

Development of Bicycle Generator Hub Dynamo Using JMAG

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Abstract :

Our company uses JMAG for design development of bicycle generator to power lights. The generator built into the hub is called Hub dynamo. This structure is a single-phase claw pole generator, when enough power is required from low rotation rate. Bicycle products also must be small and light. Our company introduces Hub dynamo developed by JMAG.

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Bicycle Components Division, SHIMANO INC.

Research & Development, System Engineering

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Presentation contents

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1. Company introduction
2. Hub dynamo introduction
3. Operation streamlining
4. A case study using JMAG
5. Conclusion

Company Introduction

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Established:	February, 1921
President:	Yozo Shimano
Location:	Osaka Prefecture, Sakai City
Capital:	¥35.6 billion
Consolidated sales:	¥213,596,000,000 (2010)
Main business:	Production and distribution of bicycle components, fishing tackles, cold forging products, and rowing equipment



To promote health and happiness through the enjoyment of nature and the world around us.

An Introduction to the Bicycle Division

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Recent Trends

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Using electricity (Electrical gears, electrical assists, electrical reels)



Electronic shifting system
Dura-Ace 7970 Series



Electric reel: Dendou-Maru 9000
Beast Master ZB



Electrical assist bicycle components STEPS

What is a Hub Dynamo?

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A generator integrated into the anterior hub

→It generates power from the hub's rotation, and supplies electricity to the lamp



DH-3N72



DH-2N30-J



Europe's Trekking Bike



Japan's City Cycle

The Characteristics of a Hub Dynamo

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Merits

- Light pedaling
- Quiet rotation sound
- Automatic illumination (with a lamp set)
- The lamp layout is adjustable

Installation beneath the basket



LP-X200



LP-X100

Lamp-stay installation



LP-X101

The Story Behind Introducing JMAG

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Operation streamlining on several levels

Construction of a design theory

Visualization of electromagnetic field phenomena

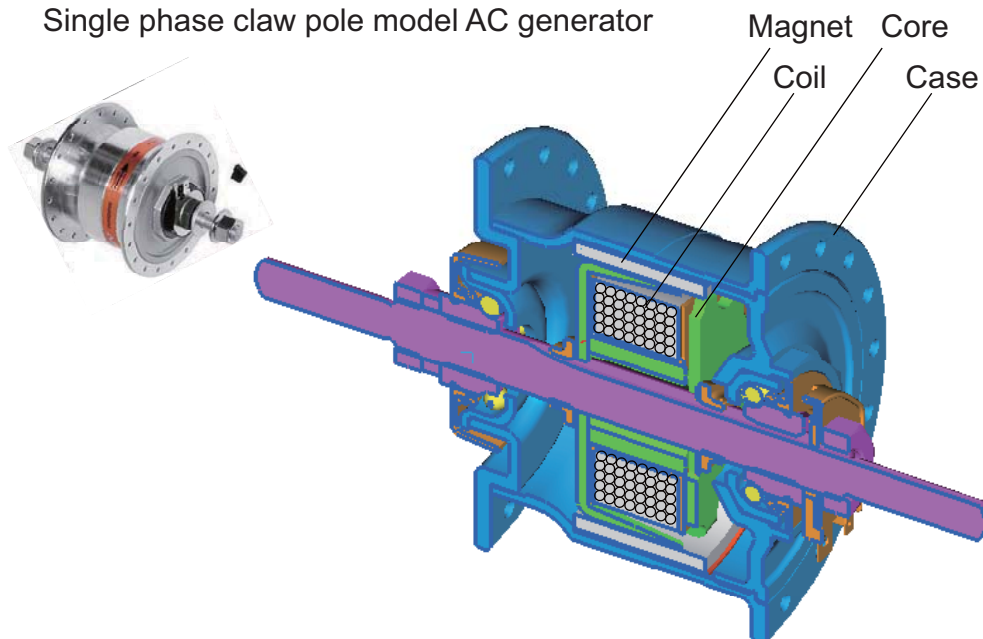
Using it as an education tool

Designers in the machine field and new hires use it,
and understand electromagnetic field phenomena quickly

Hub Dynamo Structure

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Single phase claw pole model AC generator

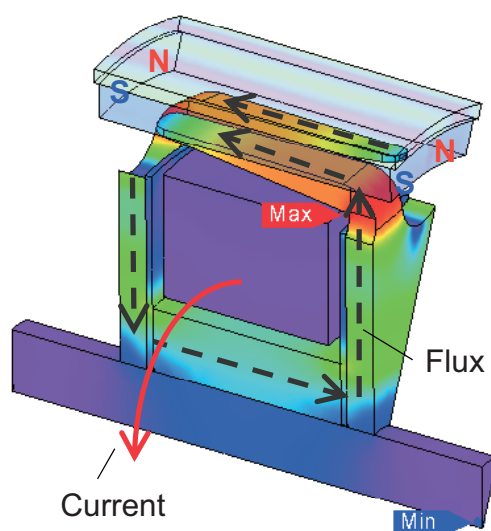


A cross section image of a hub dynamo: DH-2N30-J

Generation Mechanism

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Single phase claw pole model AC generator



Rated Specifications

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System	Outer rotor claw pole model
Outer diameter	Φ60
Rated output	2.4W
Rated voltage	6V
Rated current	0.5A
Rated speed	120rpm
Load resistance	15Ω

Required Output Properties

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The existence of a standard that corresponds to speed

Ensuring compatibility

The dynamo works no matter which manufacturer's lamp a person hooks it up to.

Standard driving characteristics: The dynamo's terminal voltage when the bicycle's speed reaches 15km/hr should be within $\pm 5\%$ of the rated voltage (6V)

Low speed driving characteristics: The dynamo's terminal voltage when the bicycle's speed is at 5km/hr is greater than 41% of the terminal voltage at a speed of 15km/hr.

High speed driving characteristics: The dynamo's terminal voltage when the bicycle's speed reaches 30km/hr is under 133% of the terminal voltage at a speed of 15km/hr.

Extracted from JIS C9502

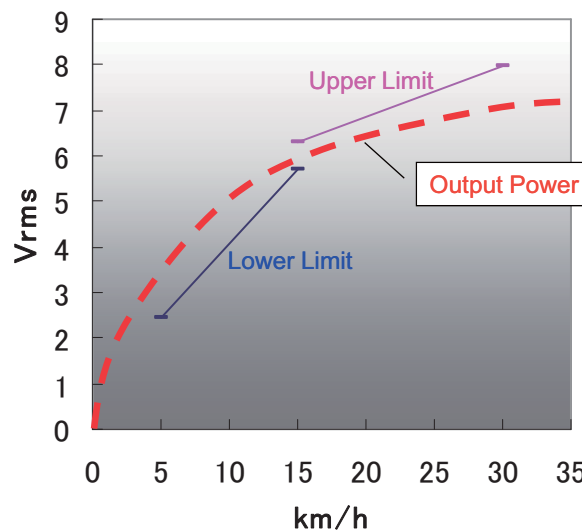
Required Output Properties

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The existence of a standard that corresponds to speed

Ensuring brightness at low speeds

Protecting the light bulb at high speeds



The standard for speed and output voltage

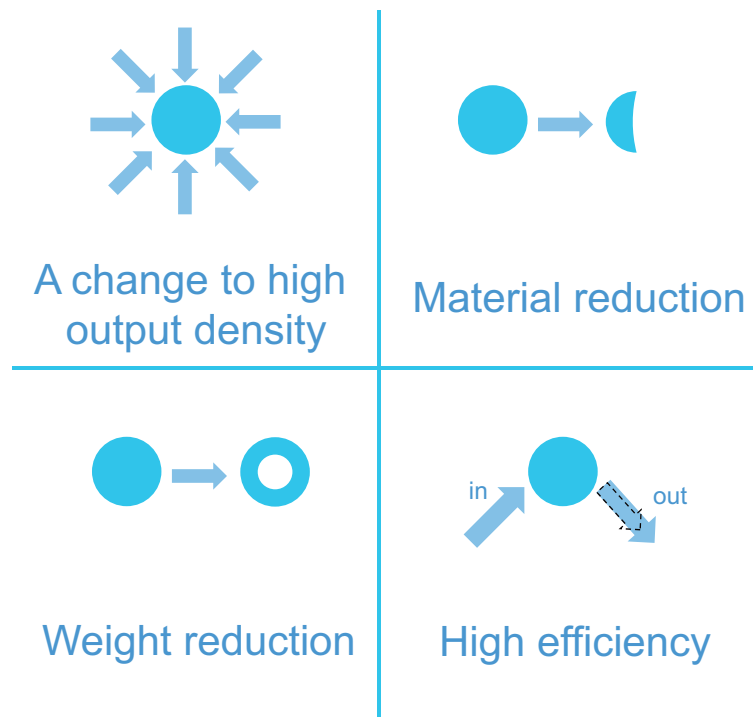
Development Mission

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***Bringing a safe and comfortable
bicycle lifestyle to more people***



Hub Dynamo Development Objectives

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Transitions in Hub Dynamos

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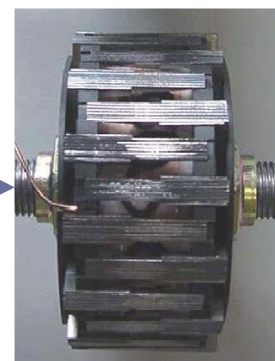
Changes toward miniaturization and high efficiency are progressing



Electromagnetic soft iron core
3 sequence construction

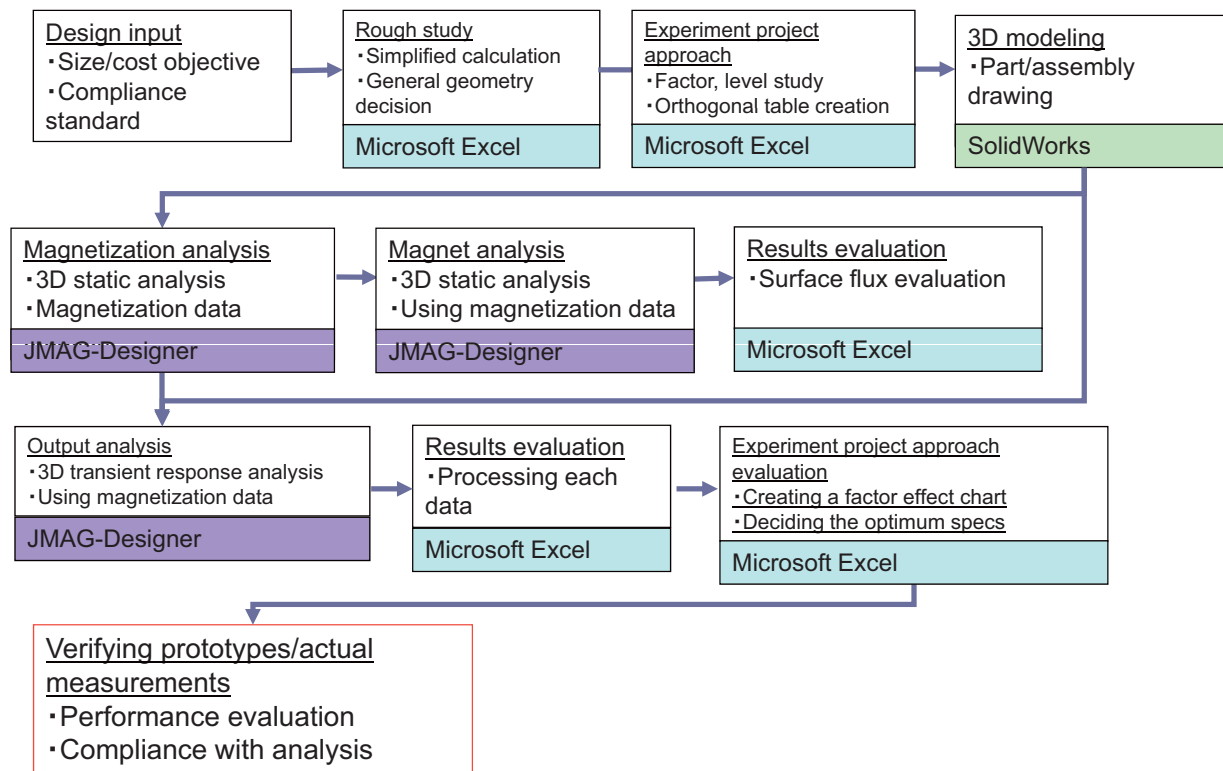


Electromagnetic soft iron core
1 sequence construction



Silicon steel plate core

Design Flow Using JMAG

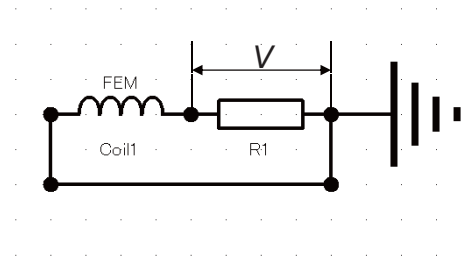
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JMAG Usage – Concrete Example

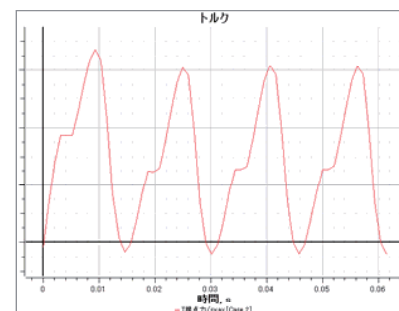
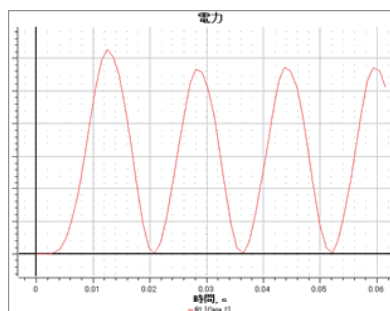
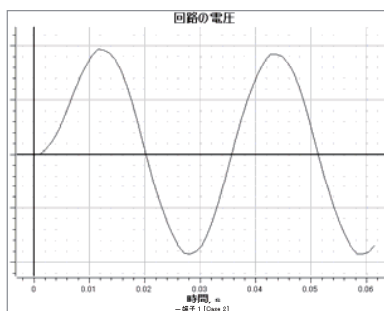
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Analysis output

{ Voltage
 Electric power
 Torque
 Iron loss



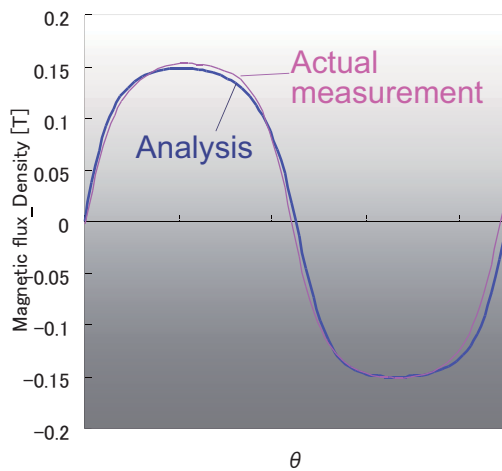
Circuit diagram



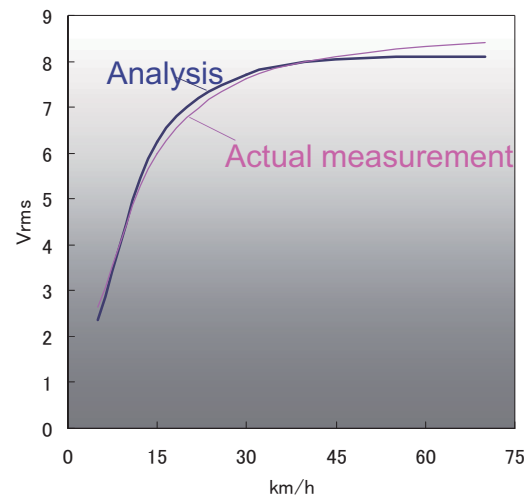
JMAG Usage – Concrete Example

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A comparison with actual measurements



The magnet's surface flux density (r direction)

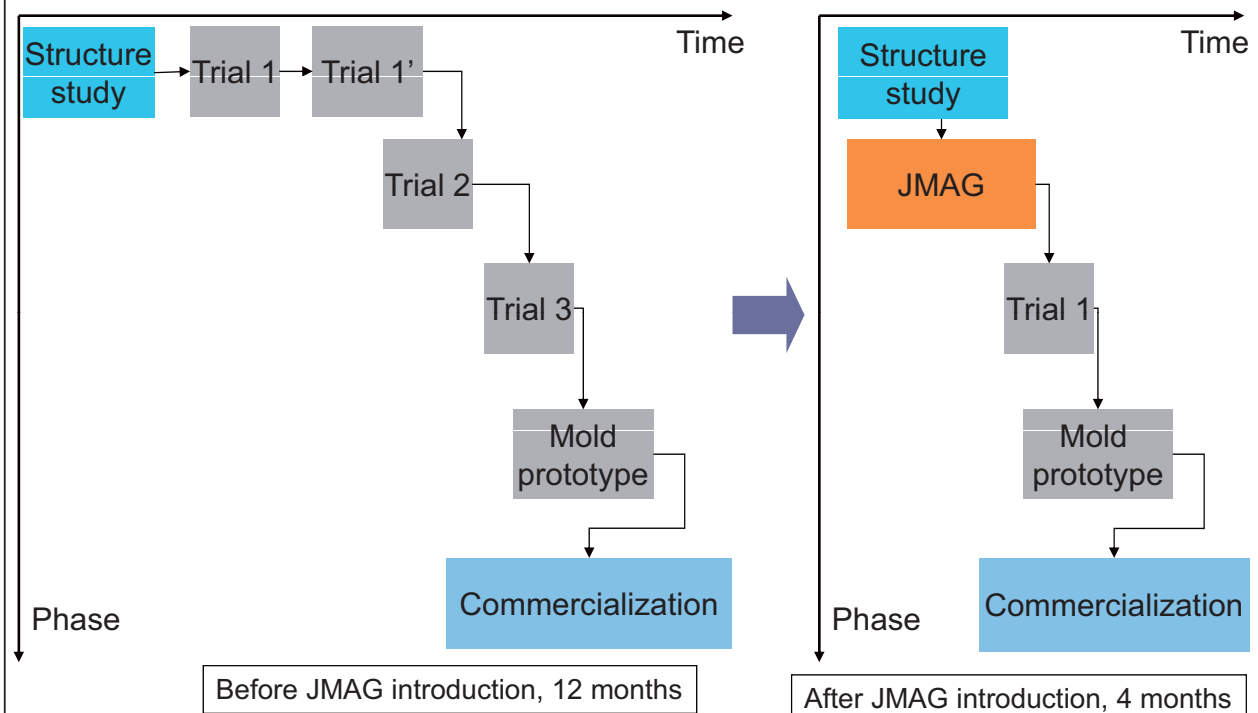


Speed and output voltage

Advantages of JMAG Introduction

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The time from structure study to commercialization is cut by 2/3!



Advantages of JMAG Introduction



Construction of a design theory

- Understanding the factors that work for performance
- Improving generation efficiency
- Making challenges like bold design changes a possibility

Anyone can design

- Both designers in the machine field and new hires
- One person two roles (Mechanism design and electric circuit design)
- Total optimization

Challenges in the Future



1. Improvement in analysis accuracy
 - Neodymium magnets, incomplete magnetization
 - Iron loss analysis
2. Reducing calculation time
 - Reducing by about 40% with introducing 2 parallel computations
 - Optimizing the mesh size even more
3. Improving the design process
 - Introducing modeFRONTIER
(CD-adapco JAPAN Co.,LTD.)