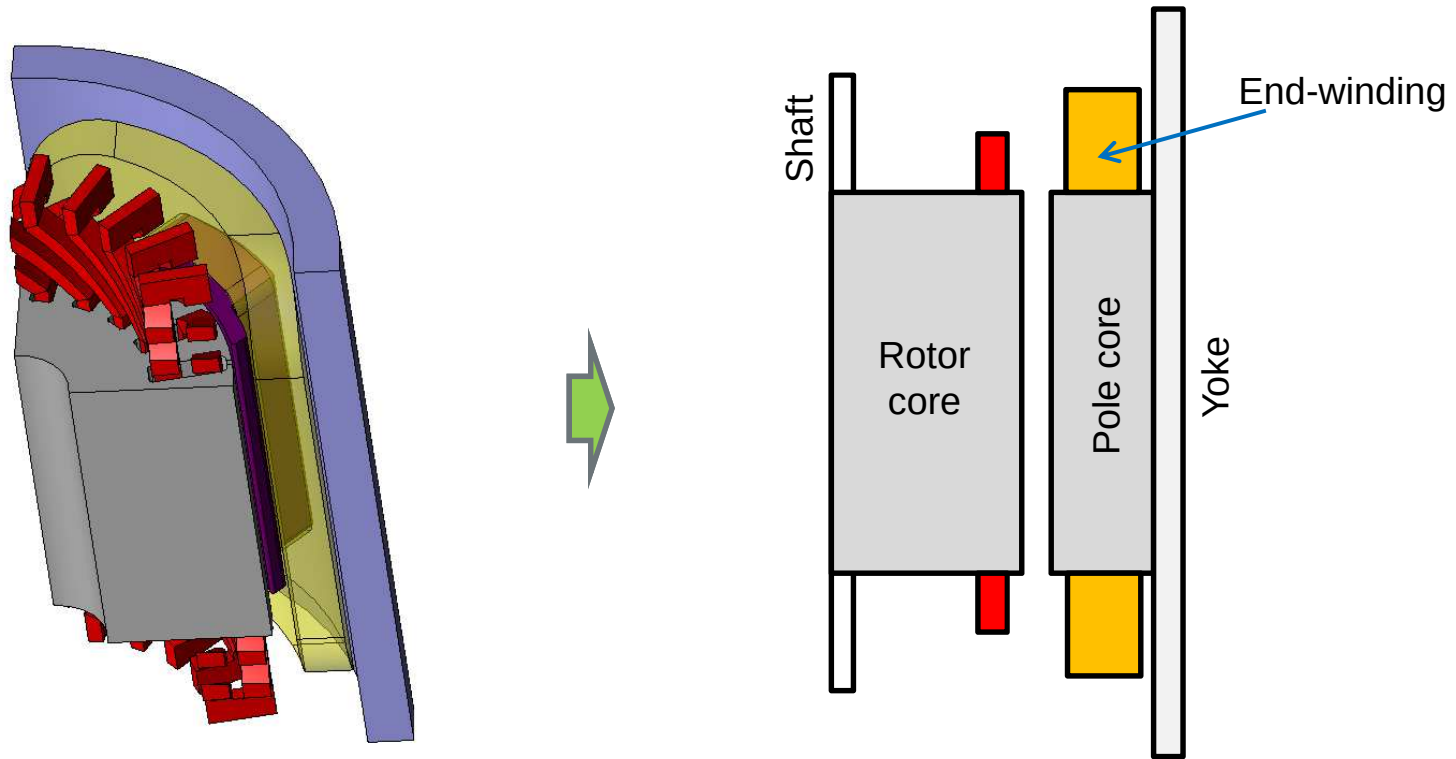


Conclusion 结论

绕线励磁式起动机的计算

COMPUTATION OF BRUSHED WOUND-TYPE STARTER

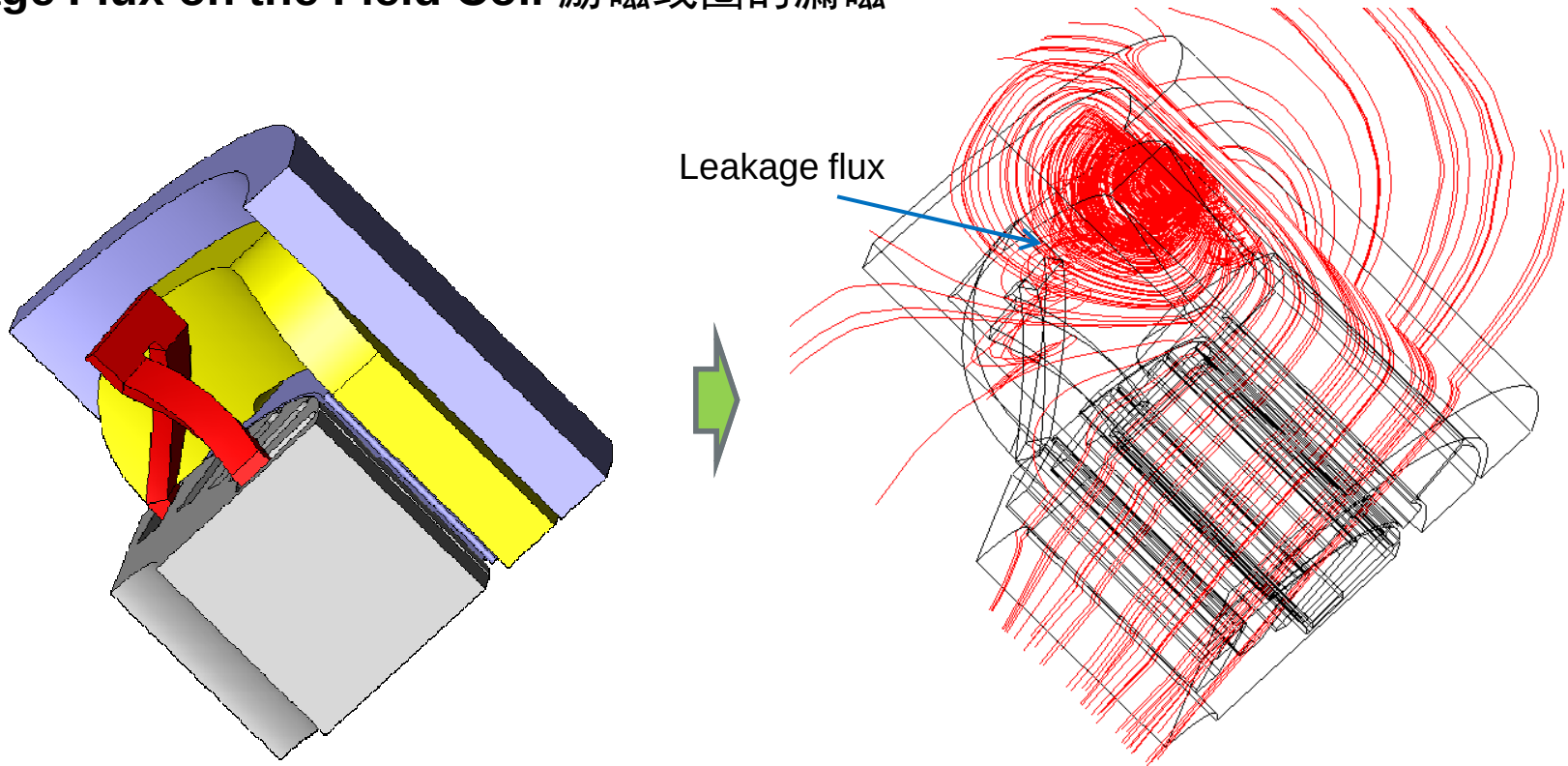
Typical Structure of Wound-Field Starter 典型的绕线式起动机的结构



Because of the similar magnetic permeability in rotor core and pole core, there is no overhang structure like PM starter. But the end-winding overhang effect cannot be ignored.

COMPUTATION OF BRUSHED WOUND-TYPE STARTER

Leakage Flux on the Field Coil 励磁线圈的漏磁

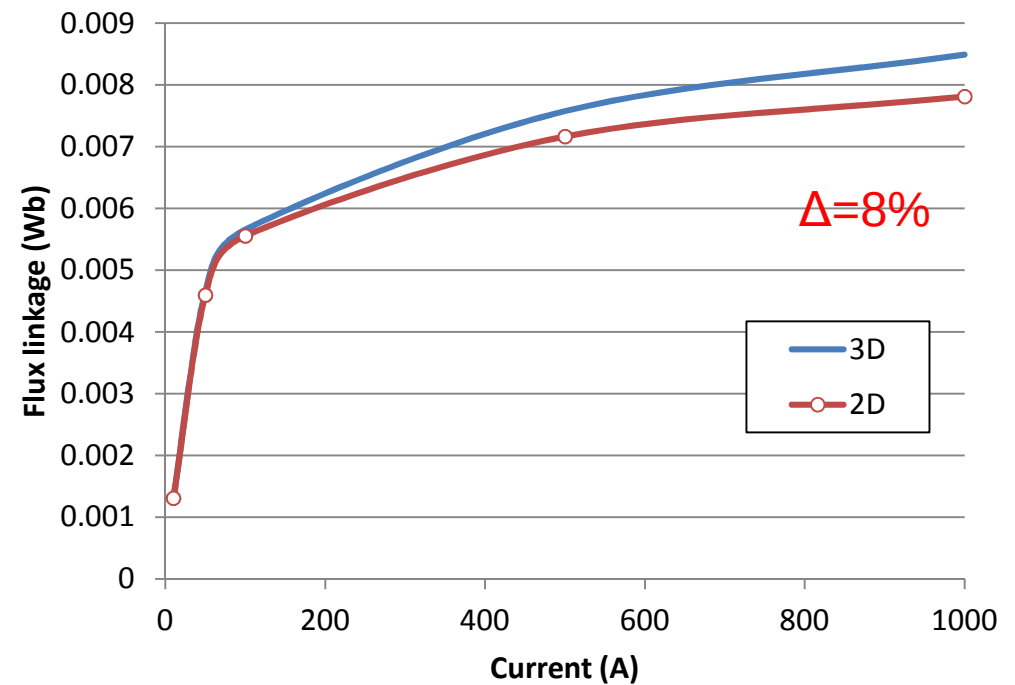
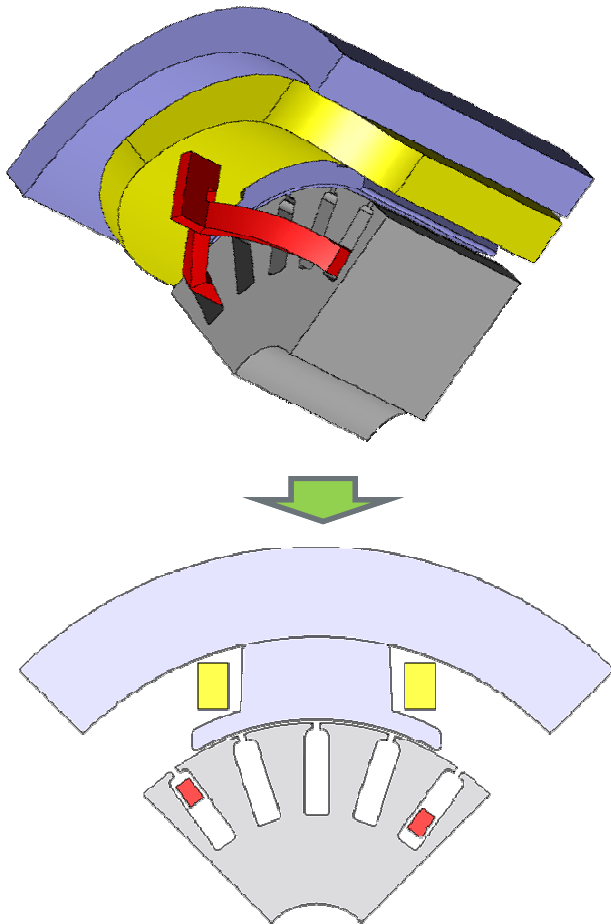


The leakage flux around the end-winding of field coil is in 3D distribution and severe. It highly influences the field and cannot be considered in any 2D simulation including the mentioned equivalent method in this presentation.

绕线励磁式起动机的计算

COMPUTATION OF BRUSHED WOUND-TYPE STARTER

Leakage Flux Effect 漏磁的影响

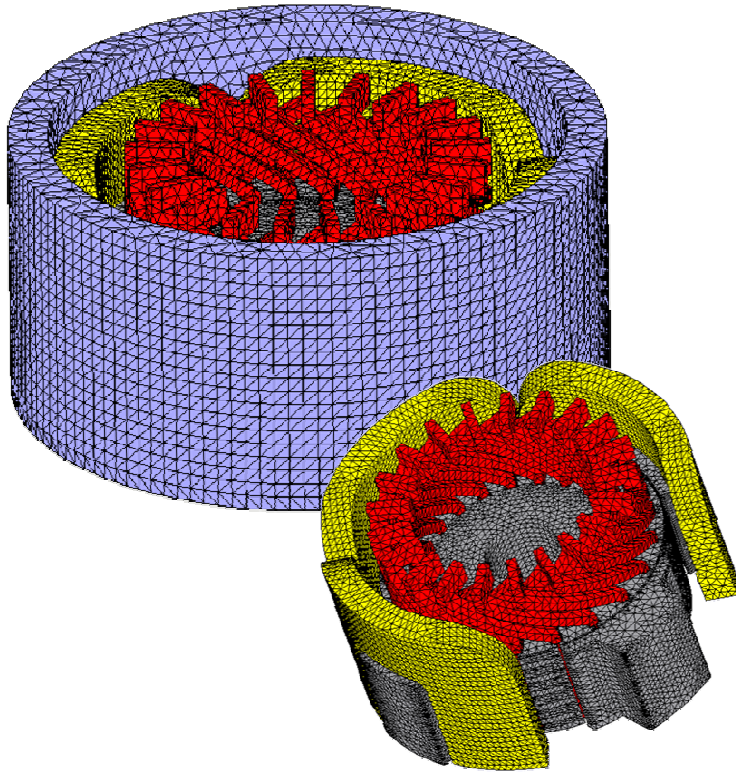


Higher current → Stronger leakage field →
Larger difference between 3D and 2D simulation

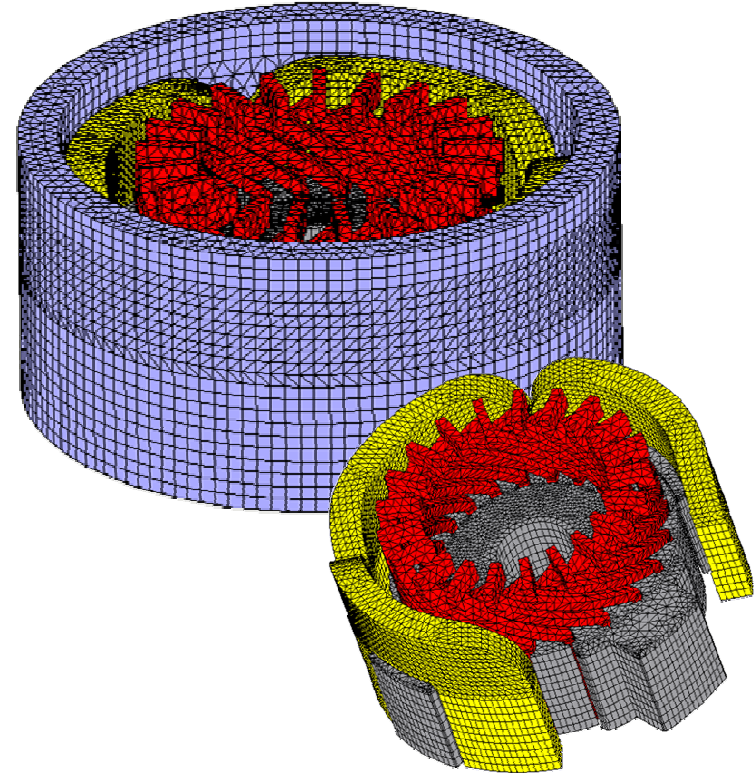
绕线励磁式起动机的计算

COMPUTATION OF BRUSHED WOUND-TYPE STARTER

Extruded Mesh Application 应用Extruded Mesh



Normal mesh ≈ 460000

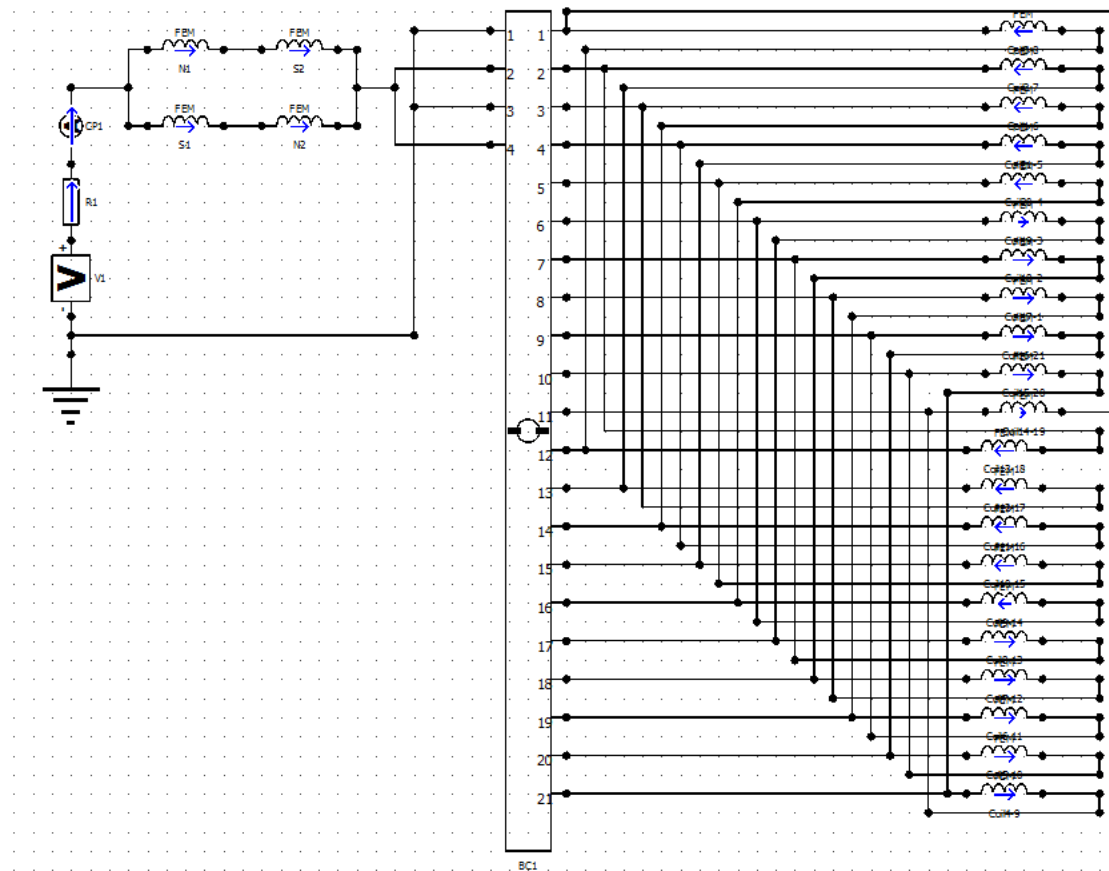


Extruded mesh ≈ 260000

绕线励磁式起动机的计算

COMPUTATION OF BRUSHED WOUND-TYPE STARTER

Circuit Model 电路模型



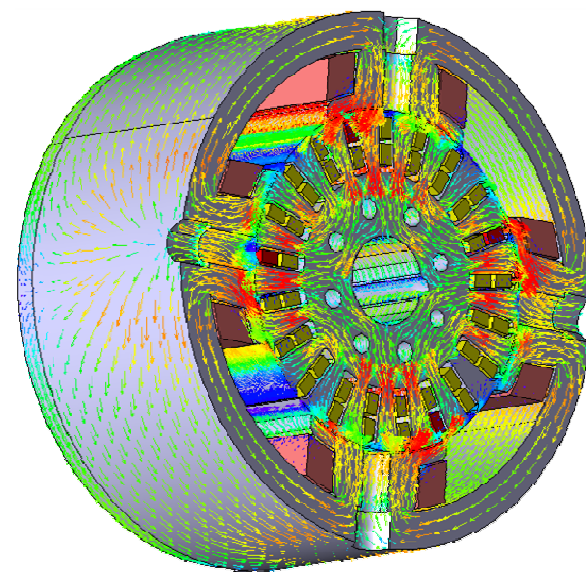
Motor Circuit (series connected field coil)
电机电路 (串励式)

绕线励磁式起动机的计算

COMPUTATION OF BRUSHED WOUND-TYPE STARTER

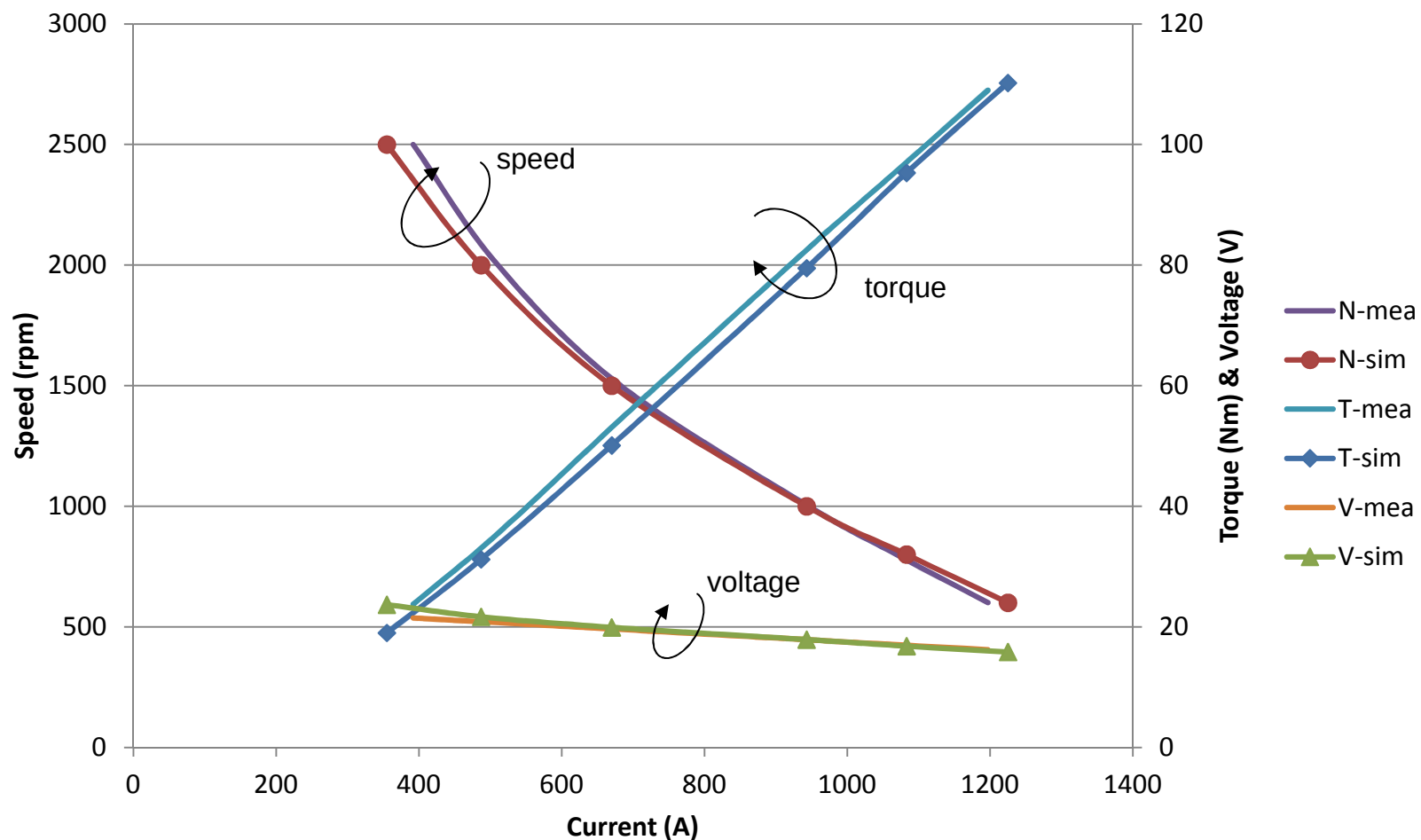
Computation Time 计算时间

Items	Normal Mesh	Extruded Mesh
CPU Frequency	3.5G Hz	
CPU Core No.	16 Cores	
RAM	48G	
Time step	8.33333e-05	
Step No.	46	
SMP	8 parallelisms	
Computation Time	≈ 40 Min	≈ 18 Min



COMPUTATION OF BRUSHED WOUND-TYPE STARTER

Measurement vs. Simulation 实测与仿真值的对比



结论

CONCLUSION

- Starter motor is mandatory for ICE engine even in most hybrid topologies
 - ▶ The compact size and low cost will be main research direction
- JMAG Designer provides the very convenient and powerful functions for the both PM-type and Wound-type starter motors
 - ▶ The PM-type starter motor could be calculated with a calibrated 2D model.
 - ▶ With DOE method, this calibration factor could be found
 - ▶ The parametric modeling and case control could be used to save the 3D modeling and pre-process time.
 - ▶ It is mandatory to use 3D computation for the wound-type starter due to the severe leakage flux of field coil.
 - ▶ With 'Extruded Mesh' function, the mesh no. is much reduced and the computation time is reduced by more than 50% of the normal mesh.

Thank You!



SMART TECHNOLOGY
FOR SMARTER CARS

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